Computer Graphics & Multimedia

Graphics and Multimedia-now a day probably the most talked about technology in the field of computer. This technology is nowadays largely adopted by most computer based applications to bridge the gap between a human user & the computer. By this , multiple media are implemented and used in computer based application to enhance their understanding ability before a common man. This multiple media include, text, sound, video, graphics animation etc. This paper will expense the students to the various concepts of these media and their implementation in computer based application. This will also expose the students to various multimedia implementation techniques like data compression, & various multimedia standards.

Course Contents **Pg.No**

Text Book :

1. Computer Graphics ; Donald Hearn , M.Pauline Baker ; PHI

2. Multimedia Systems; Buford; Pearson

3. Multimedia: Sound and Video by Jose Lozano, PHI

4. Multimedia Systems,Tech. & Communications; S.Pandey, M.Pandey; Katson

1. Applications of Computer Graphics & Multimedia

Contents

Introduction

Computer Graphics (CG) is the field of visual computing, where one utilizes computers both to generate visual images synthetically and to integrate or alter visual and spatial information sampled from the real world. Computer Graphics is the pictorial representation and manipulation of data by a computer.

Applications of Computer Graphics

Early use of computer graphics are

- Data Visualization
    - Charts and Graphs
- Computer Aided Design (CAD).

  Now a days we use in different sectors that are
- Virtual Reality
    - VR: User interacts and views with a 3D world using “more natural” means
    - Best VR
- Data Visualization
    - Scientific, Engineering, Medical data
    - Visualizing millions to billions of data points
    - See trends
    - Different schemes
- Education and Training
    - Models of physical, financial, social systems
    - Comprehension of complex systems
- Computer Art
    - Fine and commercial art

    - Performance Art
    - Aesthetic Computing
    - SIGGRAPH (Special Interest Group on Graphics and Interactive Techniques)
- Games/Movies
- Image Processing
    - Manipulating images using efficient algorithm.
- Graphical User Interfaces (GUIs)
    - WIMP interface (Windows,Icons,Menus,pointers)
    - HCI

1.1 <u>Computer graphics in CAD</u>

A major use of computer graphics is in design processes, particularly for engineering and architectural systems. For some design applications; objects are first displayed in a wireframe outline form that shows the overall sham and internal features of objects.

Software packages for CAD applications typically provide the designer with a multi-window environment. Each window can show enlarged sections or different views of objects. Standard shapes for electrical, electronic, and logic circuits are often supplied by the design package. The connections between the components have been mad automatically.

- Animations are often used in CAD applications.
- Real-time animations using wire frame displays are useful for testing performance of a vehicle.
- Wire frame models allow the designer to see the interior parts of the vehicle during motion.
- When object designs are complete, realistic lighting models and surface rendering are applied.
- Manufacturing process of object can also be controlled through CAD.
- Interactive graphics methods are used to layout the buildings.
- Three-dimensional interior layouts and lighting also provided.
- With virtual-reality systems, the designers can go for a simulated walk inside the building.

1.2 <u>Presentation Graphics</u>

- It is used to produce illustrations for reports or to generate 35-mm slides for use with projectors.

- Examples of presentation graphics are bar charts, line graphs, surface graphs, pie charts and displays showing relationships between parameters.
- 3-D graphics can provide more attraction to the presentation.

1.3 Computer Art

- Computer graphics methods are widely used in both fine art and commercial art applications.
- The fineartists use a combination of 3D modeling packages, texture mapping, drawing programs and CAD software.
- Pen plotter with specially designed software can create “automatic art”.
- “Mathematical Art” can be produced using mathematical functions, fractal procedures, Mathematica software,injet printers and other systems to create a variety of 2D and 3D shapes and stereoscopic image pairs.
- These methods are also applied in commercial art.
- Photorealistic techniques are used to render images of a product.
- Animations are also used frequently in advertising, and television commercials are produced frame by frame. Film animations require 24 frames for each second in the animation sequence.
- A common graphics method employed in many commercials is morphing, where one object is transformed into another.

1.4 Entertainment

- CG methods are now commonly used in making motion pictures, music videos and television shows.
- Many TV series regularly employ computer graphics methods.
- Graphics objects can be combined with a live action.

1.5 Education And Training

- Computer-generated models of physical, financial and economic systems are often used as educational aids.
- For some training applications, special systems are designed.
- Eg. Training of ship captains, aircraft pilots etc.,
- Some simulators have no video screens, but most simulators provide graphics screen for visual operation. Some of them provide only the control panel.

1.6 Visualization

- The numerical and scientific data are converted to a visual form for analysis and to study the behavior called visualization.
- Producing graphical representation for scientific data sets are called scientific visualization.
- Business visualization is used to represent the data sets related to commerce and industry.
- The visualization can be either 2D or 3D.

1.7 Image Processing

- Computer graphics is used to create a picture.
- Image processing applies techniques to modify or interpret existing pictures.
- To apply image processing methods, the image must be digitized first.
- Medical applications also make extensive use of image processing techniques for picture enhancements, simulations of operations, etc.

1.8 Graphical User Interface

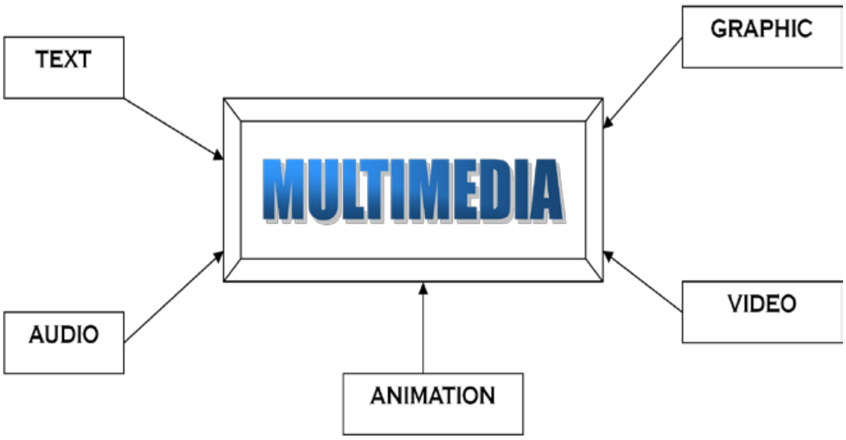
- Nowadays software packages provide graphics user interface (GUI) for the user to work easily.
- A major component in GUI is a window.
- Multiple windows can be opened at a time.
- To activate any one of the window, the user needs just to check on that window.
- Menus and icons are used for fast selection of processing operations.
- Icons are used as shortcut to perform functions. Icons take less screen space.Some other interfaces like text box, buttons, and list are also used.

1.9 Concept of Multimedia

- Multi

  Many, Multiple,
- Media
  - Tools that is used to represent or do a certain things, delivery medium, a form of mass communication – newspaper, magazine / tv.
  - Distribution tool & information presentation – text, graphic, voice, images, music and etc.

- Multimedia is a combination of text, graphic, sound, animation, and video that is delivered interactively to the user by electronic or digitally manipulated means.



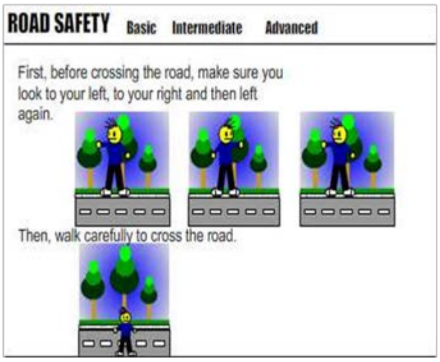
Text

- A broad term for something that contains words to express something.
- Text is the most basic element of multimedia.
- A good choice of words could help convey the intended message to the users (keywords).
- Used in contents, menus, navigational buttons.

Graphics

- Two-dimensional figure or illustration
- Could be produced manually (by drawing, painting, carving, etc.) or by computer graphics technology.
- Used in multimedia to show more clearly what a particular information is all about (diagrams, picture)

- Example



Audio

- Produced by vibration, as perceived by the sense of hearing.
- In multimedia, audio could come in the form of speech, sound effects and also music score.

Animation

- The illusion of motion created by the consecutive display of images of static elements.
- In multimedia, animation is used to further enhance / enriched the experience of the user to further understand the information conveyed to them.

Video

- Video is the technology of capturing, recording, processing, transmitting, and reconstructing moving pictures.
- Video concentrates more on photo realistic image sequence and live recording.
- Video also takes a lot of storage space.
- It broadlydivided into two types

  1.Linear

  2.Non-linear

2. Over View Of Graphics System

Contents

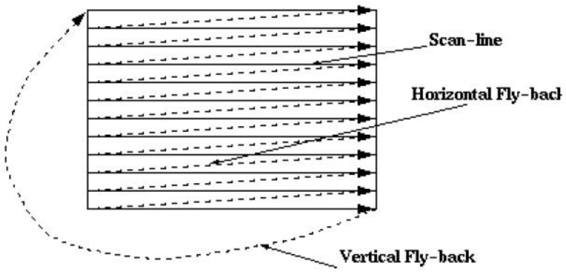
2.1 Graphics System

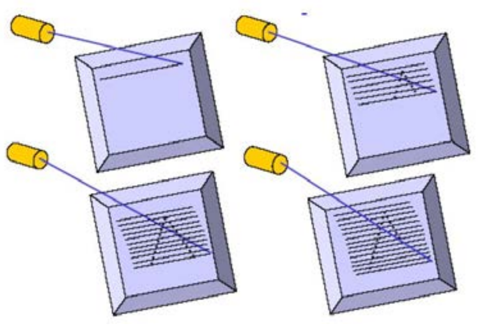
- There are different formats used for storing a picture in a computer; but, unlike text and data files, which are primarily made up of alphanumeric characters, graphics formats are more complex.
- Two major categories of graphics formats are vector graphics (objects made up of lines) and bitmapped graphics (TV-like dots).
- Images stored in vector format can be moved to another vector system typically without loss of resolution. There are 2D vector formats as well as 3D vector formats.
- During transfer of raster images among different devices, resolution is a major concern. Such transfers can occur without loss of resolution as long as the new format supports the same or is of higher resolution to the old one.
- Standard graphics formats allow images to be moved from machine to machine, while standard graphics languages let graphics programs be moved from machine to machine.
- For example, GKS, PHIGS and OpenGL are major graphics languages that have been adopted by high-performance workstation and CAD vendors. GDI and DirectX are the graphics languagesin Windows.
- High-resolution graphics is typically expensive to implement due to its large storage and fast processing requirements. However, as desktop computers become more powerful, graphics have become widely used in every application.

2.2 Raster Scan Displays

- 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 the refresh buffer or frame buffer used for redrawn.

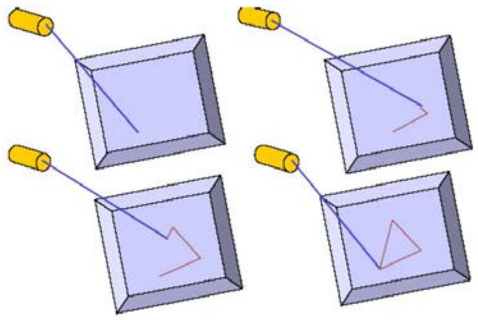
- Each screen point is referred to as a pixel or pel (picture element).
- Intensity range for pixel positions depends on the capability of the raster system.
- In a B&W system, each screen point is either on or off. So only one bit is needed.
- The frame buffer in B&W system is called as bitmap. For multi-color systems the frame buffer is called as pixmap.
- Refreshing on raster-scan displays is carried out at the rate of 60 to 80 frames per second. The unit for refreshing rate is Hertz (Hz).





2.3 Random-Scan Displays

- The CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn.
- Random-scan monitors draw a picture one line at a time, called as vector display.
- Refresh rates on a ransom-scan system depends on the number of lines to be displayed.
- Picture definition is stored as a set of line-drawing commands in the refresh display file or refresh buffer.
- To display a specified picture, the system cycles through the set of commands in the display file, drawing each component line.
- These systems are designed for the line-drawing applications and can't display realistic shaded scenes.



Difference betweenRaster Scan Display and Random Scan Display

Base of Difference	Raster Scan Display	Random Scan Display
Electron Beam	The electron beam is swept across the screen, one row at a time, from top to bottom.	The electron beam is directed only to the parts of screen where a picture is to be drawn.
Resolution	Its resolution is poor because raster system in contrast produces zig-zag lines that are plotted as discrete point sets.	Its resolution is good because this system produces smooth lines drawings because CRT beam directly follows the line path.
Picture Definition	Picture definition is stored as a set of intensity values for all screen points, called pixels in a refresh buffer area.	Picture definition is stored as a set of line drawing instructions in a display file.
Realistic Display	The capability of this system to store intensity values for pixel makes it well suited for the realistic display of scenes contain shadow and colorpattern.	These systems are designed for line-drawing and can't display realistic shaded scenes.
Draw an Image	Screen points/pixels are used to draw an image.	Mathematical functions are used to draw an image.

Vector Scan Display	Raster Scan Display
1. In vector scan display the beam is moved between the end points of the graphics primitives.	1. In raster scan display the beam is moved all over the screen one scan line at a time, from top to bottom and then back to top.
2. Vector display flickers when the number of primitives in the buffer becomes too large.	2. In raster display, the refresh process is independent of the complexity of the image.
3. Scan conversion is not required.	3. Graphics primities are specified in terms of their endpoints and must be scan converted into their corresponding pixels in the frame buffer.
4. Scan conversion hardware is not required.	4. Because each primitive must be scan-converted, real time dynamics is far more computational and requires seperate scan conversion hardware.
5. Vector display draws a continuous and smooth lines.	5. Raster display can display mathematically smooth lines, polygons, and boundaries of curved primitives only by approximating them with pixels on the raster grid.
6. Cost is more.	6. Cost is low.
7. Vector display only draws lines and characters.	7. Raster display has ability to display areas filled with solid colours or patterns.

2.4 Graphics input devices

Keyboard

- The keyboard is the most common input device for entering numeric and alphabetic data in to a computer system by pressing a set of keys which are mounted on the keyboard, which is connected to computer system.
- The keys on computer keyboards are often classified as follows:
- Alphanumeric Keys - letters and numbers.
- Punctuation Keys - comma, period, semicolon, and so on.
- Special Keys - function keys, control keys, arrow keys, Caps Lock key, and so on.

Touch Screen

- A touch screen is a display which can detect the presence and location of a touch within the display area.

- The term generally refers to touch or contact to the display of the device by a finger or hand.
- Touch screens can also sense other passive objects, such as a stylus. However, if the object sensed is active, as with a light pen, the term touch screen is generally not applicable.
- The ability to interact directly with a display typically indicates the presence of a touch screen.
- The touch screen has two main attributes. First, it enables one to interact with what is displayed directly on the screen, where it is displayed, rather than indirectly with a mouse or touchpad.
- Secondly, it lets one to do so without requiring any intermediate device.
- Such displays can be attached to computer terminals or to networks. They also play a prominent role in the design of digital appliances such as the personal digital assistant (PDA), satellite navigation devices, mobile phones, and video games.

Joystick

- A joystick is an input device consisting of a stick that pivots on a base and reports its angle or direction to the device it is controlling.
- Joysticks are often used to control video games, and usually have one or more push-buttons whose state can also be read by the computer.
- A popular variation of the joystick used on modern video game consoles is the analog stick.
- The joystick has been the principal flight control in the cockpit of many aircraft, particularly military fast jets, where centre stick or side-stick location may be employed.
- Joysticks are also used for controlling machines such as cranes, trucks, underwater unmanned vehicles and zero turning radius lawn mowers.
- Miniature finger-operated joysticks have been adopted as input devices for smaller electronic equipment such as mobile phone.

Digitizers

- A graphics tablet (or digitizing tablet, graphics pad, drawing tablet) is a computer input device that allows one to draw freehand images and graphics, similar to the way one draws images with a pencil and paper.
- These tablets may also be used to capture data or handwritten signatures.
- A graphics tablet (also called pen pad or digitizer) consists of a flat surface upon which the user may "draw" an image using an attached stylus, a pen-like drawing apparatus.

- The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor.
- Some tablets however, come as a functioning secondary computer screen that you can interact with directly using the stylus.
- Some tablets are intended as a general replacement for a mouse as the primary pointing and navigation device for desktop computers.

Voice System

- Voice input device - A device in which speech is used to input data or system commands directly into a system.
- Such equipment involves the use of speech recognition processes, and can replace or supplement other input devices.
- Some voice input devices can recognize spoken words from a predefined vocabulary, some have to be trained for a particular speaker.
- Speech recognition (also known as automatic speech recognition or computer speech recognition) converts spoken words to machine-readable input (for example, to key presses, using the binary code for a string of character codes).
- The term "voice recognition" is sometimes incorrectly used to refer to speech recognition, when actually referring to speaker recognition, which attempts to identify the person speaking, as opposed to what is being said.

Trackball

- A trackball is a pointing device consisting of a ball held by a socket containing sensors to detect a rotation of the ball about two axes—like an upside-down mouse with an exposed protruding ball.
- The user rolls the ball with the thumb, fingers, or the palm of the hand to move a cursor.
- Large tracker balls are common on CAD workstations for easy precision. Before the advent of the touchpad, small trackballs were common on portable computers, where there may be no desk space on which to run a mouse.
- Some small thumb balls clip onto the side of the keyboard and have integral buttons with the same function as mouse buttons.
- The trackball was invented by Tom Cranston and Fred Longstaff as part of the Royal Canadian Navy's DATAR system in 1952, eleven years before the mouse was invented. This first trackball used a Canadian five-pin bowling ball.

2.5 Graphics Software

- There are two general classifications for graphics software: general programming packages and special-purpose applications packages.
- A general graphics programming packages provides an extensive set of graphics functions that can be used in a high-level programming language.It includesthose for generating picture components(straight line, polygons, circles and other figures),setting color & intensity values, selecting views and applying transformations.
- Application graphics packages are designed for non-programmers.
- These computer graphics may be clip art, Web graphics, logos, headings, backgrounds, digital photos, or other kinds of digital images. Some of the graphics software title

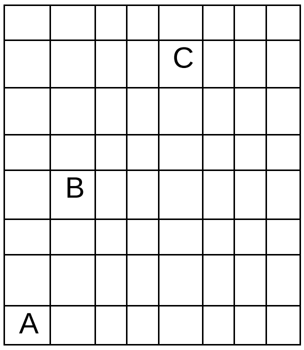
- Photoshop
- Illustrator
- Paint Shop Pro
- CorelDraw
- The GIMP
- Microsoft Paint,Digital Image Suite ,CAD

3. Graphics Output primitive

Contents

3.1 Point

- Pixel is a unit square area identified by the coordinate of its lower left corner.
- Each pixel on the display surface has a finite size depending on the screen resolution & hence a pixel can't represent a single mathematical number.
- Origin of the reference coordinate system being located of the lower left corner of the display surface.
- The each pixel is accused by non-negative integer coordinate pair(x, y).
- The x values start at the origin &increase from left to right along a scan line & y values start at the bottom & increase upwards.
- In the above diagram the coordinate of pixel A:0,0 ,B:1,4 , C:4,7.C:4,7.
- A coding position (4. 2, 7. 2) is represented by C.
- Whereas (1.5, 4.2) is represented by B.
- In order to half a pixel on the screen we need to round off the coordinate to a nearest integer.



Line Drawing

- Line drawing is accomplished by calculating intermediate point coordinates along the line path between two given end points.
- Screen pixel are referred with integervalues, plotted positions may only approximate the calculate coordinates, what is pixel which are intensified are those which lie very close to the line path.
- In a high resolution system the adjacent pixels are so closely spread that the approximated line pixels lievery close to actual line path and hence the plotted lines appear to be much smooth-almost like straight line drown on paper.
- In low resolution system the same approximation technique causes to display with stair step appearance that is not smooth.

<u>Line Drawing Algorithm</u>

➢ The equation of a straight line is

Y=mX + b

Where **m** representing slope of the line and **b** as the y intercept.

➢ Given two end points of a line segment are $(x_{1,}y_1)$&$(x_{2\,,}y_2\ )$

➢ Then the straight line can be written as$y_1\ =\ \frac{y_2-y_1}{x_2-x_1}x_1+b$ (1)

➢ We can determine the volume for the slope 'm' & y intercept 'b' with the following calculation.

$m=\frac{y_2-y_1}{x_2-x_1}$ (2)

$b=y_1\ -mx_1$ (3)

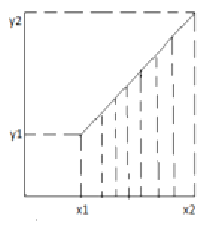
$\Rightarrow y_1\ =mx_1+b$

For any given x intervalΔx along a line, we can compute the corresponding y intervalΔy from the equ-2 $m=\frac{\Delta y}{\Delta x}\ \Rightarrow \Delta y=m\Delta x$

➢ Similarly we can obtained the x interval Δx corresponding to a specified Δy as $\Delta x=\frac{\Delta y}{m}$

➢ For a line with slope magnitude |m|<1, Δx can be set proportional to a small horizontal deflection voltage & the corresponding vertical deflection is then set proportional toΔy as calculate from the equation$\Delta y=m\ \Delta x$.

➢ For a line whose slopes have magnitudes|m|>1, Δy can be set proportional to a small vertical deflection voltage with the corresponding horizontal deflection voltage set proportional to Δxcalculate from the equation $\Delta x=\frac{\Delta y}{m}$



➢ For a line with m=1,thenΔx= $\Delta y$and vertical & horizontal deflection voltages are equal.

➢ In each case a smooth line with slope m is generated between specified end point.

3.2DDA Algorithm(Digital Differential Analyzer)

- DDA is a scan-conversion line algorithm base on either Δx or Δy.
- We sample the line at unit interval in one coordinate & determined the corresponding integer value nearest the line path for the other coordinate.
- Consider four cases for the DDA line drawing.

Case-1

Consider a line with +veslope,If the slope is less than or equal to 1.

If m<1, then x is incrementing faster.

The value of x=1 increment every time, compute& round they value.

As $\Delta x = 1$

Then $\Delta y = m$

$\Rightarrow \quad y_{k+1} - y_k = m$

$\Rightarrow \quad y_{k+1} = y_k + m$

Where k takes integer value starting from 1,for the first point b increases by one until the final end point is reached.

From the above equation we will get

$y_{k+1} = m + y_k$,Then$x = x_0 , y = y_0$

Illuminate the pixel (x,round (y))

$x = x_0 + 1$

$y = y_0 + 1 \times m$ Then illuminate Pixel(x,round (y))

Until it reaches at the end$x == x_1$

Case-2

In this case Y increment faster in m>1

The step is y=1 increment, compute& round the value of x

Then $\Delta y = 1, \Delta x = \frac{1}{m}$

$$x_{k+1} = x_k + \frac{1}{m}$$

If$x = x_0 \& y = y_0$

Then illuminate the pixel(round(x), y))

$y = y_0 + 1, x = x_0 + \frac{1}{m}$.

Illuminate the pixel(round(x), y)

Continue until $y == y_1$

- If the processing is reversed, then we havefollowing two cases .

Case -1

If m<1, then x is incrementing faster

The value of x=1 decrement every time, compute & round the y value.$\Delta x = -1$

Then $\Delta y = -m$

$\Rightarrow y_{k+1} - y_k = -m$

$\Rightarrow y_{k+1} = y_k - m$

Where k takes integer value starting from 1, for the first point b increases by one until the final end point is reached.

From the above equation we will get$y_{k+1} = -m + y_k$

Then $x = x_1 , y = y_1$

Illuminate the pixel (x,round(y))

$x = x_1 - 1$

$y = y_1 - 1 \times m$ Then illuminate Pixel(x,round (y))

Until it reaches at the end$x == x_0$

Case-2

If m>1then $\Delta y = -1, \Delta \mathrm{x} = -\frac{1}{\mathrm{m}}$

$\mathrm{x}_{\mathrm{k}+1} = \mathrm{x}_{\mathrm{k}} - \frac{1}{\mathrm{m}}$

$\mathrm{x} = \mathrm{x}_1 , \mathrm{y} = \mathrm{y}_1$

Illuminate the pixel (round (x), y)

$\mathrm{y} = \mathrm{y}_1 - 1 , \mathrm{x} = \mathrm{x}_1 - \frac{1}{\mathrm{m}}$

Illuminate the pixel (round (x), y)

Until you reaches at the endpoint $\mathrm{y} == \mathrm{y}_0$

Advantages

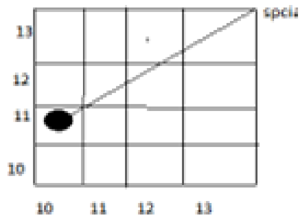
- DDA algorithm is a faster method for calculating pixel position then the equationof apixel position. Y = mx + b

Disadvantages

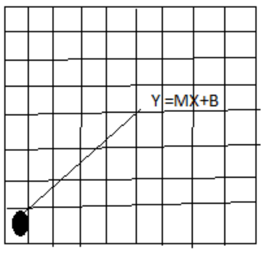
- Accumulation of round of error is successive addition of the floating point increments is used to find the pixel position but it take lot of time to compute the pixel position.

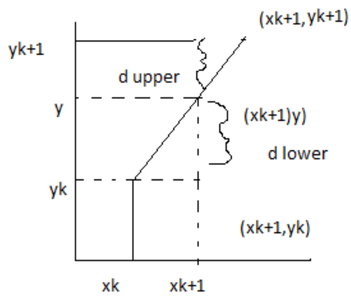
3.3 Bresenham'sLine Drawing Algorithm

- An accurate & efficient raster line– generating algorithm developed by Bresenham.
- Scan converts lines using onlyincrementalinteger calculation that can be adapted to display circle & other curves.
- The vertical axis show scans line position & horizontally axis Identify pixel columns.
- We need to decide which of two possible pixel position is closer to the line path at each sample step.



- W e first consider this scan conversion process for lines with +ve slope <1.
- Pixel position along line path are then determined by sampling x interval.
- Starting from left end point $(x_0 \ ,y_0)$ of a given line.
- We step to each successivecolumn(x position) &plot the pixel whose scan-line y value is closest to the line path.
- Consider the following diagram.





- From the above diagram figure-2 the pixel at $(x_k \ ,y_k)$ is the starting point of the line.
- We next do decide whichpixel to plot in columnx_{k+1}.
- Our choices are the pixel at position$(x_k+1 \ ,y_k \ )$ and $(x_k+1 \ ,y_k+1 \ )$
- At sapling positionx_k+1, we label vertical pixel separation from the mathematical line path as $d_1$and d_2.
- The y –coordinate on the mathematical line at pixel column position $\mathrm{x_k}+\ 1$ is calculated as $y = m(\mathrm{x_k}+1)$ +b
- Then $\mathrm{d_1} = \mathrm{y} - \mathrm{y_k}$

$$\Rightarrow m(\mathrm{x_k}+1)+\mathrm{b}-\mathrm{y_k}$$

And $\mathrm{d_2} = (\mathrm{y_k} \ +1) - \mathrm{y}$

$$= \ \mathrm{y_k}+1-\mathrm{m}(\mathrm{x_k}+1)- \ \mathrm{b}$$

The deference between thesetwo separations is

$\mathrm{d_1}-\mathrm{d_2} = \mathrm{m}(\mathrm{x_{k+1}})-\mathrm{y_k}-(\mathrm{y_{k+1}})+\mathrm{m}(\mathrm{x_{k+1}})+\ \mathrm{b}$

$$\Rightarrow 2m(\mathrm{x_{k+1}} \ )+2\mathrm{b}-\mathrm{y_k}-\mathrm{y_k}-1$$

$$\Rightarrow 2m(\mathrm{x_{k+1}} \ )-2\mathrm{y_k}+2\mathrm{b}-1 \qquad (1)$$

Suppose we use decision parameter p_k ,k^{th} step is the line algorithm by rearranging the above equation, so that it in values integer calculation.

Substitute $m = \frac{\Delta y}{\Delta x}$

Where Δx ,Δy vertical & horizontal separation of the end point position then

$$\Rightarrow d_1 - d_2 = 2\frac{\Delta y}{\Delta x}(x_{k+1}) - 2y_k + 2b - 1$$

We know that $x_{k+1} = (x_k + 1)$

$\Rightarrow p_k = \Delta x(d_1 - d_2) = 2\Delta y(x_k + 1) - 2\Delta x y_k - \Delta x\,(2b - 1)$

$\Rightarrow p_k = 2\Delta y x_k - 2\Delta y - 2\Delta x y_k - \Delta x(2b - 1)$

$\Rightarrow 2\Delta y x_k - 2\Delta x y_k + c$ (2)

The sign of p_k is the same an the sign of d_1 -d_2 since Δx> 0. C is an constant and c=2 Δy + Δx (2b -1) , which is independent pixel at y_k is closer to the line path then pixel at y_{k+1} (d_1<d_2) the decision parameter in -ve. In this case we plot lower pixel otherwise we plot upper pixel.

Coordinate changes along the line occur in unit steps either the x or y direction.

Therefore we can obtain the value of successive parameter using increment integer calculation at step $k + 1$ the decision parameter is evaluated at

$$p_{k+1} = 2\Delta y(x_{k+1}) - 2\Delta x(y_{k+1}) + c$$

$$p_{k+1} - p_k = 2\Delta y(x_{k+1} - x_k) - 2\Delta x\,(y_{k+1} - y_k)$$

As $x_{k+1} = x_k + 1$

$p_{k+1} = p_k + 2\Delta y - 2\Delta x\,(y_{k+1} - y_k)$

The y_{k+1} - y_k is either 0 or 1 depending on the sign of parameter p_k

First parameter p_0 is evaluated from the equ-2,At starting point (x_0 ,y_0)& m evaluated as $\frac{\Delta y}{\Delta x}$,then $p_0 = 2\Delta y - \Delta x$

Algorithm

Step 1 : Input the two line end points &store left end point in (x_0 ,y_0)

Step 2 : load (x_0 ,y_0) into the from buffer plot the first point.

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

Step 4 : At each x_k along the line starting at k=0, perform the following last.

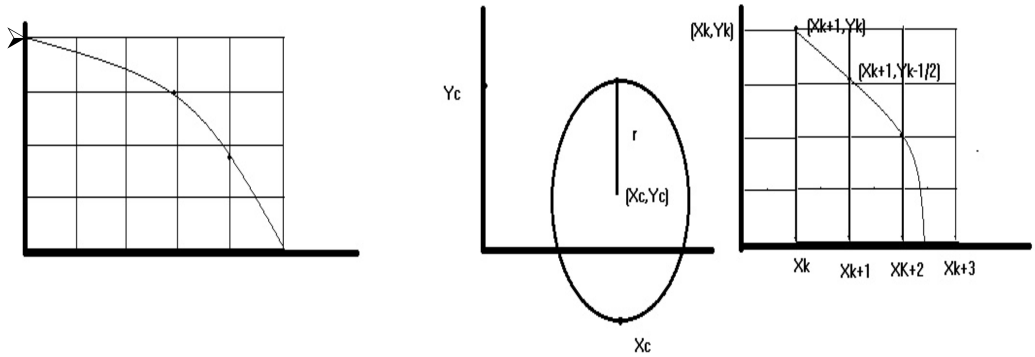
If p_k <0 the next point to plot is $(x_k + 1, y_k)$&$p_{k+1} = p_k + 2\Delta y$

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

p_{k+1} = p_k +2 Δy - 2 Δx

3.4 Midpoint Circle Algorithm

- A circle is defined as a set of points that are all a given distance r from a canter Position (x_c,y_c) then we express the equation as (x-x_c)^2+(y-y_c)^2 – r^2.
- If f(X,Y)=0 then the point lies on the circle boundary.
- If f(X,Y)<0 then the point lies inside of in the circle boundary.
- If f(X,Y) > 0 then the point lies on outside circle boundary .
- In mid point circle algorithm the decision parameter of the Kth step in the circle function evaluated using co-ordinate of the midpoint of the two pixel.
- Centers which are the next possible pixel position to be plotted.
- Let assume that we are giving unit increments to x in the plotting process & determining the y position using this algorithm.



- Assuming we have justplotted the pixel at (x_k, y_k).
- We next need to determine whether the pixel at the position $(x_k + 1, y_k)$ or the one at position$(x_k + 1, y_k - 1)$ is closer to the circle.
- Our decision parameter$p_k$at the Kth step is the circle function evaluated at the midpointbetween these two pixels.
- Let us consider the pixel (x_k+1, y_k-1/2) ,Then

  $$p_k = f_{circle}\left(x_k + 1, y_k - \frac{1}{2}\right) \Rightarrow (x_k + 1)^2 + (y_k - \frac{1}{2})^2 - r^2 \qquad (1)$$

  If the $p_k < 0$, this midpoint is inside the circle and the pixel on the scan line y_k is closer to the circle boundary .Otherwise, the midpoint is outside or on the circle boundary, and we select the pixel on the scan line $y_k - 1$

- Successive decision parameters areobtained using incremental calculation.
- Avoiding a lot of computation at each step we obtain a recursive expression for the next decision parameter by evaluating the circle function at sampling position

$$x_{k+1} + 1 = x_k + 2$$

$$p_{k+1} = f_{circle}\left(x_{k+1} + 1, y_{k+1} - \frac{1}{2}\right)$$

$$p_{k+1} = [(x_k + 1) + 1)]^2 + (y_{k+1} - \frac{1}{2})^2 - r^2$$

$$\Rightarrow (x_k + 1)^2 + 2(x_k + 1) + 1 + {y_{k+1}}^2 - y_{k+1} + \frac{1}{4} - r^2$$

$$p_{k+1} - p_k = 2(x_k + 1) + ({y_{k+1}}^2 - {y_k}^2 - (y_{k+1} - y_k) + 1 \quad (3)$$

$$p_{k+1} = p_k + 2(x_k + 1) + ({y_{k+1}}^2 - {y_k}^2 - (y_{k+1} - y_k) + 1 \quad (4)$$

- The value of $y_{k+1}$is y_k or y_k+1
  Puty_k in place of y_{k+1}

$$p_{k+1} = p_k + 2(x_k + 1) + ({y_k}^2 - {y_k}^2) - (y_k - y_k) + 1$$

$$\Rightarrow p_k + 2(x_k + 1) + 1$$

put$y_{k+1} = y_k - 1$

p_{k+1}= p_k+2(x_k +1)+((y_k-1)^2-${y_k}^2$)-(y_k-y_k)+1

p_{k+1}= p_k+2(x_k +1)+(${y_k}^2$- 2y_k+1 -${y_k}^2$)+1+1

$$p_{k+1} = p_k + 2(x_k + 1) - 2y_k - 2$$

The initial decision parameter is obtain by evaluating the circle function at the start position (x_0,y_0) = (0,r) then we will get another point (1, r-½)

p_0 = 1^2+(r-½)^2 – r^2

p_0 = 1^2+r^2 – r+$\frac{1}{4}$-r^2

$$p_0 = \frac{5}{4} - r$$

Algorithm

Step1: Input radius 'r' & circle canter (x_c,y_c)and obtain the first point on the circumference of a circle cantered on the origin as (x_0,y_0) = (0, r).

Step2: Calculate the initial value of the decision parameter as $p_0 = \frac{5}{4} - r$.

Step3: At each x_k position, starting at k=0, Perform the following test: If $p_k < 0$, the next point along the circle centred on (0,0)is (x_k+1, y_k) &

$$p_{k+1} = p_k + 2x_{k+1} + 1$$

Otherwise, the next point along the circle is $(x_k + 1, y_k - 1)$&

$p_{k+1} = p_k + 2x_{k+1+1} - 2y_{k+1}$

$Where\ 2x_{k+1} = 2x_k + 2\ and\ 2y_{k+1} = 2y_k - 2.$

Step4:Determine symmetry points in the other seven octants.

Step5: Move each calculated pixel position (x,y) on the circular path centered on (x_c,y_c)& plot the coordinate values; x = x+x_c, y= y+y_c.

Step6: Repeat step3 through 5unit x>=y.

3.5 Boundary Fill Algorithm

- There are two types of filling area i.e
  4-connected region and 8-connected region
- 4-connected region: From a given pixel, the region that you can get to by a series of 4 way moves (N, S, E and W).

- 8-connected region: From a given pixel, the region that you can get to by a series of 8 way moves (N, S, E, W, NE, NW, SE, and SW).
- Start at a point inside a region
- Paint the interior outward to the edge
- The edge must be specified in a single color
- Fill the 4-connected or 8-connected region
  - o 4-connected fill is faster, but can have problems.

Algorithm

```
void BoundaryFill4(int x, int y, int newcolor, int edgecolor)
{
  int current;
  current = ReadPixel(x, y);
  if(current != edgecolor && current != newcolor)
  {
     BoundaryFill4(x+1, y, newcolor, edgecolor);
     BoundaryFill4(x-1, y, newcolor, edgecolor);
     BoundaryFill4(x, y+1, newcolor, edgecolor);
```

```
    BoundaryFill4(x, y-1, newcolor, edgecolor);
  }}
```

Flood Fill Algorithm

- Used when an area defined with multiple color boundaries
- Start at a point inside a region.
- Replace a specified interior color (old color) with fill color
- Fill the 4-connected or 8-connected region until all interior points being replaced

Algorithm

```
void flood_fill4(intx,inty,intfill_color,intold_color)
{
int current;
   current=getpixel (x,y);
   if (current==old_color)
   {
putpixel (x,y,fill_color);
      flood_fill4(x-1,y, fill_color, old_color);
      flood_fill4(x,y-1, fill_color, old_color);
      flood_fill4(x,y+1, fill_color, old_color);
      flood_fill4(x+1,y, fill_color, old_color);
}}
```

4. Two Dimensional Geometric Transformations

Contents

Introduction

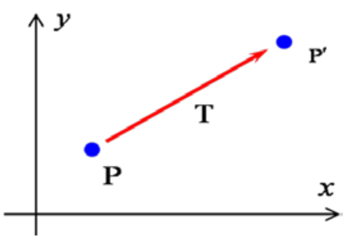
- Transformations are a fundamental part of computer graphics.
- Transformations are used to position objects, to shape objects, to change viewing positions, and even to change how something is viewed. There are 5 main types of transformations that can be performed in 2 dimensions:
- translations
- scaling
- rotation
- reflection
- shearing

4.1 Translation

A translation moves all points in an object along the same straight-line path to new positions.

The path is represented by a vector, called the translation or shift vector.

We can write the components:



$$Px' = Px + Tx$$

$$Py' = Py + Ty$$

or in matrix form: P' = P + T

$$x' = x + t_x, \quad y' = y + t_y$$

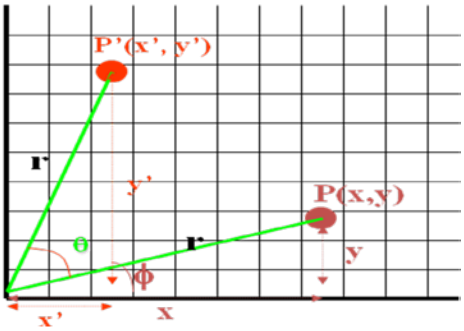
$$\mathbf{P} = \begin{bmatrix} x \\ y \end{bmatrix}, \quad \mathbf{P}' = \begin{bmatrix} x' \\ y' \end{bmatrix}, \quad \mathbf{T} = \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

$$\mathbf{P}' = \mathbf{P} + \mathbf{T}$$

4.2 Rotation

point p(X,Y) is to be rotated about the origin by angle theta to location p'(X',Y')

Let us consider the diagram



- We use some geometric concept here

$$\Rightarrow \cos\phi = x/r \quad , \sin\phi = y/r$$

$$x = r\cos\phi \; , y = r\sin\phi$$

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

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

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

$$x' = x\cos\theta - y\sin\theta$$

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

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

$$y' = r\cos\phi\sin\theta - r\sin\phi\cos\theta$$

$$y' = x\sin\theta + y\cos\theta$$

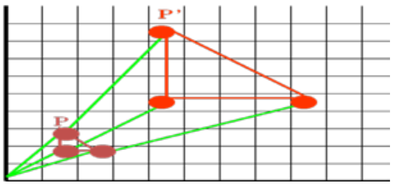
in matrix form: P' = R X P

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

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \times \begin{bmatrix} x \\ y \end{bmatrix}$$

4.3 Scaling

- Scaling changes the size of an object and involves two scale factors, S_x and S_y for the x- and y- coordinates respectively.
- Scales are about the origin.
- Consider the diagram for generating equation
- We can write the components as:



$X' = Sx . X$

$Y' = Sy . Y$

P' = S • P ,The matrix represented form is

$$S = \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix}$$

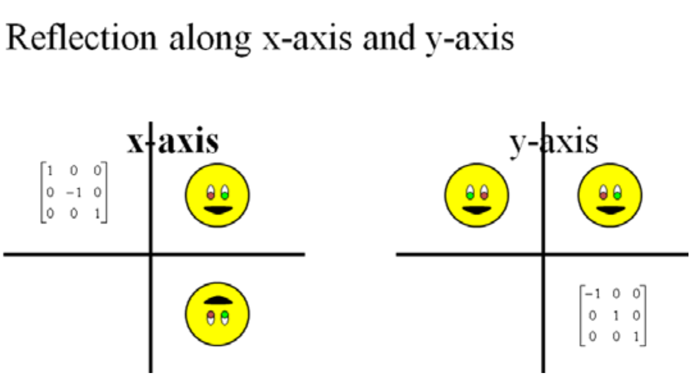
The matrix form is

$$\begin{bmatrix} X' \\ Y' \end{bmatrix} = \begin{bmatrix} S_x & 0 \\ 0 & S_y \end{bmatrix} \times \begin{bmatrix} x \\ y \end{bmatrix}$$

- If the scale factors are in between 0 and 1 ➔ the points will be moved closer to the origin ➔ the object will be smaller.
- If the scale factors are larger than 1 ➔ the points will be moved away from the origin ➔ the object will be larger.

4.4 Reflection

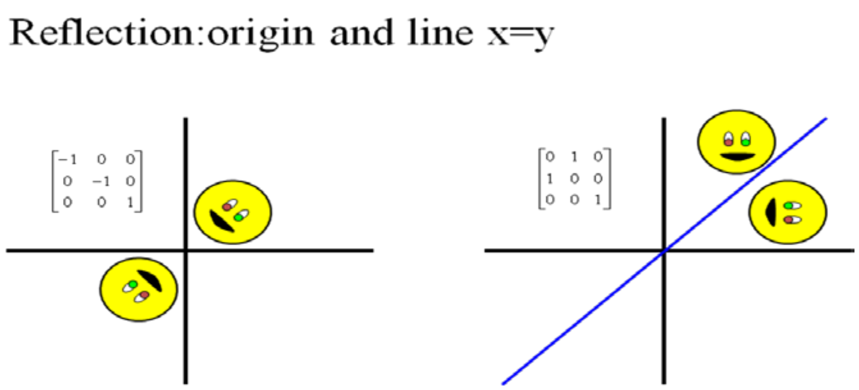
- A reflection is a transformation that produces the mirror image of an object.
- The mirror image for 2D reflection is generated relative to an axis of reflection by rotating 180^{0}.
- We can choose an axis of reflection in a xy-plane and perpendicular to the xy-plane.
- The matrix representation with homogeneous coordinate form along x-axis is



Reflection along x-axis is $\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \text{ X } \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$

Reflection along y-axis is representation in matrix form

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$



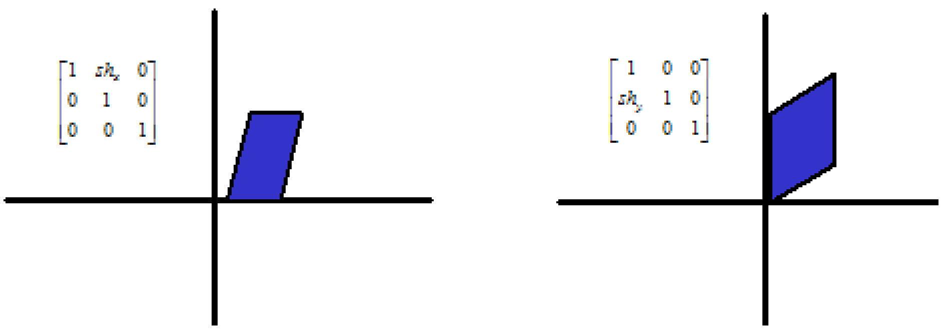
4.5 Shear

- ➢ The matrix expression for the shearing transformation of a position P = (*x*, *y*,) to produce x-axis shear and y-axis shear.
- ➢ Share along x-axis is represented in matrix form

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & sh_x & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Share along y-axis is represented in matrix form

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 1 & 0 \\ sh_y & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$



4.6 Homogenous Coordinates

- The fact that all the points along each line can be mapped back to the same point in 2D gives this coordinate system its name – homogeneous coordinates**.**
  Make displacement linear with homogeneous coordinates$(x, y) \Rightarrow (x, y, 1)$

- Transformation turns into 3X3 matrix. Very big advantage –All transformations are concatenated by matrix multiplication Using homogenous coordinates we will do all transformations

2D Translation
$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}, \quad \mathbf{P}' = \mathbf{T}(t_x, t_y) \cdot \mathbf{P}$$

2D Rotation
$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}, \quad \mathbf{P}' = \mathbf{R}(\theta) \cdot \mathbf{P}$$

2D Scaling
$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}, \quad \mathbf{P}' = \mathbf{S}(S_x, S_y) \cdot \mathbf{P}$$

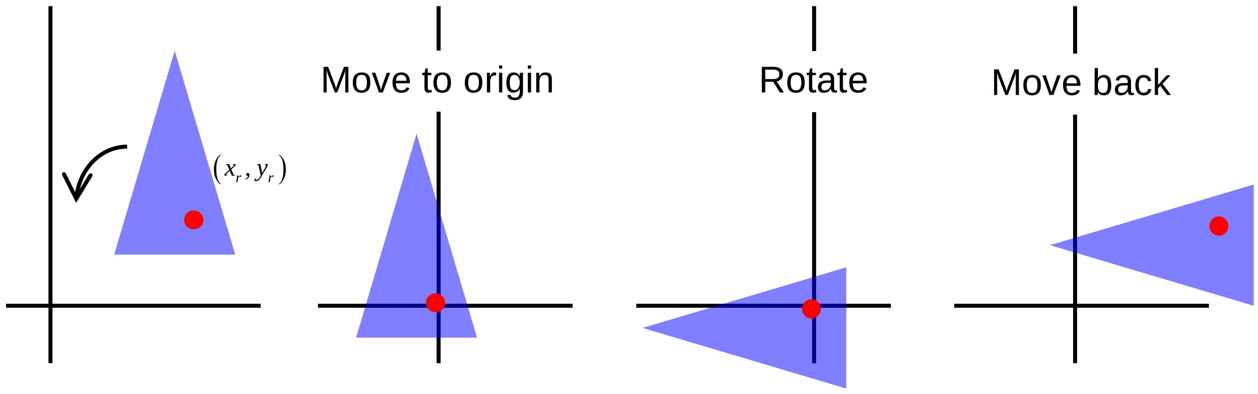
4.7 Composite Transformation Matrix

Forming products of transformation matrix is referred to as concatenation or composition. We from composite transformation by multiplying matrices in order to form left to right.

General Fixed-Point Rotation:-

- Arrange the transformation matrices in order from right to left.
- General Pivot- Point Rotation
  - Operation :-
    1. Translate (pivot point is moved to origin)
    2. Rotate about origin
    3. Translate (pivot point is returned to original position)

4. Consider the following diagram



Original position of the object & pivot point

Translate the object so that pivot point about origin

Rotate the object

Translate the object so that the point at the origin

T(pivot) • R(θ) • T(–pivot)

The transformation matrix is

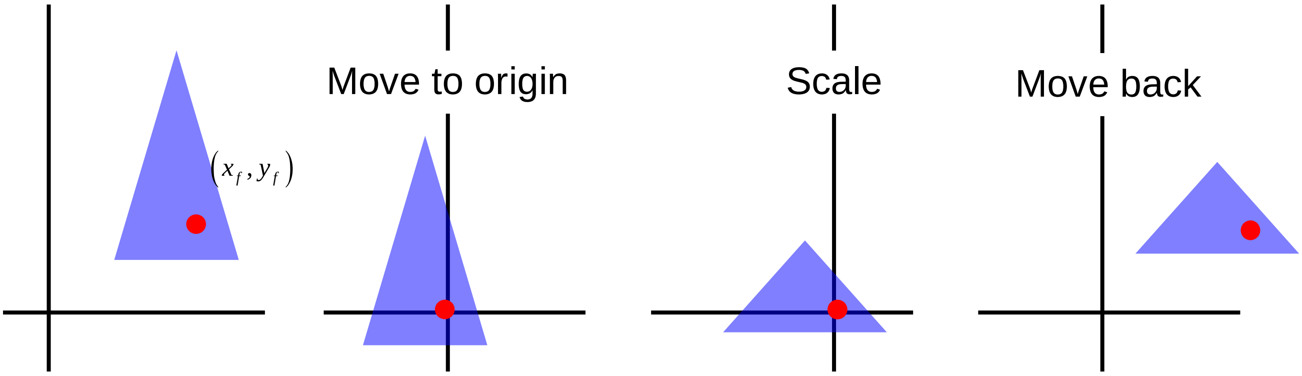
$$\begin{bmatrix} 1 & 0 & x_r \\ 0 & 1 & y_r \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & -x_r \\ 0 & 1 & -y_r \\ 0 & 0 & 1 \end{bmatrix} =$$

$$\begin{bmatrix} \cos\theta & -\sin\theta & x_r(1-\cos\theta)+y_r\sin\theta \\ \sin\theta & \cos\theta & y_r(1-\cos\theta)-x_r\sin\theta \\ 0 & 0 & 1 \end{bmatrix}$$

General Fixed-Point Scaling

Operations:

1. Translate (fixed point is moved to origin)
2. Scale with respect to origin
3. Translate (fixed point is returned to original position)



Original position of the object & pivot point

Translate the object so that pivot point about origin

Scale the object

Translate the object so that the point at the origin

T(fixed) • S(scale) • T(–fixed)

The transformation matrix is

$$\begin{bmatrix} 1 & 0 & x_f \\ 0 & 1 & y_f \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} S_x & 0 & 0 \\ 0 & S_y & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 1 & 0 & -x_f \\ 0 & 1 & -y_f \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & x_f(1-S_x) \\ 0 & S_y & y_f(1-S_y) \\ 0 & 0 & 1 \end{bmatrix}$$

5. Two Dimensional Viewing

Contents

Introduction

- The window defines what is to be viewed the view port defines where it is to be displayed.
- The two dimensional viewing transformation is referred to as window to view port transformation of windowing transformation.
- 2D viewing consist of 3 things:-
  1. Terminology
  2. Viewing pipeline
  3. Clipping

Terminology

Window

- A world coordinate area selected for display is called a window.

Viewing Port

- An area on a display device to which a window is mapped is called a view port.

Viewing transformation

- The mapping of a part of a world coordinate scene to device coordinate is referred to as viewing transformation.

Viewing coordinate system

A coordinate system defined world coordinate frame.

Viewing transformation pipeline

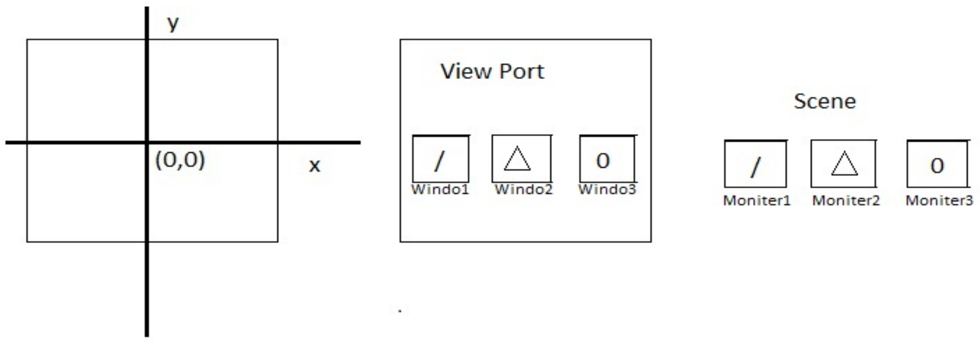
i. Construct world coordinate screen
ii. Convert world coordinate to view coordinate.
iii. Convert view coordinate to normalized view coordinate.
iv. Normalized view coordinate to device coordinate.

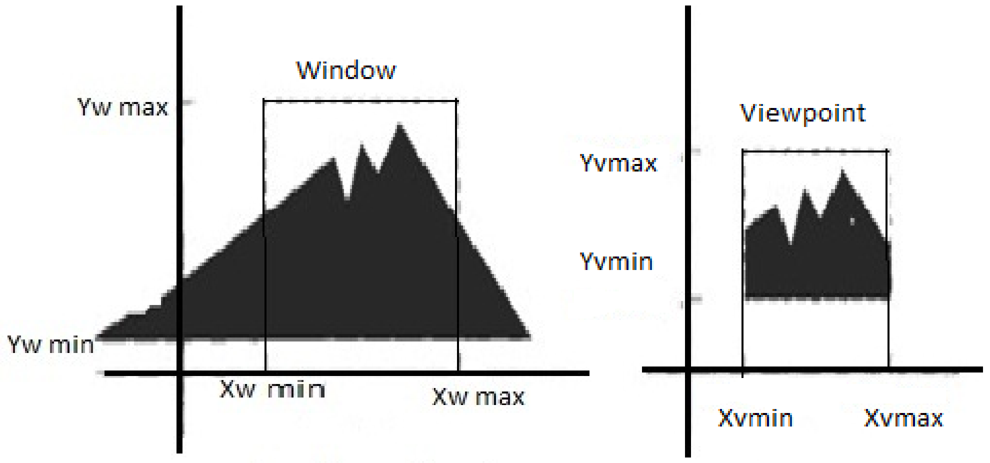
Transformation

From world to device coordinate transformation, we need translation, rotation & Scaling operation.

5.1 Viewing pipeline

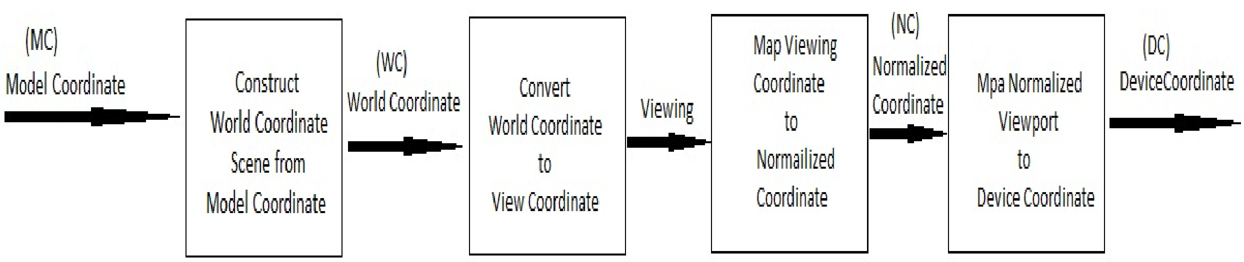
- A world coordinate area are selected for display window .
- An area on a display device to which a window is mapped is called a view port.
- The window defines what is to be view.
- View port define where it is to be display.
- Mapping of a world coordinate screen scale to a device coordinate is referred to as viewing transformation.
- Sometime 2D viewing transformation is simple referred to as window to view port transformation.





(World Coordinate) **(Device Coordinate)**

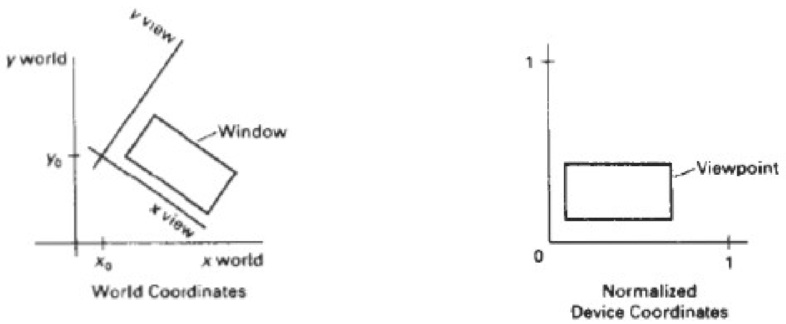
5.2 The two dimensional viewing transformation pipeline



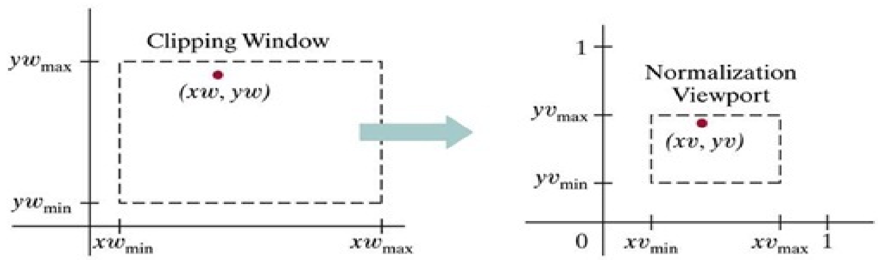
The viewing transformation in several steps, as indicated in above Fig.

- First, we construct the scene in world coordinates using the output primitives.

- Next to obtain a particular orientation for the window, we can set up a two-dimensional viewing- coordinate system in the world coordinate plane, and define a window in the viewing- coordinate system.
- The viewing- coordinate reference frame is used to provide a method for setting up arbitrary orientations for rectangular windows.
- Once the viewing reference frame is established, we can transform descriptions in world coordinates to viewing coordinates.
- We then define a viewport in normalized coordinates (in the range from 0 to 1) and map the viewing-coordinate description of the scene to normalized coordinates.
- At the final step all parts of the picture that lie outside the viewport are clipped, and the contents of the viewport are transferred to device coordinates.
- By changing the position of the viewport, we can view objects at different positions on the display area of an output device.



5.3 Window to Viewport coordinate Transformation



A point (xw, yw) in a world-coordinate clipping window is mapped to viewport coordinates (xv, yv), within a unit square, so that the relative positions of the two points in their respective rectangles are the same.

- A point at position(x_W,y_W)in a designated window is mapped to viewport coordinates (x_V,y_V) ,so that the relative positions in the two areas are the same. The figure illustrates the window to viewport mapping.
- A point at position (x_W,y_W)in the window is mapped into position(x_V,y_V)in the associated viewport. To maintain the same relative placement in viewport as in window

$$\frac{Xv - Xvmin}{Xvmax - Xvmin} = \frac{Xw - Xwmin}{Xwmax - Xwmin}$$

$$\frac{Yv - Yvmin}{Yvmax - Yvmin} = \frac{Yw - Ywmin}{Ywmax - Ywmin}$$

$$Xv = Xw + (Xv\,min - Xwmin)Sx$$

$$= Xv\,\min + (Xw - Xwmin)\,Sx$$

$$Sx = \left(\frac{Xvmax - Xvmin}{Xwmax - Xwmin}\right)$$

$$Yv = Yw + (Yvmin - Ywmin)Sy$$

$$= Yvmin + (Yw - Ywmin)Sy$$

$$Sy = \left(\frac{Yvmax - Yvmin}{Ywmax - Ywmin}\right)$$

5.1 Clipping

Clipping Operation

- Any procedure that identifies those positions of picture is either inside or outside of a specified reason of space is referred to as clipping algorithm or simply clipping.
- The reason against which an object is clip is called clipping windows.
- Application of clipping in to extracting the part of a defined seen for viewing.
- Depending on the application the clip window can be general polygon for it can even have curve boundary.
- For the viewing transformation we want to display only those picture parts that are within the window.
- Everything the outside the window is discarded.
- Clipping algorithm can be applied in world coordinate so that the contents of window integer are mapped to device coordinate.
- The clipped against the view port boundary.
- View port clipping can reduced calculation by allowing concatenation of viewing and geometric transformation matrix.
- There are number of clipping algorithm are used.
  - I. Point Clipping Algorithm
  - II. Line Clipping Algorithm
  - III. Polygon Clipping Algorithm
  - IV. Text Clipping Algorithm

V. Curve Clipping Algorithm

Clipping individual Point

- Clipping individual point we need two coordinate if X coordinate boundary of clipping rectangle are X_{max} and X_{min}. Y coordinate boundary of clipping rectangle are Y_{max} and Y_{min}
- Following inequalities must be satisfied for point at (X,Y) to be inside the clipping rectangle.

  $X_{min} < X < X_{max}$.

  $Y_{min} < Y < Y_{max}$

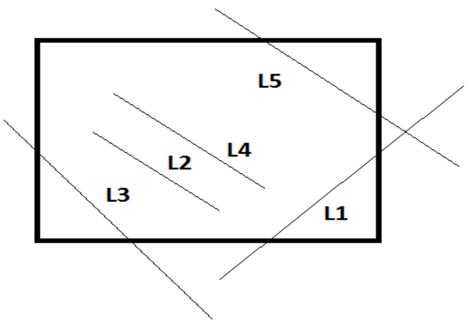
If any of the for inequalities doesn't hold then the point is outside the clipping rectangle

a. $X > X_{min}$
b. $X < X_{max}$
c. $Y > Y_{min}$
d. $Y < Y_{max}$

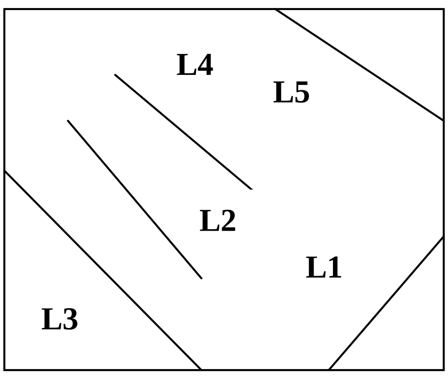
1. Line Clipping

- Line clipping algorithm involves several parts.
- First we can test a given line segment to determine whether the line completely inside the clipping window.
- If it doesn't, we try to determine whether the line completely outside the clipping window.
- Finally it can't identify a line as completely inside and outside, we must perform intersection, calculation with one or more clipping boundary.
- We process the line through the inside outside test by checking the line and point.
- Lines with both end points inside such lines are L_2&L_4.

Before clipping



After Clipping



- A line with end point outside the boundaries is rejected which is outside the window.
- We use clipping algorithm that can efficiently identify outside line and reduce intersection calculation.

- For a line segments with two end points (X_1,Y_1) and (X_2,Y_2)

  X = X1+U (X2-X1)

  Y = Y1+U (Y2-Y1)   0≤U≤1

Cohen Sutherland line clipping algorithm

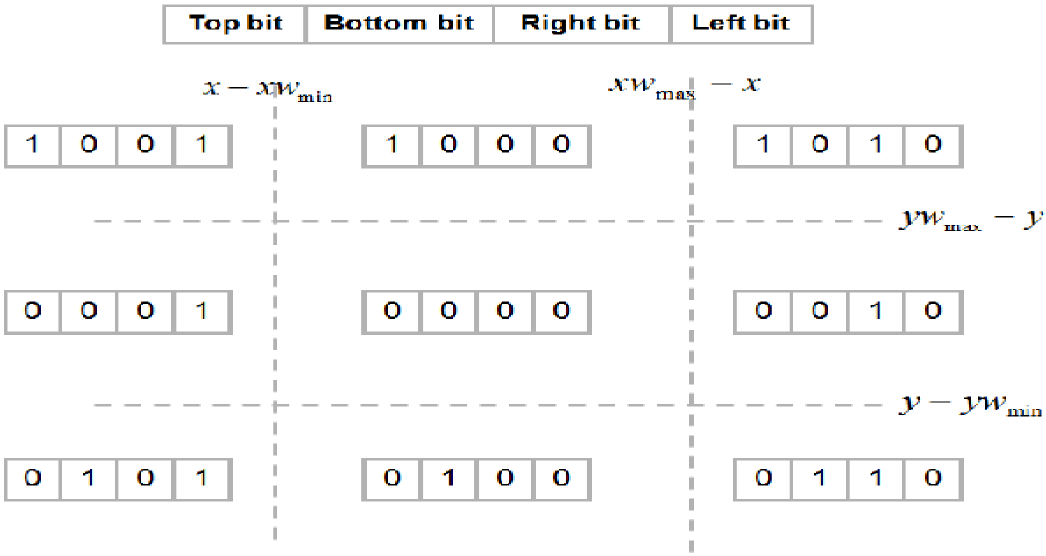
- This algorithm divides a 2D space into 9 parts, of which only the middle part (viewport) is visible.
- These 9 regions can be uniquely identified using a 4 bit code, often called an out code. The 9 regions are: top-left, top-centre, top-right, centre-left, centre, centre-right, bottom-left, bottom-centre, and bottom-right.
- If the beginning coordinate and ending coordinate both fall inside the viewport then the line is automatically drawn in its entirety.
- If both fall in the same region outside the viewport, it is disregarded and not drawn. If a line's coordinates fall in different regions, the line is divided into two, with a new coordinate in the middle.
- Bit1 is the sign bit of $x - xw_{min}$;bit 2 is the sign bit of $xw_{max} - x$;bit 3 is sign bit of $y - yw_{min}$;bit 4 is the sign of $yw_{max} - y$.
- The algorithm is repeated for each section; one will be drawn completely, and the other will need to be divided again, until the line is only one pixel
- The algorithm includes, excludes or partially includes the line based on where the two endpoints are:

  1).Both endpoints are in the viewport (bitwise OR of endpoints == 0000): trivial accept.

  2).Both endpoints are on the same side of the rectangle, which is not visible(bitwise AND of endpoints!= 0000): trivial reject.

  3).Both endpoints are in different parts: In case of this non trivial situation the algorithm finds one of the two points that are outside the viewport (there is at least one point outside). The intersection of the outpoint and extended viewport border is then calculated (i.e. with the parametric equation for the line) and this new point replaces the outpoint. The algorithm repeats until a trivial accept or reject occurs.
- An out code is computed for each of the two points in the line. The first bit is set to 1 if the point is above the viewport.
- The bits in the out code represent: Top, Bottom, Right, Left. For example the out code 1010 represents a point that is top-right of the viewport.

- Note that the out codes for endpoints must be recalculated on each iteration after the clipping occurs.



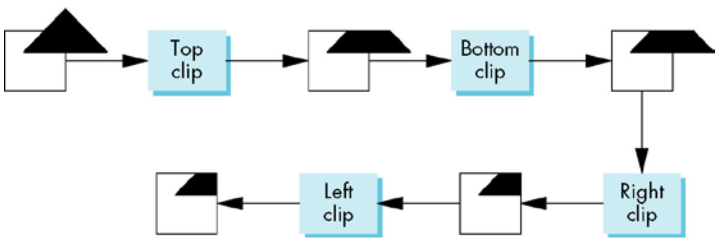
5.5 Polygon clipping

- Clipping polygons is more complex than clipping the individual lines.
- Input: polygon
- Output: polygon, or nothing
- Not as simple as line segment clipping
- Clipping a line segment yields at most one line segment
- Clipping a polygon can yield multiple polygons

However, clipping a convex polygon can yield at most one other polygon.

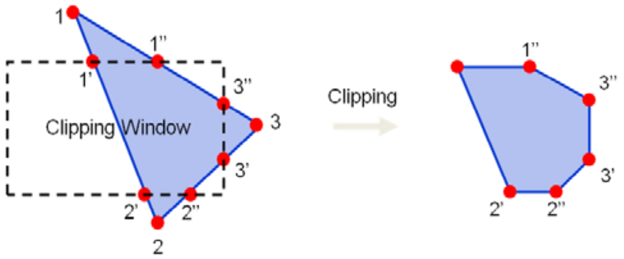
Pipeline Clipping of Polygons

- Three dimensions: add front and back clippers
- Strategy used in SGI Geometry Engine
- Small increase in latency

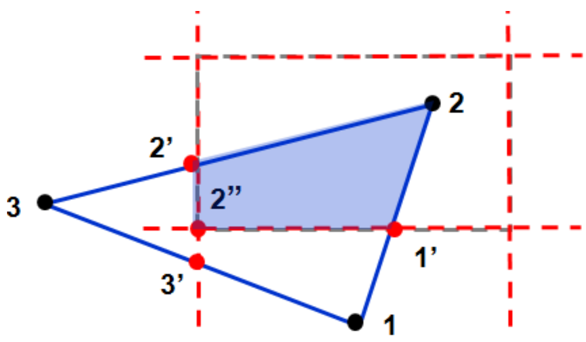


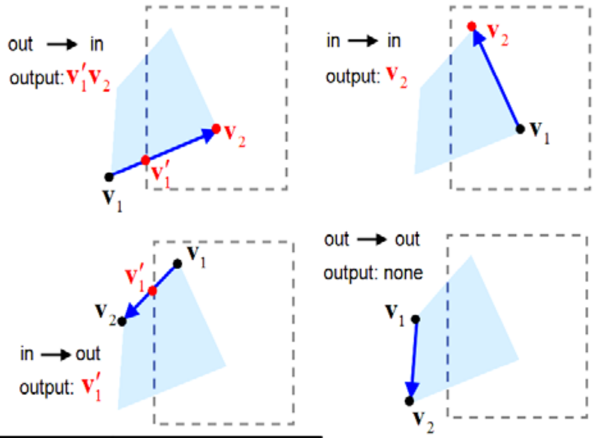
Sutherland-Hodgman Polygon Clipping

- It is efficient algorithm for clipping convex polygons.
- Edges are clipped against every border line of clipping window. Edges are processed successively.
- Allows pipelining of edge clipping of polygons, as well as pipelining of different polygons.



- The four possible outputs generated by the left clipper, depending on the relative position of pair of edge endpoints.





Input	Left Clipper	Right Clipper	Bottom Clipper	Top Clipper
[1,2]:	(in-in)>{2}			
[2,3]:	(in-out)>{2'}	[2,2']:(in-in)>{2'}		
[3,1]:	(out-in)>{3',1}	[2',3']:(in-in)>{3'}	[2',3']:(in-out)>{2"}	
		[3',1]:(in-in)>{1}	[3',1]:(out-out)>{}	
		[1,2]:(in-in)>{2}	[1,2]:(out-in)>{1',2}	[2",1']:(in-in)>1'}
			[2,2']:(in-in)>{2'}	[1',2]:(in-in)>{2}
				[2,2']:(in-in)>{2'}
				[2',2"]:(in-in)>{2"}

The four clippers can work in parallel.

- Once a pair of endpoints it output by the first clipper, the second clipper can start working.
- The more edges in a polygon, the more effective parallelism is.

- Processing of a new polygon can start once first clipper finished processing.
    - No need to wait for polygon completion.

6. Three Dimensional object Representation

Contents

Introduction

- Graphics scenes can contain many different kinds of objects and material surfaces such asTrees, flowers, clouds, rocks, water, bricks, wood paneling, rubber, paper, steel, glass, plastic and cloth
- Not possible to have a single representation for all
  - Polygon surfaces
  - Spline surfaces
  - Procedural methods
  - Physical models
  - Solid object models
  - Fractals

3D object representation

- 3D solid object representations can be generally classified into two broad categories

1. Boundary Representation (B-reps)

   It describes a three dimensional object as a set of surfaces that separate the object interior from the environment. Examples are polygon facets and spline patches.

2. Space Partitioning representation

   It describes the interior properties, by partitioning the spatial region containing an object into a set of small, non overlapping, contiguous solids (usually cubes).

   Eg: Octree Representation

6.1 Polygon Surfaces

- Polygon surfaces are boundary representations for a 3D graphics object is a set of polygons that enclose the object interior.
- Set of adjacent polygons representing the object exteriors.
- All operations linear, so fast.

- Non-polyhedron shapes can be approximated by polygon meshes.
- Smoothness is provided either by increasing the number of polygons or interpolated shading methods.

6.2 Polygon Tables

- The polygon surface is specified with a set of vertex coordinates and associated attribute parameters.
- For each polygon input, the data are placed into tables that are to be used in the subsequent processing.
- Polygon data tables can be organized into two groups: Geometric tables and attribute tables.
  - **Geometric Tables**

    Contain vertex coordinates and parameters to identify the spatial orientation of the polygon surfaces.
  - **Attribute tables**

    Contain attribute information for an object such as parameters specifying the degree of transparency of the object and its surface reflectivity and texture characteristics.

A convenient organization for storing geometric data is to create three lists:

1. The Vertex Table

Coordinate values for each vertex in the object are stored inthis table.

2. The Edge Table

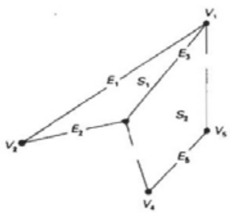
It contains pointers back into the vertex table to identify the vertices for each polygon edge.

3. The Polygon Table

It contains pointers back into the edge table to identify the edges for each polygon.

This is shown in fig

Vertex table	Edge Table	Polygon surface table
V1 : X1, Y1, Z1	E1 : V1, V2	S1 : E1, E2, E3
V2 : X2, Y2, Z2	E2 : V2, V3	S2 : E3, E4, E5, E6
V3 : X3, Y3, Z3	E3 : V3, V1	
V4 : X4, Y4, Z4	E4 : V3, V4	
V5 : X5, Y5, Z5	E5 : V4, V5	
	E6 : V5, V1	



- Listing the geometric data in three tables provides a convenient to the individual component (vertices, edges and polygons) of each object.
- The object can be displayed efficiently by using data from the edge table to draw the component lines.
- Extra information can be added to the data tables for faster information extraction. For instance, edge table can be expanded to include forward points into the polygon table so that common edges between polygons can be identified more rapidly.

E_1 : V_1, V_2, S_1

E_2 : V_2, V_3, S_1

E_3 : V_3, V_1, S_1, S_2

E_4 : V_3, V_4, S_2

E_5 : V_4, V_5, S_2

E_6 : V_5, V_1, S_2

- This is useful for the rendering procedure that must vary surface shading smoothly across the edges from one polygon to the next. Similarly, the vertex table can be expanded so that vertices are cross-referenced to corresponding edges.
- Additional geometric information that is stored in the data tables includes the slope for each edge and the coordinate extends for each polygon. As vertices are input, we can calculate edge slopes and we can scan the coordinate values to identify the minimum and maximum x, y and z values for individual polygons.
- The more information included in the data tables will be easier to check for errors.
- Some of the tests that could be performed by a graphics package are:

1. That every vertex is listed as an endpoint for at least two edges.
2. That every edge is part of at least one polygon.
3. That every polygon is closed.
4. That each polygon has at least one shared edge.
5. That if the edge table contains pointers to polygons, every edge referenced by a polygon pointer has a reciprocal pointer back to the polygon.

6.3 <u>Plane Equations</u>

To produce a display of a 3D object, we must process the input data representation for the object through several procedures such as,

- o Transformation of the modelling and world coordinate descriptions to viewing coordinates.
  - Then to device coordinates:

- Identification of visible surfaces
- The application of surface-rendering procedures.

- For these processes, we need information about the spatial orientation of the individual surface components of the object.
- This information is obtained from the vertex coordinate value and the equations that describe the polygon planes.
- The equation for a plane surface is

Ax + By+ Cz + D = 0 ----(1)

Where (x, y, z) is any point on the plane, and the coefficients A,B,C and D are constants describing the spatial properties of the plane.

- We can obtain the values of A,B,C and D by solving a set of three plane equations using the coordinate values for three non collinear points in the plane.
- For that, we can select three successive polygon vertices (x1, y1, z1), (x2, y2, z2) and (x3, y3, z3) and solve the following set of simultaneous linear plane equations for the ratios A/D , B/D and C/D .

$$(A/B)\ x_k + (B/D)\ y_k + (C/D)\ z_k = -1\ ,\ Where\ k = 1,2,3 \qquad (2)$$

The solution for this set of equations can be obtained in determinant form, using Cramer's rule as

$$A = \begin{bmatrix} 1 & y1 & z1 \\ 1 & y2 & z2 \\ 1 & y3 & z3 \end{bmatrix}\ B = \begin{bmatrix} x1 & 1 & z1 \\ x2 & 1 & z2 \\ x3 & 1 & z3 \end{bmatrix}\ C = \begin{bmatrix} x1 & y1 & 1 \\ x2 & y2 & 1 \\ x3 & y3 & 1 \end{bmatrix}\ D = -\begin{bmatrix} x1 & y1 & z1 \\ x2 & y2 & z2 \\ x3 & y3 & z3 \end{bmatrix} \qquad (3)$$

Expanding the determinants, we can write the calculations for the plane coefficients in the form:

$$A = y_1(z_2 - z_3) + y_2(z_3 - z_1) + y_3(z_1 - z_{3)}$$

$$B = z_1\ (x_2 - x_3) + z_2\ (x_3 - x_1) + z_3(x_1 - x_3)$$

$$C = x_1(\ y_2 - y_3) + x_2\ (y_3 - y_1) + x_3\ (y_1 - y_3)$$

$$D = -x_1(y_2\ z_3 - y_3\ z_2) - x_2(y_3\ z_1 - y_1 z_3) - x_3(\ y_1 z_2 - y_2 z_1) \qquad (4)$$

- As vertex values and other information are entered into the polygon data structure, values for A, B, C and D are computed for each polygon and stored with the other polygon data.
- Plane equations are used also to identify the position of spatial points relative to the plane surfaces of an object. For any point (x, y, z) hot on a plane with parameters A,B,C,D, we have $Ax + By + Cz \neq 0$

We can identify the point as either inside or outside the plane surface according o the sigh (negative or positive) of $Ax + By + Cz + D$:

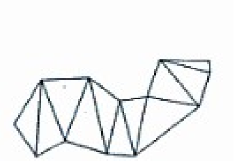
$if\ Ax + By + Cz + D < 0$, the point (x, y, z) is inside the surface.

$if\ Ax + By + Cz + D > 0$, the point (x, y, z) is outside the surface.

- These inequality tests are valid in a right handed Cartesian system, provided the plane parameters A,B,C and D were calculated using vertices selected in a counter clockwise order when viewing the surface in an outside-to-inside direction.

6.4 Polygon Meshes

- A single plane surface can be specified with a function such as fill Area. But when object surfaces are to be tiled, it is more convenient to specify the surface facets with a mesh function.
- One type of polygon mesh is the triangle strip A triangle strip formed with 11 triangles connecting 13 vertices.



- This function produces n-2 connected triangles given the coordinates for n vertices.
- Another similar function in the quadrilateral mesh, which generates a mesh of (n-1) by (m-1) quadrilaterals, given the coordinates for an n by m array of vertices. Figure shows 20 vertices forming a mesh of 12 quadrilaterals.

Curved Lines and Surfaces

- Displays of three dimensional curved lines and surface can be generated from an input set of mathematical functions defining the objects or from a set of user specified data points.
- When function are specified ,a package can project the defining equations for a curve to the display plane and plot pixel positions along the path of the projected function.
- For surfaces, a functional description in decorated to produce a polygon-mesh approximation to the surface.

6.5 Quadric Surfaces

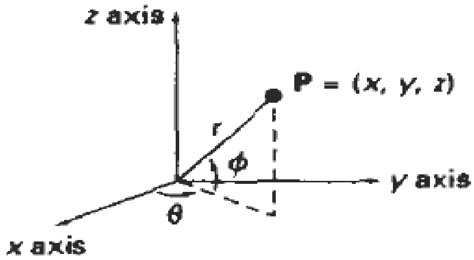
The quadric surfaces are described with second degree equations (quadratics). They include spheres, ellipsoids, tori, parabolids, and hyperboloids.

6.6 Sphere

In Cartesian coordinates, a spherical surface with radius r cantered on the coordinates origin is defined as the set of points (x, y, z) that satisfy the equation.

$$x^2 + y^2 + z^2 = r^2 \qquad (1)$$

The spherical surface can be represented in parametric form by using latitude and longitude angles, the parameter representation in eqn (2) provides a symmetric range for the angular parameter θ and φ.



x = r cosφ cosθ, -π/2 <= φ<= π/2

y = r cosφ sinθ, -π <= φ <= π (2)

z = rsinφ

Ellipsoid

- Ellipsoid surface is an extension of a spherical surface where the radius in three mutually perpendicular directions can have different values the Cartesian representation for points over the surface of an ellipsoid centered on the origin is

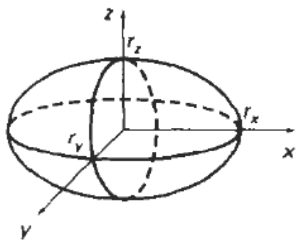
$$\frac{x^2}{r_x}+\frac{y^2}{r_y}+\frac{z^2}{r_z}=1$$

- The parametric representation for the ellipsoid in terms of the latitude angle φ and the longitude angle θ is

$x = r_x \cos\varphi \cos\theta$, $-\pi/2 <= \varphi <= \pi/2$

$y = r_y \cos\varphi \sin\theta$, $-\pi <= \varphi <= \pi$

$z = r_z \sin\varphi$



6.7 <u>Spline Representations</u>

- A Spline is a flexible strip used to produce a smooth curve through a designated set of points.
- Several small weights are distributed along the length of the strip to hold it in position on the drafting table as the curve is drawn.
- The Spline curve refers to any sections curve formed with polynomial sections satisfying specified continuity conditions at the boundary of the pieces.
- A Spline surface can be described with two sets of orthogonal spline curves.
- Splines are used in graphics applications to design curve and surface shapes, to digitize drawings for computer storage, and to specify animation paths for the objects or the camera in the scene.
- CAD applications for splines include the design of automobiles bodies, aircraft and spacecraft surfaces, and ship hulls.

Interpolation and Approximation Splines

- Spline curve can be specified by a set of coordinate positions called control points which indicates the general shape of the curve.
- These control points are fitted with piecewise continuous parametric polynomial functions in one of the two ways.

Interpolation

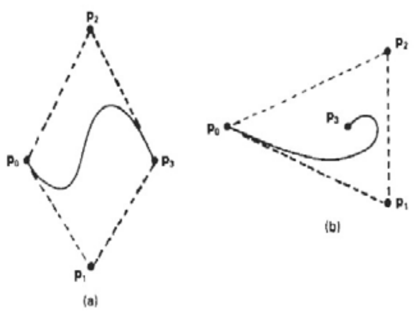
- When polynomial sections are fitted so that the curve passes through each control point the resulting curve is said to interpolate the set of control points.
- A set of six control points interpolated with piecewise continuous polynomial sections

Approximation

When the polynomials are fitted to the general control point path without necessarily passing through any control points, the resulting curve is said to approximate the set of control points.

- A set of six control points approximated with piecewise continuous polynomial sections

- Interpolation curves are used to digitize drawings or to specify animation paths.
- Approximation curves are used as design tools to structure object surfaces.
- A spline curve is designed , modified and manipulated with operations on the control points. The curve can be translated, rotated or scaled with transformation applied to the control points.
- The convex polygon boundary that encloses a set of control points is called the convex hull.
- The shape of the convex hull is to imagine a rubber band stretched around the position of the control points so that each control point is either on the perimeter of the hull or inside it.
- Convex hull shapes (dashed lines) for two sets of control points



Parametric Continuity Conditions

- For a smooth transition from one section of a piecewise parametric curve to the next various continuity conditions are needed at the connection points.

- If each section of a spline in described with a set of parametric coordinate functions or the form x = x(u), y = y(u), z = z(u), u1<= u <= u2 (a)
  we set parametric continuity by matching the parametric derivatives of adjoining curve section at their common boundary.
- Zero order parametric continuity referred to as C^0 continuity, means that the curves meet. (i.e) the values of x,y, and z evaluated at u2 for the first curve section are equal. Respectively, to the value of x,y, and z evaluated at u1 for the next curve section.
- First order parametric continuity referred to as C^1 continuity means that the first parametric derivatives of the coordinate functions in equation (a) for two successive curve sections are equal at their joining point.
- Second order parametric continuity, or C2 continuity means that both the first and second parametric derivatives of the two curve sections are equal at their intersection equation (a) for two successive curve sections are equal at their joining point.
- Second order parametric continuity, or C2 continuity means that both the first and second parametric derivatives of the two curve sections are equal at their intersection.
- Piecewise construction of a curve by joining two curve segments using different orders of continuity

  a)Zero order continuity only

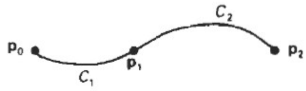
  b)First order continuity only

  c) Second order continuity only

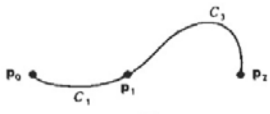
Geometric Continuity Conditions

- To specify conditions for geometric continuity is an alternate method for joining two successive curve sections.
- The parametric derivatives of the two sections should be proportional to each other at their common boundary instead of equal to each other.
- Zero order Geometric continuity referred as G^0 continuity means that the two curves sections must have the same coordinate position at the boundary point.
- First order Geometric Continuity referred as G^1 continuity means that the parametric first derivatives are proportional at the interaction of two successive sections.

- Second order Geometric continuity referred as G^2 continuity means that both the first and second parametric derivatives of the two curve sections are proportional at their boundary. Here the curvatures of two sections will match at the joining position.
  a) Three control points fitted with two curve sections joined with a parametric continuity



  b) geometric continuity where the tangent vector of curve C3 at point p1 has a greater magnitude than the tangent vector of curve C1 at p1.



(b)

Spline specifications

There are three methods to specify a spline representation:

1. We can state the set of boundary conditions that are imposed on the spline;
2. We can state the matrix that characterizes the spline; (or)
3. We can state the set of blending functions that determine how specified geometric constraints on the curve are combined to calculate positions along the curve path.

To illustrate these three equivalent specifications, suppose we have the following parametric cubic polynomial representation for the x coordinate along the path of a spline section.

$$x(u) = a_x u^3 + b_x u^2 + c_x u + d_x \qquad Where\ 0 \le u \le 1 \qquad (1)$$

- Boundary condition for this curve might be set ,for example on the end point coordinates x(0) and x(1) and on parametric derivatives $x'(0)$ and $x'(1)$.These four boundary conditions are sufficient to determine the values of four coefficients a_x, b_x ,c_x and d_x.
- From the boundary conditions, we can obtain the matrix that characterizes the spline curve by first rewriting the eq-1 as the matrix product

$$x(u) = [u^3 \ u^2 \ u \ 1].\begin{bmatrix} a_x \\ b_x \\ c_x \\ d_x \end{bmatrix} \qquad (2)$$

= U.C

Where the U is the row matrix of [powers of parameter u and C is the coefficient column matrix. From the above equation the boundary conditions in the matrix form and solve for the coefficient matrix C.

$$C = M_{spline} . M_{geom} \qquad (3)$$

Where M_{geom} is a four-element column matrix containing geometric constraint values on the spline and M_{spline} is 4-by-4 matrix that performs the geometric constraint values to the polynomial coefficients and provides a characterization for spline curve. Matrix M_{geom} contains control point coordinate values and other geometric constraints that have been specified. We can substitute the matrix representation for C into equ-2 then

x (u) = U. M_{spline} . M_{geom} (4)

The matrix M_{spline} ,characterizing a spline representation, sometimes called the basis matrix ,is particularly useful for transforming from one spline representation to another.

Finally we can expand the eq-4 to obtain a polynomial representation for coordinate x in terms of geometric constraint parameters

$$x\,(u) = \sum_{0}^{3} g_k \;.BFk(u)$$

Where g_k are the constraint parameters, such as the control-point coordinates and slope of the curve at the control points. BFk(u) are the polynomial blending function.

6.8 Bézier Curves and surfaces

- This spline approximation method was developed by the French engineer Pierre Bézier for the use of Renault automobile bodies .
- Bézier splines have a number of properties that make them highly useful and convenient for curves surface design.
- They are also easy to implement.
- It is also widely available in various CAD systems, in general graphics packages and in assorted drawing and painting packages.

Bézier Curves

- Bézier Curve section can be fitted to any number of control points.
- The number of control points to be approximated and their relative position determined the degree of the Bézier polynomial
- Suppose we are given n+1 control points position: p_k = (x_k , y_k , z_k) with k varying from 0 to n.
- These coordinate points can be blended to produce the following position vector p(u) ,Which describes the path of an approximating Bézier polynomial function between p_0 and p_n .

$$P(u) = \sum_{k=0}^{n} p_k \; BEZ_{k,n}\,(u) \; where \; 0 \le u \le 1 \qquad (1)$$

The Bézier blending function $BEZ_{k,n}(u)$ are the Bernstein Polynomials:

$$BEZ_{k,n}(u) = c(n,k)u^k\,(1-u)^{n-k} \qquad (2)$$

Where C(n,k) are the binomial coefficients:

$$c(n,k) = \frac{n!}{k!(n-k)!} \qquad (3)$$

Equivalently, we can define Bézier blending functions with the recursive calculation

$$BEZ_{k,n}(u) = (1-u)BEZ_{k,n-1}(u) + uBEZ_{k-1,n-1}(u), n > \; k \ge 1 \qquad (4)$$

With $BEZ_{k,k}(u)$ = u^k and $BEZ_{0,k}(u)$ = $(1-u)^k$ .Vector eq-1 represents a set of three parametric equations for the individual curve coordinates:

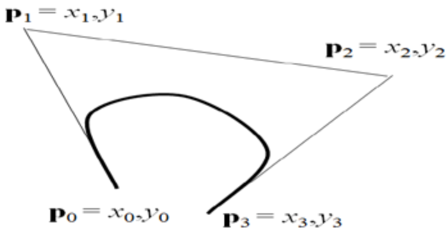
$$x(u) = \sum_{k=0}^{n} x_k \ BEZ_{k,n}\ (u)$$

$$y(u) = \sum_{k=0}^{n} y_k \ BEZ_{k,n}\ (u)$$

$$z(u) = \sum_{k=0}^{n} z_k \ BEZ_{k,n}\ (u)$$

As a rule Bézier curve is a polynomial of degree one less than the control points used: Three points generate a parabola, Four points generate a cubic curve and so forth. Example of four control point in the following diagram

Proerties Of Bézier Curve



- A very useful property of a Bézier Curves is that it always passes through the first and last control points
- That is boundary conditions at the two ends of the curve are

  P(0) = p_0

  P(1) = p_n

Value of the parametric first derivatives of a Bézier Curve at the end points can be calculated from control-point coordinates as

P'(0) = $-np_0 + np_1$

P'(1) = $-np_{n-1} + np_n$

Thus the slope at the beginning of the curve is along the line joining the first two control points , and the slope at the end of the curve is along the line joining the last two end points.

- Another important property of any Bézier curve is that it is lies within the convex hull of control points .This following form the properties of Bézier blending functions:

  They are all positive and their sum is always 1,

$$\sum_{k=0}^{n} BEZ_{k,u}\ (u) = 1$$

So that any curve simply the weighted the sum of the control-point positions.

Cubic Bézier curve

- Many graphics package provide only cubic spline functions.
- Cubic Bézier curves are generated with four control points
- Four blending functions for cubic Bézier curves obtained by substituting n=4. Then the equations are

  $BEZ_{0,3}\ (u) = (1-u)^3$

  $BEZ_{1,3}\ (u) = 3u(1-u)^2$

$BEZ_{2,3}\,(u) = 3u^2(1-u)$

$BEZ_{3,3}\,(u) = u^3$

At the end position of the cubic Bézier curve, parametric first derivatives are

$P'(0) = 3(p_1 - 2p_0)$,$p'(1)=3(p_3 - p_2)$

And parametric second derivatives are

$P''(0) = 6(p_0 - 2p_1 + p_2)$, $P''(0) = 6(p_1 - 2p_2 + p_3)$

We can use these expressions for the parametric derivatives to construct piece wise curves with c^1 or c^2 continuity sections.

Bézier surfaces

- Two sets of orthogonal Bézier curves can be used to design an object surface by specifying by an input mesh of control points.
- The parametric vector function for the Bézier blending functions:

$$\sum_{j=0}^{m}\sum_{k=0}^{n} p_{j,k}\ BEZ_{j,m}\,(v) BEZ_{k,n}\,(u)$$

With $p_{j,k}$ specifying the location of the (m+1) by(n+1) control points.

Bézier surfaces have the same properties as Bézier curves and they provide a convenient method for interactive design applications .For each surface patch, we can select a mesh of control points in the xy “ground” plane, then we choose elevations above the ground plane for z-coordinate values of the control points. Patches then pieced together using the boundary constraint.

6.9 B-Splines (for basis splines)

- B-splines have two advantage over Bézier splines: 1.the degree of a B-spline polynomial can be set independently of the no of control points and 2.B-spline allow local control over the shape of a spline curve and surface.

B-spline curves

- We can write a general expression for the calculation of coordinate positions along a B-spline curve in a blending-function formulation as

$$P(u) = \sum_{k=0}^{n} p_k\ \ B_{k,d}\,(u), \qquad u_{min}\ \le u\ \le u_{\max}\quad 2 \le d \le n+1 - - - - - - - - (1)$$

Where p_k are an input set of n+1 control points. The B-spline blending functions $B_{k,d}$ are polynomial of degree d-1 ,where parameter d can be chosen to be any integer value in the range from 2 up to the number of control points,n+1.Local control for B-spline is achieved by defining the blending functions over subintervals of the total range of u.

Blending functions for B-spline curves are defined by the Cox-deBoor recursion formulas

$$B_{k,1}(u) = \begin{cases} 1, & if\ u_k \le u\ \le\ u_{k+1}\ otherwise - - - - - - - - - - - - - - (2) \\ 0, & \end{cases}$$

$$B_{k,d}(u) = \frac{u - u_k}{u_{k+d-1} - u_k}\ B_{k,d-1}(u) + \frac{u_{k+d} - u}{u_{k+d} - u_{k+1}}\ B_{k+1,d-1}(u)$$

B-spline curves have the following properties

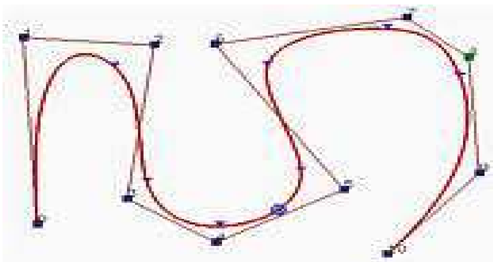
- The polynomial curve has degree $d-1$ and C^{d-2} continuity over the range of u.
- For $n+1$ control points , the curve is described with n+1 blending functions.
- Each blending function $B_{k,d}$ is defined over d subintervals of the total range of u, starting at knot value u_k.
- The range of parameter u is divided into $n+d$ subintervals by the $n+d+1$ values specified in the knot vectors.
- With knot values labeled as $\{u_0\ , u_1\ , \ldots \ldots \ldots \ldots \ldots \ldots .., u_{n+d}\}$,the resulting B-spline curve is defined only the interval from knot value u_{d-1} up to knot value u_{n+1}.
- Each section of the spline curve is influenced by d control points.
- Any one control point can affect the shape of at most d curve section

  A B-spline curve lies within the convex hull at most $d+1$ control points ,so that B-spline tightly bound to the input position. Any value u in the interval from knot value

  u_{d-1} to u_{n+1} ,the sum over all basis function is:

$$\sum_{k=0}^{n} B_{k,d}\ (u) = 1$$

- Consists of curve segments whose polynomial coefficients only depend on just a few control points
- Local control are Segments joined at knots.
- The curve does not necessarily pass through the control points
- The shape is constrained to the convex hull made by the control points
- Uniform cubic B-splines has C^2 continuity
  - o Higher than Hermite or Bezier curves.



Basis Functions

- We can create a long curve using many knots and B-splines
- The unweighted cubic B-Splines have been shown for clarity.
- These are weighted and summed to produce a curve of thedesired shape

7. Three Dimensional Geometric and Modeling Transformations

Contents

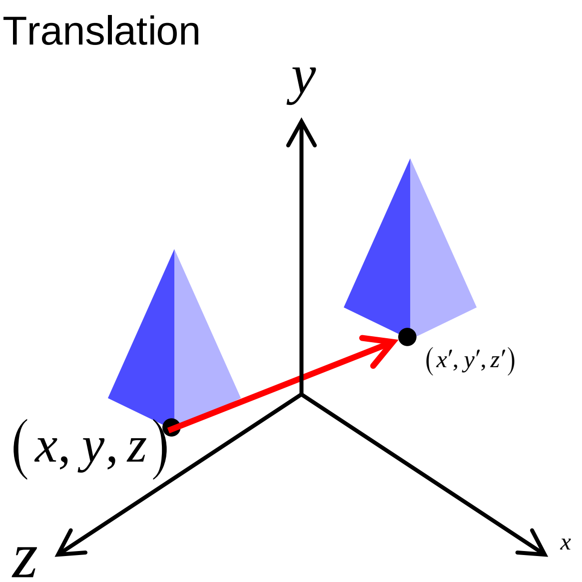
Introduction

- It is very similar to 2D. It uses 4x4 matrices rather than 3x3.
- A 3D point P is represented in homogeneous coordinates by a 4-dimensional vector

7.1 Translation

- A translation moves all points in an object along the same straight line path to new positions.
- The path is represented by a vector, called the translation or shift vector.

  We can write the components as



$$x' = x + t_x$$
$$y' = y + t_y$$
$$z' = z + t_z$$

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & t_x \\ 0 & 1 & 0 & t_y \\ 0 & 0 & 1 & t_z \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

7.2 Rotation

- For 3D object rotation transformation we need to pick an axis to rotate about and the amount of angular rotation.
- 3D rotation can be specified around any line in space

The most common choices are the X-axis, the Y-axis, and the Z-axis.

Rotation about Z-axis

Rotation about z axis in Three-dimensional

Z-axis rotation is identical to the 2D case:

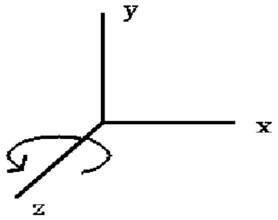
$x' = x\cos\theta - y\sin\theta$

$y' = x\sin\theta + y\cos\theta$

$z' = z$

The parameter θ is specifies the rotation angle. In homogeneous coordinate form ,the 3D z-axis rotation equations are expressed as

$$[x', y', z', 1] = \begin{bmatrix} \cos\theta & -\sin\theta & 0 & 0 \\ \sin\theta & \cos\theta & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$



We can write more compactly as

$P' = R_z(\theta).P$

Transformation equations for rotation about the other two coordinate axes can be obtained with a cyclic permutation of the coordinate parameters x,y and z in the above equation. That is we use the replacements

$x \to y \to z \to x$

Rotation about X- axis

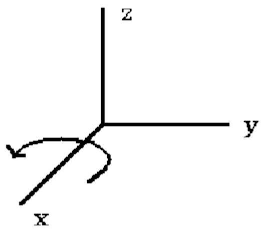
X-axis rotation looks like Z-axis rotation if replace: X axis with Y axis ,Y axis with Z axis Z axis with X axis.So we do the same replacement in the equations:

Same argument as for rotation about *z* axis For rotation about *x* axis, *x* is unchanged

$x' = x$

$y' = y\cos\theta - z\sin\theta$

$z' = y\sin\theta + z\cos\theta$

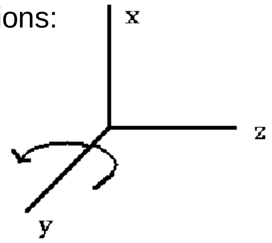


$$[x', y', z', 1] = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$P' = R_x(\theta).P$

Rotation about y axis

- Y-axis rotation looks like Z-axis rotation if replace: X axis with Z axis ,Y axis with X axis ,Z axis with Y axis. So we do the same replacement in equations:



- Same argument as for rotation about *z* axis
- For rotation about *y* axis, *y* is unchanged

  $x' = x\cos\theta + z\sin\theta$

  $y' = y$

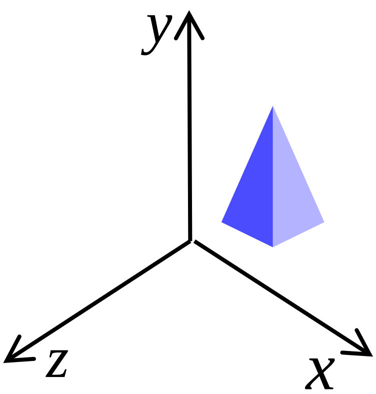
  $z' = z\cos\theta - x\sin\theta$

$$[x', y', z', 1] = \begin{bmatrix} \cos\theta & 0 & \sin\theta & 0 \\ 0 & 1 & 0 & 0 \\ -\sin\theta & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

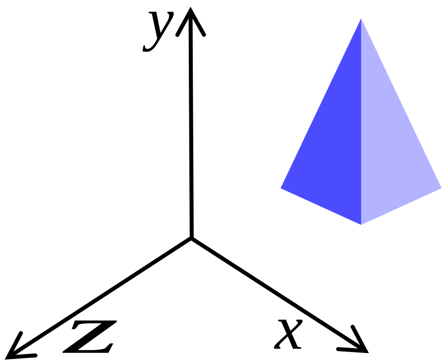
$P' = R_y(\theta).P$

7.3 Scaling

- Scaling changes the size of an object and involves the scale factors.
- The scaling parameters S_x , S_y and S_z are assigned any positive values.
- Scales the object about the origin, Here changes the size of the object along x,y and z-coordinate is same



The object before scaling



Object after scaling

Enlarging object also moves it from origin

$x' = S_x .x$

$y' = S_y .y$

$z' = S_z .z$

$$\mathbf{P}' = \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} S_x & 0 & 0 & 0 \\ 0 & S_y & 0 & 0 \\ 0 & 0 & S_z & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \mathbf{S} \cdot \mathbf{P}$$

7.4 Reflections

- A Three-dimensional can be performed relative to a selected reflection axes or with respect to selected reflected plane.
- Three-dimensional reflection matrices are set up similar to those for two dimensional.
- Reflection relative to given axis are equivalent to 180° rotation about that axis.
- The reflection planes are either xy, xz or yz

- The matrix expression for the reflection transformation of a position P = (*x*, *y*, *z*) relative to *xy* plane can be written as:

$$RF_z = \begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

Transformation matrices for inverting *x* and *y* values are defined similarly, as reflections relative to *yz* plane and *xz* plane, respectively

7.5 Shears

The matrix expression for the shearing transformation of a position P = (*x*, *y*, *z*), to produce *z*-axis shear, can be written as:

$$\begin{bmatrix} x' \\ y' \\ z' \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & a & 0 \\ 0 & 1 & b & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

- Parameters *a* and *b* can be assigned any real values. The effect of this transformation is to alter *x*- and *y*- coordinate values by an amount that is proportional to the *z* value, while leaving the *z* coordinate unchanged.
- Shearing transformations for the *x* axis and *y* axis are defined similarly.

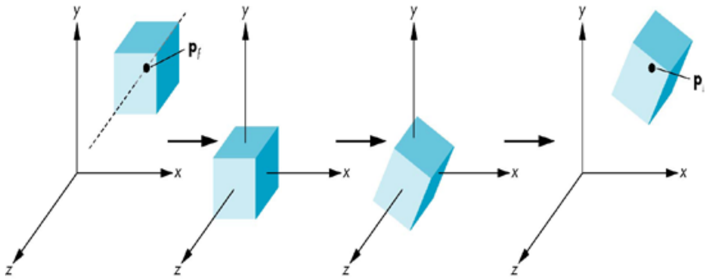
7.6 Composite transformation

- We can form arbitrary affine transformation matrices by multiplying together rotation, translation, and scaling matrices
- Because the same transformation is applied to many vertices, the cost of forming a matrix M=ABCD is not significant compared to the cost of computing Mp for many vertices p
- The difficult part is how to form a desired transformation from the specifications in the application
- Consider the composite transformation matrix **M**=**ABC**
- When we calculate **Mp,** matrix C is the first applied, then B, then A
- Mathematically, the following are equivalent

  p' = **ABCp** = **A**(**B**(**Cp**))
- Hence composition order really matters.

Rotation About Point P

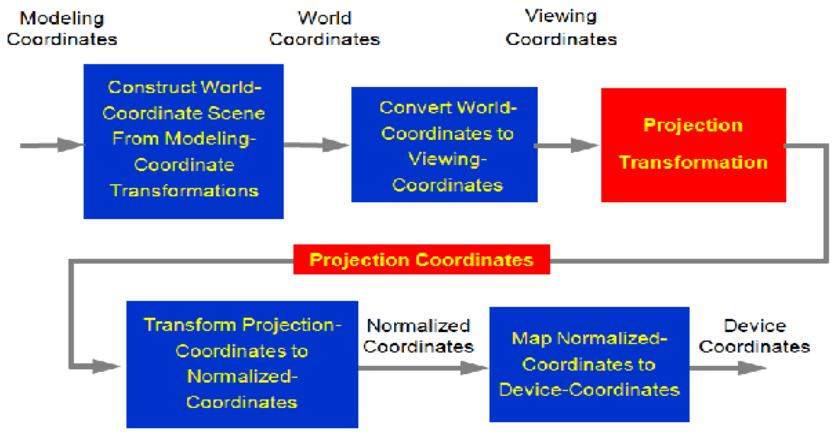
- Move fixed point P to origin
- Rotate by desired angle
- Move fixed point P back
- M = $T(p_f)\ R(q)\ T(-p_f)$



8. Three Dimensional Viewing

Contents

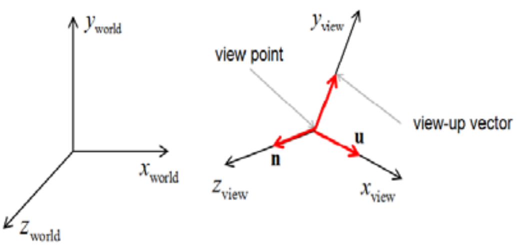
8.1 Viewing Pipeline



Processing Steps

- Once the scene has been model, world coordinates position is converted to viewing coordinates.
- The viewing coordinates system is used in graphics packages as a reference for specifying the observer viewing position and the position of the projection plane.
- Projection operations are performed to convert the viewing coordinate description of the scene to coordinate positions on the projection plane, which will then be mapped to the output device.
- Objects outside the viewing limits are clipped from further consideration, and the remaining objects are processed through visible surface identification and surface rendering procedures to produce the display within the device viewport.

8.2 Viewing Coordinates



- A view of an object in 3D is similar to photographing the object.
- Whatever appears in the viewfinder is projected into the flat film surface.
- The type and the size of the camera lens determineswhich parts of the scene appear in the final picture.

- These ideas incorporated into 3D graphics packages so that views of ascene can be generated, given the spatial position, orientation, and aperture size of the camera

Specifying the View Plane

- We choose a particular view for a scene by first establishes the viewing-coordinate system also called view reference coordinate as shown in above diagram.
- A view plane or projection plane is then set up perpendicular to the viewing z_v axis.
- World-coordinate position in the scene are transferred to viewing coordinates, then viewing coordinates are transferred into device coordinate.

$\mathbf{n}$: viewing directionon

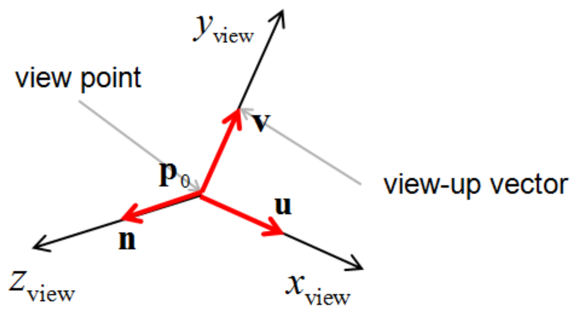
$\mathbf{u}-\mathbf{v}$: viewing plane

$\mathbf{u}=(u_x,u_y,u_z)$

$\mathbf{v}=(v_x,v_y,v_z)$

$\mathbf{n}=(n_x,n_y,n_z)$

$\mathbf{p}_0=(x_0,y_0,z_0)$

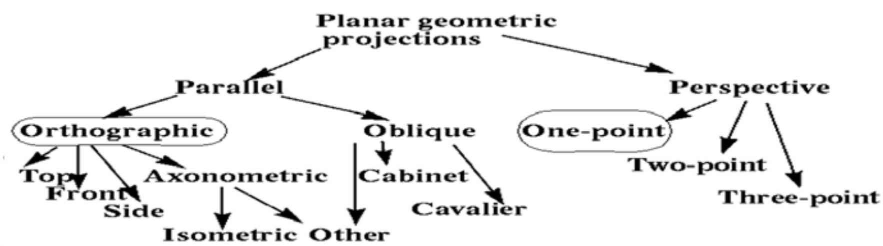


world to viewing transformation

$$\mathbf{M}_{\text{WC,VC}}=\underbrace{\begin{bmatrix} u_x & u_y & u_z & 0\\ v_x & v_y & v_z & 0\\ n_x & n_y & n_z & 0\\ 0 & 0 & 0 & 1\end{bmatrix}}_{\text{rotation}}\cdot\underbrace{\begin{bmatrix} 1 & 0 & 0 & -x_0\\ 0 & 1 & 0 & -y_0\\ 0 & 0 & 1 & -z_0\\ 0 & 0 & 0 & 1\end{bmatrix}}_{\text{translation}}$$

Projection

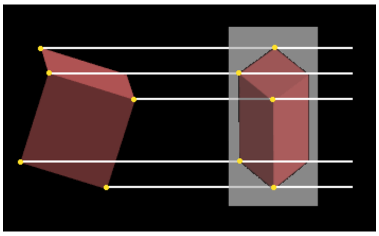
- In computer graphics, you can use the virtual camera to generate a picture on the window of the viewing plane, either by using parallel projection or perspective projection. Types of Projection is represented as diagram



8.3 Parallel Projections

- If COP (center of projection) is located at infinity all the projectors are parallel and the result is parallel projection.

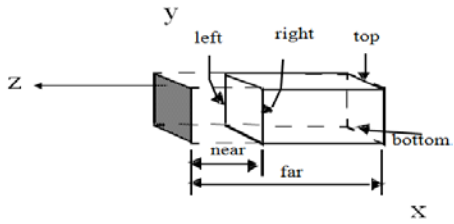
- In parallel projection, the polygons are projected on to the viewing plane using parallel lines called projectors. In this case the direction of projection (DOP) needs to be defined.
- Parallel projection offers no sense of depth. As a line of fixed height moves away from the camera it is drawn as the same size.



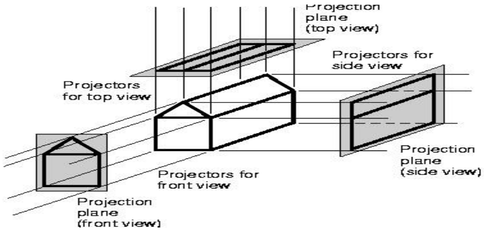
- centre of projection infinitely far from view plane
- projectors will be parallel to each other
- need to define the direction of projection (vector)
- 2 sub-types
  - orthographic - direction of projection is normal to view plane
  - oblique - direction of projection not normal to view plane
- better for drafting / CAD applications

<u>Orthographic Parallel Projections</u> -The direction of projection normal to the projection plane

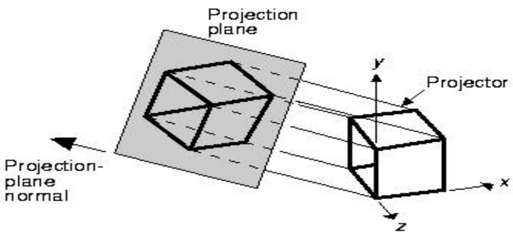
<u>Oblique Parallel Projection</u>-otherwise



<u>Orthographic Parallel Projections</u>

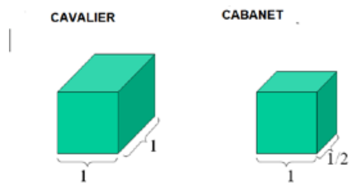


- Projection plane perpendicular to a principle axis
- Most common types
  - Front-elevation
  - Top-elevation (plane-elevation)
  - Side-elevation
- Used in engineering drawing (such as machine parts)
- Hard to deduce 3D nature
- Axonometric orthographic projections
  - Projection plane not normal to a principle axis
  - Several faces of an object can be shown at once
  - Parallelism reserved, distances can be measured
  - Example: Isometric projection
    - VPN = DOP = (dx, dy, dz), where |dx| = |dy| = |dz| Where VPN=View-plane normal, DOP=Direction of projection
    - 8 directions



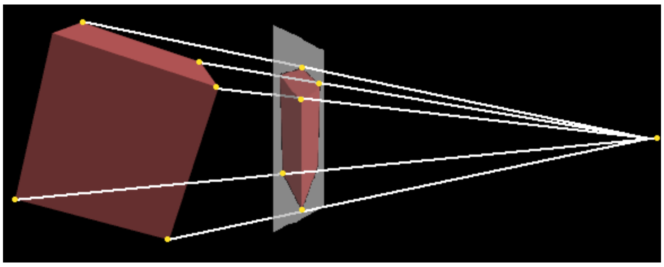
Oblique Parallel Projections

- Projection plane normal and DOP(Direction of projection) differ
- Projection plane is normal to a principle axis
- Measurement of distance and angle of faces parallel to the plane allowed
- Widely used (easy to draw)
- Cavalier
  - o DOP makes 45 degree with projection plane
- Cabinet
  - o DOP makes angle of arctan(2) with projection plane

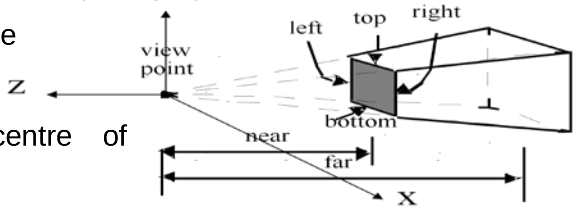


8.4 Perspective Projections

- If COP(centre of projection) is located at finite point in 3 space ,the result is prospective projection.
- In perspective projection, projectors are projected towards a point referred to as the centre of projection or the projection reference point (PRP). When a scene is rendered using perspective projection, a line of a fixed height will be drawn shorter as it moves away from the camera. Therefore this technique allows the viewer to perceive depth in a two dimensional image.



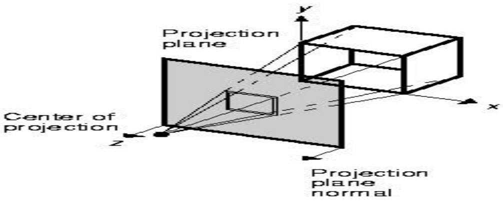
- Vanishing point: the perspective projections of any set of parallel lines that are not parallel to the projection plane converge to a vanishing point (a point at infinity) .
- If a set of lines is parallel to a coordinate axis, the vanishing point is called the principle vanishing point.
- Perspective projections are categorized by their number of principal vanishing points; current graphics projection only deals with the one point projection.
- centre of projection finitely far from view plane
- projectors will not be parallel to each other
- need to define the location of the centre of projection (point)



- classified into 1, 2, or 3-point perspective
- more visually realistic - has perspective foreshortening (objects further away appear smaller)

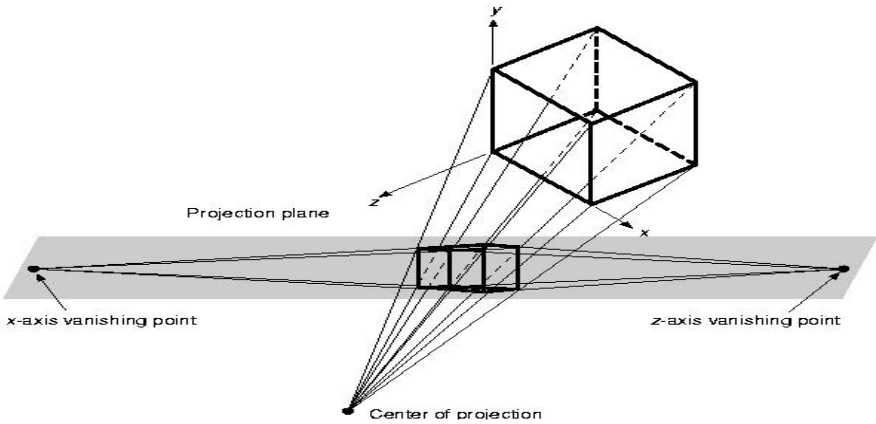
Number of Axis Vanishing Points

- One-point



Number of Axis Vanishing Points-Two point

- Commonly used in architecture, engineering, industrial design, and advertising drawings.



8.5 3D Clipping

- 3D Clipping, in graphics technology is used to speed up your rendering engine. The most common clipping method is the 2D clipping algorithm.
- 2D clipping is done at the last stage of rendering.
- The triangle-routine used to render the polygons onto the screen make sure that you don't draw outside the screen.
- This can be very fast, but increases the complexity of the triangle-filler.
- This clipping method works directly with two-dimensional screen-coordinates.
- In 3D clipping you do everything in 3D space.
- Map graphics are clipped to one side of an arbitrary clipping plane in one or more clipping stages.
- For example, to draw a hemisphere centred on a given point, the clipping plane passes through the centre of the sphere and has a normal vector that coincides with the given point.

9. Illumination Model & Surface Rendering Methods

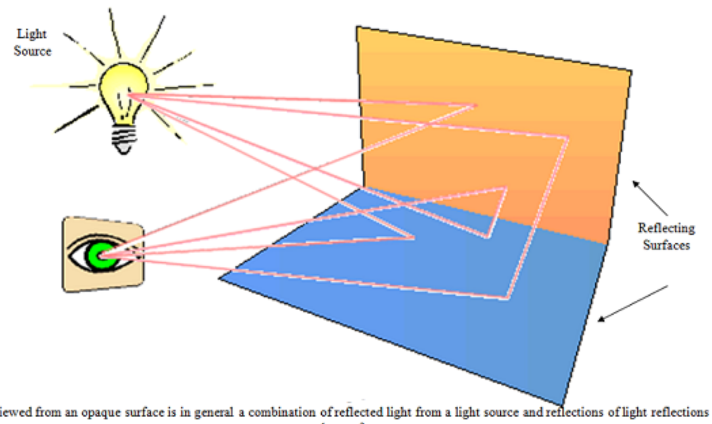
Contents

Introduction

- Illumination: the transport of energy (luminous flux of visible light) from light sources to surfaces, indirect and direct.
- Often a confusion between lighting and shading
- Lighting
  – The process of computing the luminous intensity (outgoing light) at a particular 3D point.
  – Illumination model (shading model!) (Hearn Baker)
- Shading
  – The process of assigning colors to pixels
  – Surface-rendering method (Hearn Baker)

9.1 Different light sources used in 3D modelling

- When we view an opaque no luminous object, we see reflected light from the surfaces of the object.
- The total reflected light is the sum of the contributions from *light sources* and other reflecting surfaces in the scene.



Light viewed from an opaque surface is in general a combination of reflected light from a light source and reflections of light reflections from other surfaces.

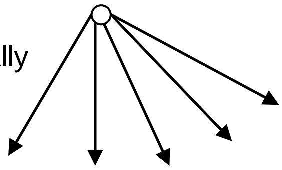
- Light sources = *light-emitting sources.*
- Reflecting surfaces = *light-reflecting sources.*
- Light source: object that radiates energy.

Sun, lamp, globe, sky…

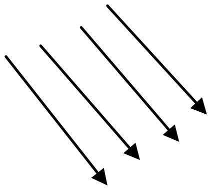
Intensity $I = (I_{red}, I_{green}, I_{blue})$,If $I_{red} = I_{green} = I_{blue}$: white light

Light Source Models

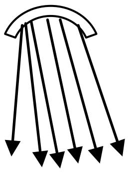
- Point Source: All light rays originate at a point and radially diverging. A reasonable approximation for sources whose dimensions are small compared to the object size.



- Parallel source: Light rays are all parallel. May be modelled as a point source at infinity (the sun).

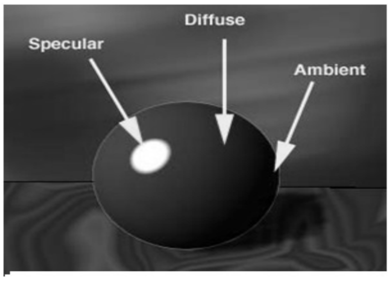


- Distributed source : All light rays originate at a finite area in space. – A nearby sources such as fluorescent light.



9.2 Basic Illumination model

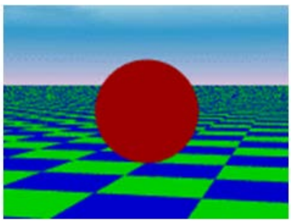
- Simplified and fast methods for calculating surfaces intensities.
- Calculations are based on optical properties of surfaces and the lighting conditions (no reflected sources nor shadows).
- Light sources are considered to be point sources.
- A reasonably good approximation for most scenes.



Phong Shading Model

1. ambient
2. diffuse
3. specular

9.3 Ambient Light



Ambient light shading.

- Even though an object in a scene is not directly lit it will still be visible. This is because light is reflected from nearby objects.
- Ambient light has no spatial or directional characteristics.
- The amount of ambient light incident on each object is a constant for all surfaces and over all directions.
- The amount of ambient light that is reflected by an object is independent of the objects position or orientation and depends only on the optical properties of the surface.
- The level of ambient light in a scene is a parameter I_a , and each surface illuminated with this constant value.

- Illumination equation for ambient light is

$$I = k_a I_a$$

where

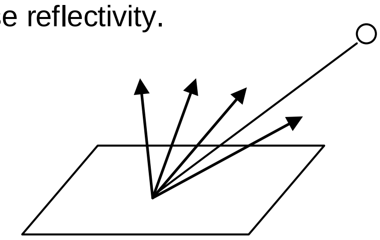
I is the resulting intensity

I_a is the incident ambient light intensity

k_a is the object's basic intensity, *ambient-reflection coefficient*.

9.4 Diffuse Reflection

- Diffuse reflections are constant over each surface in a scene, independent of the viewing direction.
- The amount of the incident light that is diffusely reflected can be set for each surface with parameter k_d, the diffuse-reflection coefficient, or diffuse reflectivity.



$0 \le k_d \le 1$;

k_d near 1 – highly reflective surface;

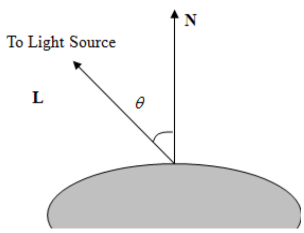
k_d near 0 – surface that absorbs most of the incident light;

k_d is a function of surface color;

- Diffuse (Lambertian) surfaces are rough or grainy (like clay, soil,fabric).
- The surface appears equally bright from all viewing directions.
- The brightness at each point is proportional to cos(θ)

This is because a surface (A) perpendicular to the light direction is more illuminated than a surface (B) at an oblique angle.

- As the angle between the surface normal and the incoming light direction increases, les of the incident light falls on the surface.
- We denote the angle of incidence between the incoming light direction and the surface normal as θ. Thus, the amount of illumination depends on cosθ. If the incoming light from the source is perpendicular to the surface at a particular point, that point is fully illuminated.



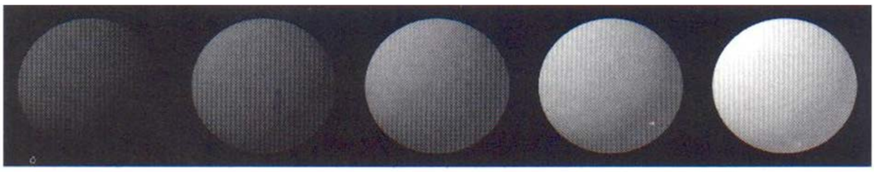
- If I_l is the intensity of the point Light source, then the diffuse reflection equation for a point on the surface can be written as

$$I_{l,diff} = k_d I_l \cos\theta \quad \text{or} \quad I_{l,diff} = k_d I_l (N \cdot L)$$

where N is the unit normal vector to a surface and L is the unit direction vector to the point light source from a position on the surface. Angle of incidence θ between the unit light-source direction vector L and the unit surface normal N

- We can combine the ambient and point-source intensity calculations to obtain an expression for the total diffuse reflection.

  $I_{diff} = k_a I_a + k_d I_l (N \cdot L)$ where both k_a and k_d depend on surface material properties and are assigned values in the range from 0 to 1.

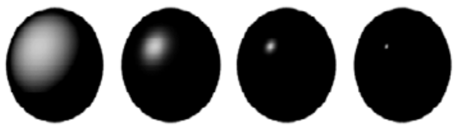


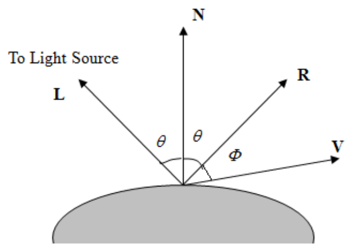
Series of pictures of sphere illuminated by ambient and diffuse reflection model.
$I_a = I_l = 1.0$, $k_d = 0.4$ and k_a values (0.0, 0.15, 0.30, 0.45, 0.60).

9.5 Specular Reflection

- *Specular reflection* is the result of total, or near total, reflection of the incident light in a concentrated region around the *specular-reflection angle.*
- Shiny surfaces have a narrow specular-reflection range.

  Dull surfaces have a wider reflection range.





Modeling specular reflection.

The above Figure shows the specular reflection direction at a point on the illuminated surface. In this figure,

- R represents the unit vector in the direction of specular reflection;
- L – unit vector directed toward the point light source;
- V – unit vector pointing to the viewer from the surface position;
- Angle Φ is the viewing angle relative to the specular-reflection direction R.

10. Introduction to Digital Audio

Contents

10.1 Basics of Acoustics

- Sound is a form of energy similar to heat and light.
- Sound is generated from vibration objects and can flow through a material medium from one place to another.
- Acoustic is the branch of physics that studied sound. Sound is a physical phenomenon produced by the vibration of matter.
- As the matter vibrates, pressure variations are created in the air surrounded it.

Psychoacoustics

- Psychoacoustics is the scientific study of sound perception. It is the branch of science studying the psychological and physiological responses associated with sound.
- Categories are

Frequency range of human hearing

As the frequency of periodic disturbances in the air increases, the human ear starts hearing sound when the disturbances are in the region of about 20 cycles per second. The upper range of audibility lies around 20,000 hertz. Frequency is expressed in hertz or cycles per second.

Dynamic range of human hearing

Human hearing ranges from 1 decibel called the threshold of hearing, to over 120 decibels, the threshold of pain.

Elements of Audio System

An elementary sound system is where we can record, manipulate and playback sound. It consists of different components.

10.2 Musical sound and noise

Musical sounds are periodic and somewhat regular. They are pleasing to our ears and minds, and sound has been one of the greatest forms of expression since the beginning of time. Unpleasant sound is often described as noise. Noise is more irregular. When looking at the **waveform**, a visual representation of sound, music has more patterns and gradual variances in volume, but noise is jagged and sporadic.

The three characteristics which differentiate musical sounds from one another are:

- Loudness
- Pitch
- Quality or timbre

Loudness

It is that characteristic of a musical sound that determines the degree of sensation that the sound can produce in the ear. It depends on the intensity of the sound which is objective in nature and the sensitivity of the ear which is subjective in nature.

Pitch

It is that characteristic of a musical sound by which a shrill sound can be distinguished from a grave one, even though the two sounds may be of the same intensity. It is also defined as that characteristic of sound by which the ear assigns it a place on a musical scale. When a stretched string is plucked, a sound of a certain pitch sensation is produced. If the tension in the string is increased, the pitch (the shrillness) becomes higher. Increasing the tension, also increases the frequency of vibration. Therefore, pitch is intimately related to frequency. But frequency alone does not determine the pitch. Below 1000Hz, the pitch is slightly higher than the frequency and above 1000Hz the position is reversed. The loudness of sound also affects the pitch up to 1000Hz. An increase in loudness causes a decrease in pitch. From about 1000 to 3000Hz, the pitch is independent of loudness, while above 3000Hz an increase in loudness causes an increase in pitch.

The voice of a woman or a child is shrill but that of a man is hoarse (i.e., flat or grave). The sound emitted by a cuckoo is shrill while that by a crow or a lion is hoarse. The buzzing of a mosquito, though low in intensity has a high pitch. The pitch of the sound changes when the source or the observer or both are in relative motion.

Quality or timbre

It is that characteristic of a musical sound which enables us to distinguish between the sounds produced by two different musical instruments or two different persons although their pitch and loudness may be same. It is because of this characteristic that we are able to recognize the voice of a known person over the telephone or to distinguish between the sounds produced by different musical instruments in an orchestra.

The quality depends primarily on the waveform of the sound. The waveform of the sound emitted by a tuning fork is a simple sine curve. But most bodies vibrate in a very complex manner. Besides the fundamental frequency f, they consist of additional frequencies of 2f, 3f, 4f, etc. These additional tones are called overtones or harmonics. According to Helmholtz, the quality of a musical note is determined by the number, relative frequency and intensities of the component simple tones of which a complex vibration is composed of. One can produce the same tone with the same frequency and intensity as one's favorite singer, but the singer's voice has a better quality because of a different combination of the overtones in it.

Noise

Noise is an abrupt sound of a complex character with an irregular period and amplitude, originating from a source in non-periodic motion. The horn of a motor car, the sound of a hammer striking an anvil, the report of a gun, the sound from a motorbike or a flying aeroplane and bursting of crackers are examples of noise. Noises produce a jarring effect on the ear. Airborne noise is mainly due to the variations in the air pressure with respect to the mean atmospheric pressure. Structural borne noise is due to mechanical vibrations in elastic bodies. Noise is considered as an undesired sound whose effect is to disturb the normal work, sleep or peace of mind of human beings. Sometimes, it produces strain, irritation and headache. A high noise level (industrial or from over amplified music) can cause permanent hearing impairment. It affects the concentration of mind of workers, decreases their efficiency and may lead to errors being committed.

10.3 Microphone

- Device for converting sound waves into electric power that has wave characteristics essentially similar to those of the sound.
- By proper design, a microphone may be given directional characteristics so that it will pick up sound primarily from a single direction, from two directions, or more or less uniformly from all directions.
- In addition to their use in telephone transmitters, microphones are most widely applied in sound-recording systems (principally magnetic and digital tape recorders), and public-address systems.
- An electro acoustic device containing a transducer which is actuated by sound waves and delivers electric signals proportional to the sound pressure.
- Microphones are usually classified with respect to the transducer principle used.
- Their directional characteristics are also of interest, that is, the voltage output as a function of the direction of incidence for constant sound pressure. See also Directivity; Sound; Sound pressure; Transducer.

- In addition to directional characteristics, some other important characteristics of microphones include open-circuit sensitivity, equivalent noise level, dynamic range, and vibration sensitivity.
- Open-circuit sensitivity is defined as the ratio of open-circuit output voltage and sound pressure. The pressure sensitivity refers to the actual pressure acting upon the diaphragm of the microphone, while the free-field sensitivity refers to the pressure that existed in the sound field before insertion of the microphone. Pressure sensitivity and free-field sensitivity are equal at low frequencies. Sensitivities are measured in volts/pascal (V/Pa).
- Equivalent noise level is equal to the level of a sound pressure which generates an output voltage of the microphone corresponding to its inherent A-weighted noise voltage. It is measured in dB(A).
- Dynamic range is defined as the range of sound pressure levels in decibels (dB) extending from the equivalent noise level to the level where the nonlinear distortion reaches 3%.
- Vibration sensitivity is defined as the ratio of the output voltage of the microphone as a result of acceleration of its case to the magnitude of the acceleration. Vibration sensitivities are measured in volts/*g*, where *g* is the acceleration of the Earth's gravity, or in volts/(m/s^2).

Electrostatic (condenser) microphones

These consist of a fixed electrode (the backplate), a movable electrode (the diaphragm), and an air gap between the electrodes. To decrease the acoustic stiffness of the airgap, which is generally about 20 to 30 micrometers (0.8 to 1.2 mils) thick, the backplate is often perforated with holes connecting the air gap to a larger air cavity. The diaphragm is a thin [typically 4 to 6 μm thick (0.16 to 0.24 mil)] foil under mechanical tension. .

Dynamic microphones

- These consist of a conductor located in the gap of a permanent magnet. Motion of the conductor produces a voltage proportional to its velocity.
- In the moving-coil microphone the coil, often referred to as voice coil, is connected to a diaphragm actuated by the sound waves.
- Motion of the coil induces a voltage proportional to its velocity. To obtain a frequency-independent sensitivity, the coil must respond to the sound pressure with frequency-independent velocity.

- This is accomplished by resistance-controlling the system: the acoustical resistance is made larger in magnitude than the acoustical reactance due to the mass of the diaphragm and coil and due to the compliance of the suspension.
- A silk cloth or a piece of felt placed behind the voice coil is used for this purpose. In modern moving-coil microphones, the diaphragm is made of a plastic film. The impedance of the voice coil is typically 200 to 1000 ohms.

Magnetic microphones

- These consist of a diaphragm connected to an armature which, when vibrating, varies the reluctance in a magnetic field.
- The variation in reluctance leads to a variation in the magnetic flux through a surrounding coil and therefore to an induced voltage.
- This voltage is proportional to the velocity of the armature. To obtain a frequency-independent sensitivity, the velocity of the armature in response to the sound pressure must be independent of frequency.
- As in dynamic microphones, this is accomplished by resistance-controlling the system, for example, by placing an acoustic resistance behind the diaphragm.

Silicon microphones

- The methods of silicon technology make it possible to fabricate batch-processed, high-performance microphones.
- Utilizing the transducer principles outlined above, many types of such micro machined acoustic sensors have been built.
- In addition, new concepts of transducer design, such as the modulation of the drain current of a field-effect transistor or the modulation of light propagation in an optical waveguide by the sound waves, have been realized in silicon.
- Closest to commercial application are the silicon microphones based on the condenser and piezoelectric principles..

Amplifier

- An electronic amplifier, amplifier, or (informally) amp is an electronic device that increases the power of a signal.
- An amplifier is an electronic device that increases the voltage, current, or power of a signal. Amplifiers are used in wireless communications and broadcasting, and in audio equipment of all kinds.
- They can be categorized as either weak-signal amplifiers *or* power amplifiers.

- Weak-signal amplifiers are used primarily in wireless receivers. They are also employed in acoustic pickups, audio tape players, and compact disc players.
- A weak-signal amplifier is designed to deal with exceedingly small input signals, in some cases measuring only a few nanovolts (units of 10^{-9} volt).
- Such amplifiers must generate minimal internal noise while increasing the signal voltage by a large factor.
- The most effective device for this application is the field-effect transistor. The specification that denotes the effectiveness of a weak-signal amplifier is sensitivity, defined as the number of microvolts (units of 10^{-6} volt) of signal input that produce a certain ratio of signal output to noise output

Audio File Format

An **audio file format** is a file format for storing digital audio data on a computer system. The bit layout of the audio data (excluding metadata) is called the audio coding format and can be uncompressed, or compressed to reduce the file size, often using lossy compression. The data can be a raw bit stream in an audio coding format, but it is usually embedded in a container format or an audio data format with defined storage layer.

Format types

It is important to distinguish between the audio coding format, the container containing the raw audio data, and an audio codec. A codec performs the encoding and decoding of the raw audio data while this encoded data is (usually) stored in a container file. Although most audio file formats support only one type of audio coding data (created with an audio coder), a multimedia container format (as Matroska or AVI) may support multiple types of audio and video data.

There are three major groups of audio file formats:

- Uncompressed audio formats, such as WAV, AIFF, AU or raw header-less PCM;
- Formats with lossless compression, such as FLAC, Monkey's Audio (filename extension .ape), WavPack (filename extension .wv), TTA, ATRAC Advanced Lossless, Apple Lossless (filename extension .m4a), MPEG-4 SLS, MPEG-4 ALS, MPEG-4 DST, Windows Media Audio Lossless (WMA Lossless), and Shorten (SHN).
- Formats with lossy compression, such as MP3, Vorbis, Musepack, AAC, ATRAC and Windows Media Audio Lossy (WMA lossy).

10.4 Audio compression (LPC, Sub Band Encoding)

Linear predictive coding (LPC) is a tool used mostly in audio signal processing and speech processing for representing the spectral envelope of a digital signal of speech in compressed form, using the information of a linear predictive model. It is one of the most powerful speech analysis techniques, and one of the most useful methods for encoding good quality speech at a low bit rate and provides extremely accurate estimates of speech parameters.

LPC coefficient representations

- LPC is frequently used for transmitting spectral envelope information, and as such it has to be tolerant of transmission errors.
- Transmission of the filter coefficients directly (see linear prediction for definition of coefficients) is undesirable, since they are very sensitive to errors.
- In other words, a very small error can distort the whole spectrum, or worse, a small error might make the prediction filter unstable.
- There are more advanced representations such as log area ratios (LAR), line spectral pairs (LSP) decomposition and reflection coefficients.
- Of these, especially LSP decomposition has gained popularity, since it ensures stability of the predictor, and spectral errors are local for small coefficient deviations.

Applications

- LPC is generally used for speech analysis and resynthesis. It is used as a form of voice compression by phone companies, for example in the GSM standard. It is also used for secure wireless, where voice must be digitized, encrypted and sent over a narrow voice channel; an early example of this is the US government's Navajo I.
- LPC synthesis can be used to construct vocoders where musical instruments are used as excitation signal to the time-varying filter estimated from a singer's speech. This is somewhat popular in electronic music. Paul Lansky made the well-known computer music piece not just more idle chatter using linear predictive coding.A 10th-order LPC was used in the popular 1980s Speak & Spell educational toy.
- Waveform ROM in some digital sample-based music synthesizers made by Yamaha Corporation may be compressed using the LPC algorithm
- LPC predictors are used in Shorten, MPEG-4 ALS, FLAC, SILK audio codec, and other lossless audio codecs.
- LPC is receiving some attention as a tool for use in the tonal analysis of violins and other stringed musical instruments.

Sub Band Encoding

In signal processing, **Sub-band coding** (**SBC**) is any form of transform coding that breaks a signal into a number of different frequency bands and encodes each one independently. This decomposition is often the first step in data compression for audio and video signals.

Basic principles

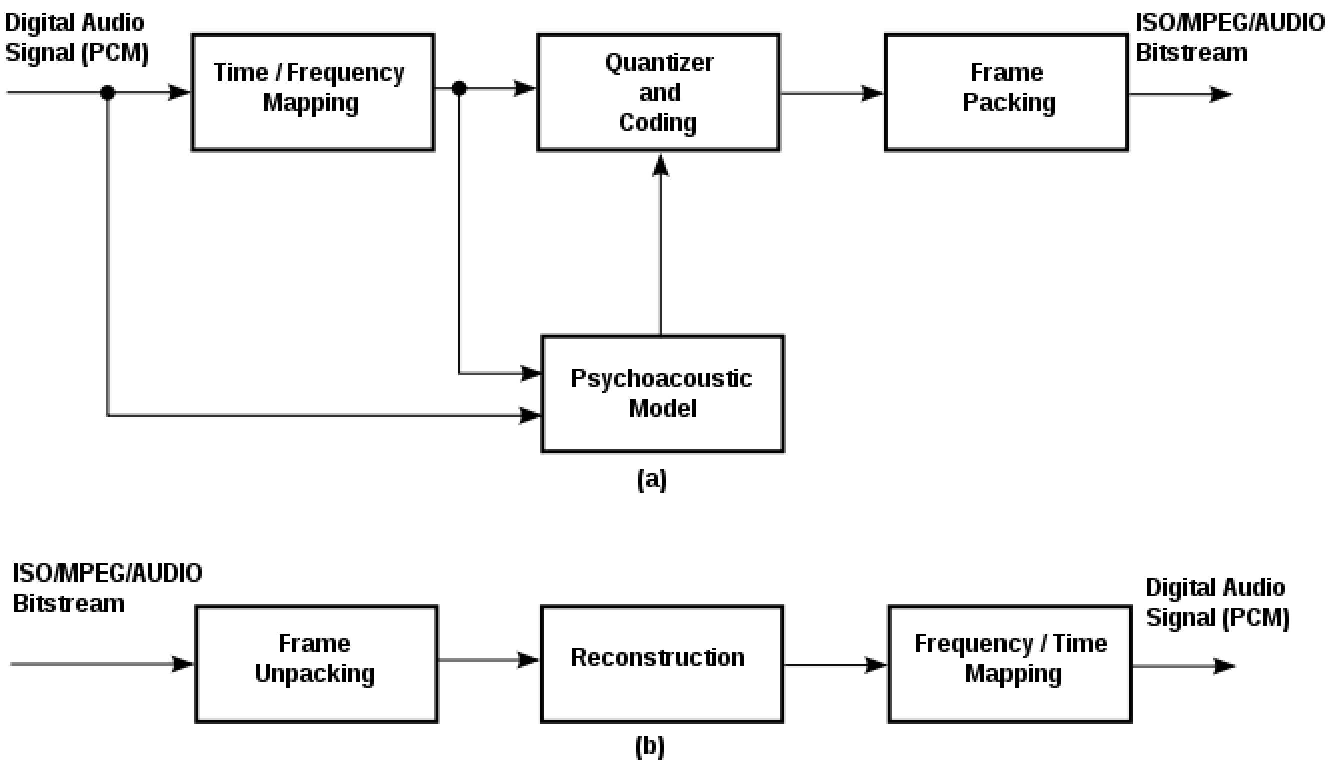
- The utility of SBC is perhaps best illustrated with a specific example. When used for audio compression, SBC exploits auditory masking in the human auditory system.
- Human ears are normally sensitive to a wide range of frequencies, but when a sufficiently loud signal is present at one frequency, the ear will not hear weaker signals at nearby frequencies. We say that the louder signal masks the softer ones.
- The louder signal is called the masker, and the point at which masking occurs is known as the masking threshold.
- The basic idea of SBC is to enable a data reduction by discarding information about frequencies which are masked.
- The result differs from the original signal, but if the discarded information is chosen carefully, the difference will not be noticeable, or more importantly, objectionable.

Encoding audio signals

- The simplest way to digitally encode audio signals is pulse-code modulation (PCM), which is used on audio CDs, DAT recordings, and so on.
- Digitization transforms continuous signals into discrete ones by sampling a signal's amplitude at uniform intervals and rounding to the nearest value represent able with the available number of bits.
- This process is fundamentally inexact, and involves two errors: discretization error, from sampling at intervals, and quantization error, from rounding.
- The more bits used represent each sample, the finer the granularity in the digital representation, and thus the smaller the error.
- Such quantization errors may be thought of as a type of noise, because they are effectively the difference between the original source and its binary representation. With PCM, the only way to mitigate the audible effects of these errors is to use enough bits to ensure that the noise is low enough to be masked either by the signal itself or by other sources of noise.

- A high quality signal is possible, but at the cost of a high bitrate (e.g., over 700 kbit/s for one channel of CD audio). In effect, many bits are wasted in encoding masked portions of the signal because PCM makes no assumptions about how the human ear hears.
- More clever ways of digitizing an audio signal can reduce that waste by exploiting known characteristics of the auditory system.
- A classic method is nonlinear PCM, such as mu-law encoding (named after a perceptual curve in auditory perception research).
- Small signals are digitized with finer granularity than are large ones; the effect is to add noise that is proportional to the signal strength. Sun's Au file format for sound is a popular example of mu-law encoding. Using 8-bit mu-law encoding would cut the per-channel bitrate of CD audio down to about 350 kbit/s, or about half the standard rate. Because this simple method only minimally exploits masking effects, it produces results that are often audibly poorer than the original.
- Sub-band coding is used for example in G.722 codec. It uses sub-band adaptive differential pulse code modulation (SB-ADPCM) within a bit rate of 64 kbit/s. In the SB-ADPCM technique used, the frequency band is split into two sub-bands (higher and lower) and the signals in each sub-band are encoded using ADPCM.

A basic SBC scheme



- To enable higher quality compression, one may use subband coding. First, a digital filter bank divides the input signal spectrum into some number (e.g., 32) of subbands. The psychoacoustic model looks at the energy in each of these subbands, as well as in the original signal, and computes masking thresholds using psychoacoustic information. Each of the subband samples is quantized and encoded so as to keep the quantization noise below the dynamically computed masking threshold. The final step is to format all these quantized samples into groups of data called frames, to facilitate eventual playback by a decoder.

- Decoding is much easier than encoding, since no psychoacoustic model is involved. The frames are unpacked, subband samples are decoded, and a frequency-time mapping reconstructs an output audio signal.
- Over the last five to ten years, SBC systems have been developed by many of the key companies and laboratories in the audio industry.
- Beginning in the late 1980s, a standardization body called the Motion Picture Experts Group (MPEG) developed generic standards for coding of both audio and video. Sub band coding resides at the heart of the popular MP3 format (more properly known as MPEG-1 Audio Layer III).

11. Introduction to Digital Image

Contents

11.1 Raster Graphics

- Raster graphics are digital images created or captured (for example, by scanning in a photo) as a set of samples of a given space.
- A *raster* is a grid of x and y coordinates on a display space. (And for three-dimensional images, a z coordinate.)
- A raster image file identifies which of these coordinates to illuminate in monochrome or color values.
- The raster file is sometimes referred to as a bitmap because it contains information that is directly mapped to the display grid.
- A raster file is usually larger than a vector graphics image file.
- A raster file is usually difficult to modify without loss of information, although there are software tools that can convert a raster file into a vector file for refinement and changes. Examples of raster image file types are: BMP, TIFF, GIF, and JPEG files.

Vector Graphics

- Vector graphics are created from mathematical formulas used to define lines, shapes and curves.
- Edited in draw programs
- Shapes can be edited by moving points called nodes (drawing points)

Uses of Vector Graphics

- Graphics that will be scaled (or resized)
    - Architectural drawings and CAD programs

    - Flow charts
    - Logos that will be scaled (resized)
- Cartoons and clip art
- Graphics on websites
    - Because they have very small file sizes.
    - This allows them to load quickly.
- Fonts and specialized text effects

Advantages of Vectors

- Resolution Independent
    - Regardless of how much the image is enlarged or reduced, the image definition and quality remain the same.
- Small File Sizes
    - Easily transferred over the Internet.

Disadvantages of Vectors

- Lower color quality than raster images.
    - They do not support as many colors.
- Not good for photographic images

Popular Vector Graphic Software

- Xara Xtreme
- Adobe Illustrator
- CorelDraw
- Inkscape – open source software similar to Adobe Illustrator.

11.2 Digital Representation Of Image

- Use a single bit to represent each pixel.
- 0 is represented as white and 1 represented as black.
- 8 Bit Grey Scale Images ,That is 1pixel is 8 bit

Colour Depth

- The other measurement of a digital image's quality is its color depth.
- Each pixel in a digital image will be assigned a color value.
- The color bit depth, or color depth, determines how many different colors each pixel can display.
- The larger the color bit depth, the more colors can be displayed.
- Bit depths are named according to numbers which represent the amount of computer storage space needed to store the color information.

- These numbers are powers of two. Two is used because computer information is binary; one "bit" is one binary value: either 0 or 1.
- Different color depths use different ways of encoding information.
- 8-bit color images usually use a custom palette of 256 colors.
- Numerical values in the computer's memory refer to particular colors in the palette.
- The palette acts as an index where colors can be looked up. 16-bit and 24-bit images don't use a palette; they store the red, green, and blue components of each pixel directly in the computer's memory.

1-bit: black & white ( )

A single bit has value 1 or 0. It stores either black or white. Often used for text.

4-bit:16 colors (: 2x2x2x2=16)

8-bit: 256 colors (: 2x2x2x2x2x2x2x2=256)

An 8-bit image has a fixed palette of 256 shades of gray or 256 different colors.

16-bit: Thousands of colors ( )

A 16-bit image contains up to 32,768 different colors. This color depth is common on most computer monitors.

24-bit and **32-bit**: Millions of colors

Both 24-bit and 32-bit images provide about 16.7 million available colors, more than the eye can actually see. Many computer monitors can support this many colors. Only the first 24 bits are used to determine color. In a 32-bit image, the last eight bits are reserved for information other than color (like transparency and overlays).Files getting larger. We can now represent 16 million colours. The human eye can only see 10 million of them. Extra colours useful for image processing and special effects. Colour resolution is the number of colours a single pixel may display

11.3 Colour Characteristics-Hue, saturation, Luminance

Hue

- Hue is the most obvious characteristic of a color.
- There is really an infinite number of possible hues.
- A full range of hues exists, for example, between red and yellow. In the middle of that range are all the orange hues.
- Similarly, there is a range of hues between any other two hues.
- This color wheel shows each of its six colors with medium value, and high saturation.

Saturation

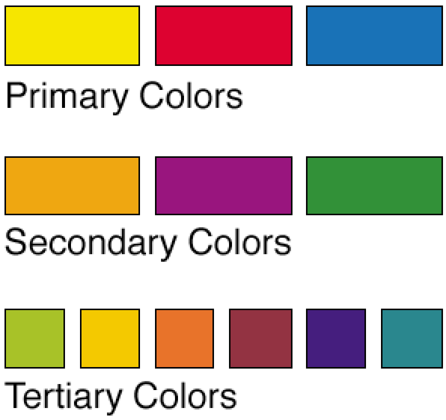
- Saturation is the purity of a color. High saturation colors look rich and full. Low saturation colors look dull and greyish.

Luminance

- Value is the lightness or darkness of a color.
- Light colors are sometimes called tints, and dark colors shades.
- All high saturation colors have medium values (because light and dark colors are achieved by mixing with white or black).

11.4 Colour Palette

A primary color is a color that cannot be made from a combination of any other colors. A secondary color is a color created from a combination of two primary colors. Tertiary color is a combination of three colors (primary or secondary).

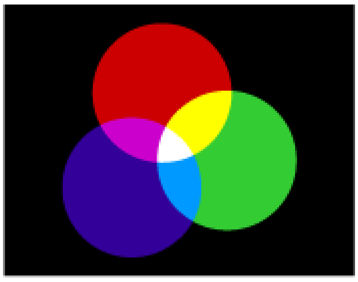


Printers and artists have different definitions for primary colors. The traditional primary colors that painters have used are red, yellow, and blue. Modern printing press secondary colors are magenta, yellow, and cyan. These two primary color systems obviously do not agree. Additive and subtractive are the two primary methods for reproducing a range of color.

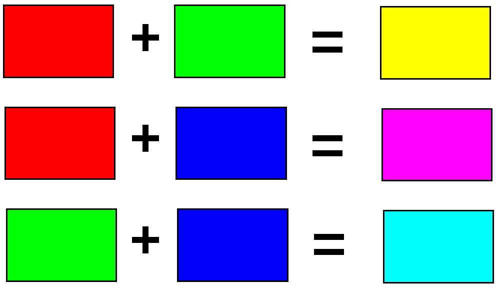
Additive Color

- Additive color synthesis is the creation of color by mixing colors of light.
- Human vision relies on light sensitive cells in the retina of the eye. There are two basic kinds of sensors.
- These are rods and cones. Rods are cells which can work at very low intensity, but cannot resolve sharp images or color.
- Cones are cells that can resolve sharp images and color, but require much higher light levels to work.
- The combined information from these sensors is sent to the brain and enables us to see.

- There are three types of cone.
- Red cones are sensitive to red light, green cones are sensitive to green light, and blue cones are sensitive to blue light.
- The perception of color depends on an imbalance between the stimulation level of the different cell types.
- Additive color processes, such as television, work by having the capability to generate an image composed of red, green, and blue light.
- Since the intensity information for each of the three colors is preserved, the image color is preserved as well.
- The spectral distribution of the image will probably be wrong, but if the degree of intensity for each of the primary colors is correct, the image will appear to be the right color.
- The three primaries in light are red, blue, and green, because they correspond to the red, green, and blue cones in the eye. Example 1 shows how the light from red, green and blue flashlights would appear if shone on a dark wall.



Example 1: Additive principle of color combining (light)



Derivation of Additive Secondaries from Additive Primary Colors.

Red + Green = Yellow

Red + Blue = Magenta

Green + Blue = Cyan

Printers' primaries—yellow, cyan, and magenta—are typically used by professional designers and printing presses .

When all of the colors of the spectrum are combined, they add up to white light.

2 parts Red + 1 part Green = Orange

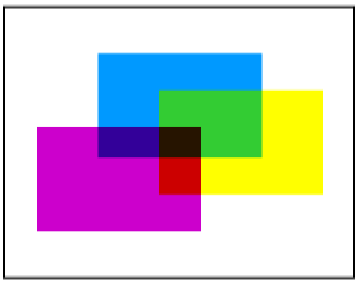
2 parts Green + 1 part Red = Lime

4 parts Red + 1 part Blue + 1 part Green = Brown

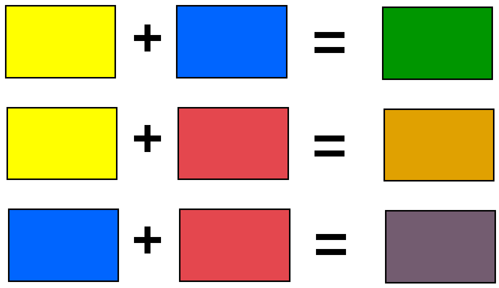
Subtractive Color

- Subtractive color synthesis is the creation of color by mixing colors of pigment, such as paint or ink in your computer's printer.

- This type of color is what is used in the art and design world. When learning basic color theory, art students typically use familiar colors like red, yellow, and blue.
- Subtractive color processes work by blocking out parts of the spectrum.
- The idea of subtractive color is to reduce the amount of undesired color reaching the eye. If, for example, you had a yellow image, you would want to have a dye that would let red and green reach the eye, and block out blue.
- The additive secondaries become the printers' subtractive primaries, because each of the additive secondaries will reflect two of the additive primaries, and absorb one of the additive primaries.
- The three primaries on the artists' color wheel are red, blue, and yellow. Example 2 illustrates subtractive color by showing how primary colors mix on a piece of white paper.



Example 2: Subtractive principle of color combining (pigment)



Painting Primaries Mixing chart

Yellow + Blue = Green

Yellow + Red = Orange

Blue + Red = Violet

When all of the colors are combined, they create black pigment.

Additive Primaries/Secondaries Absorption Chart

Color	Reflects	Absorbs
Yellow	Red and Green	Blue
Magenta	Red and Blue	Green
Cyan	Green and Blue	Red

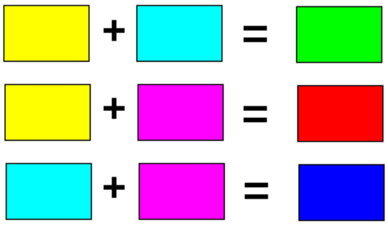
With this information, if we wanted red, we would mix magenta and yellow. Magenta would absorb green, and yellow would absorb blue, leaving only red to be reflected back to the eye. For black, a combination of all three would be used, which should block out all light in theory. Printers use black as well, since the dyes used in printing are not perfect, and some light from other parts of the spectrum gets through.

For printers' mixing:

Yellow + Cyan = Green

Yellow + Magenta = Red

Cyan + Magenta = Blue



Subtractive Primaries Mixing Chart

11.5 Image Formats

JPEG

- Joint Photographic Experts Group; compresses file size by selectively discarding data, unlike GIF format, JPEG retains colour information.
- Joint Photographic Experts Group
- .jpg is the file extension (normally)
- Bitmap format
- Lossy compression
- 24-bit color or 8-bit gray-scale
- Like you'd get from a digital camera or scanner

TIFF

- Tagged-Image File Format; used to exchange files between applications and computer platforms; "flexible" bitmap image supported by virtually all paint , image editing, and page-layout applications and by scanning, faxing, word processing, optical character recognition and other applications
- **TIFF** is a computer file format for storing raster graphics images, popular among graphic artists, the publishing industry and professional photographers in general.

BMP

- It is a raster graphics image file format used to store bitmap digital images, independent of the display device.
- The BMP file format is capable of storing 2D digital images of arbitrary width, height, and resolution, both monochrome and color, in various color depths, and optionally with data compression, alpha channels, and color profiles.
- **B**it**map** is the standard Windows image format

GIFF

- **G**raphics **I**nterchange **F**ile **F**ormat; designed to minimize file size and download (electronic transfer) time .
- .gif file extension
- Bitmap format
- Lossless compression
- Used a lot on the web
- Good for simple animations and simple transparency
- Limited to 8-bit color (256 colors)
- Compression algorithm is patented

11.6 Layers

- By default, the Layers palette should show in the Palette Bin. If not, choose Window > Show Layers.
- The Layers palette displays all the layers in your document with the layer name and a thumbnail of the layer's image. You can view or hide a layer using the eye icon.
- Click the eye icon on a layer. Notice that the icon disappears and the layer is hidden. Click the empty icon box again. Both the eye icon and the layer's content reappear.

Type Layers

Any new text you enter is placed on its own layer. Each of those layers is labeled according to the text on the layer.

Adjustment Layers

- Go to the Layers palette and select "new adjustment layer" or you can also go to Layer > adjustment layer.
- Adjustment layers work like filters.
- When you remove them from your image, the original image remains.
- This means you can make your tonal adjustments on layers separate from your image, so they don't become permanent until you flatten the image (merge all the layers).
- To move a selection to a new layer, go to the Layer menu at the top of the screen and choose "New via Cut" or "Copy" This will either move or copy your selection to a new layer.

Aligning Layers

- Now layers (and therefore text or objects on separate layers) can be aligned individually to a selection border or to each other.
- To align a layer to a selection, make the layer active, and under the layer menu, choose "align to selection".
- To align two or more layers to each other, first link them by selecting a layer and clicking in the box to the left of all layers you want to link to it. (You will see the linking icon appear.)
- Next, go to the layer menu and choose "align linked". You can use this method to align text on the page to other text or to selections. While the text is linked, you can move it as one block.

Layer Effects

- In the Layer palette you will now find a series of effects you can apply to text or other objects on that layer, such as drop shadow, glow effects, and others.

Merge Down

- This command in the Layers palette allows you to select a layer and merge it with the one beneath it.
- You can change the order of the layers to merge any two.
- Remember, though, that for adjustment layers to work, they need to be above, or higher on the list, than the original image.

Changing order of layers

- Click a layer and hold down the mouse button, then drag the layer to a different stacking position. Release the mouse button.

Adding a layer

- Click the Create a New Layer icon in the Layers palette. A new layer appears above the active layer in the Layers palette. You’ll also discover that creating type with the type tool and using the shape tool will automatically add a new layer.
- Here’s how to name a layer. Double-click a layer thumbnail to open the Layer Properties dialog box. Type the name of the layer in the text box, then click OK. Or, you can just double-click the layer name in the Layers palette and type a new name.

Edit artwork on a layer

- Click the three hats layer in the Layers palette to make it active. Then select the Move tool and drag the artwork on the active layer. Notice that only the artwork on the active layer is moved. You can position a hat over the dummy's head.
- While working on this tutorial, use the Undo button to undo (Control + z) any action and restore the artwork.

11.7 Filters

- Filter is used for changing the appearance of an image in the multimedia
- The features which are not of our interest are suppressed during filtering.
- Suitable conditions or criteria are chosen to focus the features of an image during filtering
- Filtering is set of tools in image processing packages which change the appearance of an image by applying some effects.
- Filters are used to change the appearance of an image, layer or selection in Photoshop.
- Filters can be categorised as four types depending on their effect on the image.
  - Edge Filter
  - Normal Filter
  - Special Filter
  - User defined Filter
- **Edge Filter**-This type of filter changes the edge of an image without affecting the interior part.
- **Normal Filter**-This filter used in most of the image editing packages such as soften,sarphen etc.
- **Special Filter**-Special type of filter available in image editing package which facilitate for adding noise,disort etc.
- **User defined Filter-**It is used for user requirements

11.8 Image Manipulation

Scaling

- Scaling does NOT change the image pixels in any way.
- Its only action is to change the single number for dpi (ppi), which only changes the size this image will print on paper.
- It has no effect on images on the computer screen.

- Scaling is sometimes called Resize, and Resample is even sometimes called scaling, (not really unreasonable), so the terms can be questionable (what they actually mean in the given usage).
- My definition of Scaling is about changing the size the image will print on paper (inches), specifically WITHOUT any pixel re-sampling.
- It is about declaring the dpi number, in preparation for printing a certain size on paper.
- This is by far the simplest operation, but sometimes a bit harder to grasp it.
- So scaling stretches the image on the paper, without changing any actual pixels.
- It changes only the actual dpi number (printing resolution, the spacing of the pixels on paper), which changes only the number of inches the same image pixels will fill on paper (spaced at so many pixels per inch).
- Because, the image simply prints larger with a smaller dpi number (wider pixel spacing, fewer pixels per inch), or prints smaller with a larger dpi number.

Cropping

- There are usually two purposes for cropping.
- Compositional enlargement, like zooming in the camera, so we can remove any surrounding blank space, trimming away any uninteresting, or distracting areas around our image, concentrating the subject larger, leaving only what we want to see, for a better and more pleasing view (this image for example).
- And also very important, we can make our image shape fit the paper shape (or the desired video screen shape), so something important wont' be cut off, past the edge, off of the paper.
- You can see the two different shapes here, right? The overall image is aspect ratio 2:3 (taller narrow shape), and the marked rectangle is 4:5 (shorter wider shape).
- When crop area is selected (drawn to include the image we want to include), then the menu Image - Crop will trim away all else, leaving only the area we marked to be included.

Rotation

- Rotation is a noun and means the act or process of turning around an axis or centre. In mathematics, rotation is a circular motion of a configuration around a line or given point without changing shape. Rotation either clockwise or anticlockwise
- Start Photoshop and open the image to be rotated. Ad. 2. Click Rotate from the Image menu and choose the degrees of rotation. 3. Enter a specific number, select Free and type in the number. Click OK. 4. Save the file under a different name

12. Introduction to Video

Contents

12.1 Video in Multimedia

- Video is an important component of multimedia because it is very useful for illustrating concepts that involve movement.
- Video basically combines sound and stack of images and these are displayed over a period of time. Animation and video deals with the display of a sequence of images to generate an effect of motion.
- Video typically deals with recording of a real-life event produced by clip of video takes maximum storage space.

12.2 Basics of Motion-Video

- Computer video deals with the recording and display of a sequence of images as a reasonable speed to create an impression of movement.
- Each individual image of a sequence of images is called a frame.
- The projection of several frames per second create the illusion of motion because our brain cannot register the individual images.
- For a motion video,24 to 30 frames have to be displayed per second. the information recorded on videotape reside on several tracks, one of them being occupied by the visual frame. Additional tracks contain the audio signals and a time-code signal.
- Video information travels medium in the form of light waves, which are analog in nature for computer usage of video information, light waves must be converted from analog to digital form. Video camera is a transducer, which is commonly used to convert electrical signal into light waves. Monitor is a transducer which is commonly used to convert electrical signal into light waves.

12.3 Sources of Motion-Video

Hardware Requirement for Video

- A video camera (input device) for capturing video data.
- A video monitor (TV monitor or computer monitor) for displaying video data.
- A video board (or video card), which is equipped with A/D converters.
- Video editors are used to cut and paste video sequences, to add special effects and to create new video sequences from existing video sequences.

Software Requirements For Video

- Video Clips:- A video clip library often provides the facility to add a new video clip or delete an existing video clip from the library.
- Recording And Playback Capability:- It allows the user to control the recording and display of a video sequence. [Replay the video sequence]

12.4 Video Formats, Lines, Frames, Fields

- The computer video format depends on the input and output device for the motion video medium. Formats and systems for staring and playing digitized video to and from disk files are available with quick time and AVI (Audio Video Interleaved) both systems depend on special algorithm that control the amount of information per video frame that is sent to the screen and the rate at which new frames are displayed. Both provide a methodology for interleaving audio data with video and other data so that sand remains synchronized with the video.
- A video signal is composed of two parts the odd fields and the even fields. On a television screen, an electron beam draws the first field the odd lines and then the even field. The constant alternating between the odd and the even fields is known as interlacing. Each video frame contains two fields which must be processed at the time of digitizing. A computer screen is redrawn from top to bottom every 1/60 of a second (60 times per second).for a computer to display the original video image, each video frame with its two fields must be digitized-converted to pixels. Each frame of video contains 252000pixels (Calculated from 525 line, 480pixel across).
- A computer screen at 640x480 resolution contains 307, 200 pixels. An 8bit color computer display one byte (8bit) per pixel. An 8bit resolution is poor when used to display video. The preferred standard for video display is 24-bit (millions of colors) which produces a high quality image but demand three times the resolution or 921, 600 bytes of information per digitized frame.

Synchronization Aspect Ratio

The purpose of a video camera is to convert an image in front of the camera into an electrical signal. An electrical signal has only one value at any instant in time, it is one-dimensional but an image is two-dimensional having many values at all the different position in the image. Conversion of the two-dimensional image into a one-dimensional electrical signal is accomplished by scanning that image in an orderly pattern called a raster.

Aspect Ratio

It is the ratio of the length of a scanning line horizontally on the image to the distance covered vertically on the image by all the scanning lines.
Aspect ratio can also be thought of as the width to height ratio of a frame. In present day-television aspect ratio is 4: 1

12.5 TV Broadcast standards

Most countries around the World use one of three main television broadcast Standards. These three main standards are NTSC, PAL and SECAM. However, each standard is not compatible with the other. The charts below give a description of each standard and the technical variations within each.

NTSC

The first colour TV broadcast system was implemented in the United States in 1953.This was based on the NTSC (**N**ational **T**elevision **S**ystem **C**ommittee) standard. NTSC is used by many countries on the American continent as well as many Asian countries including Japan. NTSC runs on 525 lines/frame.

SYSTEM	NTSC M
Lines/Field	525/60
Horizantal Frequency	15.734 kHz
Vertical Frequency	60 Hz
Colour Subcarrier Frequency	3.579545 mHz
Video Bandwidth	4.2 mHz
Sound Carrier	4.5 mHz

PAL

The PAL (Phase Alternating Line) standard was introduced in the early 1960's and implemented in most European countries except for France.The PAL standard utilises a wider channel bandwidth than NTSC which allows for better picture quality. PAL runs on 625 lines/frame.

SYSTEM	PAL B,G,H	PAL I	PAL D	PAL N	PAL M
Line/Field	625/50	625/50	625/50	625/50	525/60
Horizontal Frequency	15.625 kHz	15.625 kHz	15.625 kHz	15.625 kHz	15.750 kHz
Vertical Frequency	50 Hz	50 Hz	50 Hz	50 Hz	60 Hz
Colour Sub Carrier Frequency	4.433618 MHz	4.433618 MHz	4.433618 MHz	3.582056 MHz	3.575611 MHz
Video Bandwidth	5.0 MHz	5.5 MHz	6.0 MHz	4.2 MHz	4.2 MHz
Sound Carrier	5.5 MHz	6.0 MHz	6.5 MHz	4.5 MHz	4.5 MHz

SECAM

The SECAM (Sequential Couleur Avec Memoire or Sequential Colour with Memory) standard was introduced in the early 1960's and implemented in France. SECAM uses the same bandwidth as PAL but transmits the colour information sequentially. SECAM runs on 625 lines/frame.

SYSTEM	SECAM B,G,H	SECAM D,K,K1,L
Line/Field	625/50	625/50
Horizontal Frequency	15.625 kHz	15.625 kHz
Vertical Frequency	50 Hz	50 Hz
Video Bandwidth	5.0 MHz	6.0 MHz
Sound Carrier	5.5 MHz	6.5 MHz

12.6 MPEG Compression

- The MPEG stands for Moving Picture Expert Group, which worked to generate the specifications under ISO, the International Organization for Standardization and IEC, the International Electro technical Commission. What is commonly referred to as "MPEG video" actually consists at the present time of two finalized standards, MPEG-11 and MPEG-22, with a third standard, MPEG-4, was finalized in 1998 for *Very Low Bitrate Audio-Visual Coding*.
- The MPEG-1 and MPEG-2 standards are similar in basic concepts. They both are based on motion compensated block-based transform coding techniques, while MPEG-4

deviates from these more traditional approaches in its usage of software image construct descriptors, for target bit-rates in the very low range, < 64Kb/sec.

- Because MPEG-1 and MPEG-2 are finalized standards and are both presently being utilized in a large number of applications, this paper concentrates on compression techniques relating only to these two standards.
- Note that there is no reference to MPEG-3. This is because it was originally anticipated that this standard would refer to HDTV applications, but it was found that minor extensions to the MPEG-2 standard would suffice for this higher bit-rate, higher resolution application, so work on a separate MPEG-3 standard was abandoned.
- The current thrust is MPEG-7 "Multimedia Content Description Interface" whose completion is scheduled for July 2001. Work on the new standard MPEG-21 "Multimedia Framework" has started in June 2000 and has already produced a Draft Technical Report and two Calls for Proposals.

MPEG-1

- MPEG-1 was finalized in 1991, and was originally optimized to work at video resolutions of 352x240 pixels at 30 frames/sec (NTSC based) or 352x288 pixels at 25 frames/sec (PAL based), commonly referred to as Source Input Format (SIF) video.
- It is often mistakenly thought that the MPEG-1 resolution is limited to the above sizes, but it in fact may go as high as 4095x4095 at 60 frames/sec.
- The bit-rate is optimized for applications of around 1.5 Mb/sec, but again can be used at higher rates if required. MPEG-1 is defined for progressive frames only, and has no direct provision for interlaced video applications, such as in broadcast television applications.

MPEG-2

- MPEG-2 was finalized in 1994, and addressed issues directly related to digital television broadcasting, such as the efficient coding of field-interlaced video and scalability.
- Also, the target bit-rate was raised to between 4 and 9 Mb/sec, resulting in potentially very high quality video. MPEG-2 consists of profiles and levels.
- The profile defines the bit stream scalability and the colorspace resolution, while the level defines the image resolution and the maximum bit-rate per profile.
- Probably the most common descriptor in use currently is Main Profile, Main Level (MP@ML) which refers to 720x480 resolution video at 30 frames/sec, at bit-rates up to 15 Mb/sec for NTSC video.
- Another example is the HDTV resolution of 1920x1080 pixels at 30 frame/sec, at a bit-rate of up to 80 Mb/sec. This is an example of the Main Profile, High Level (MP@HL) descriptor.

Model Question of Computer Graphics and Multimedia

Short question (2 mark)

1. What do you mean by graphics?
2. Define multimedia.
3. Define image processing.
4. Define trackball.
5. Define digitizer.
6. Define line & point.
7. What do you mean by line drawing algorithm?
8. What do you mean by raster scan display?
9. Define vector scan display.
10. Define translation in 2D.
11. Define scaling in 2D.
12. Define rotation in 2D.
13. Differentiate between 2D & 3D graphics.
14. Define 3D object representation.
15. What do you mean by vertex table?
16. Define parallel projection.
17. Define prospective projection.
18. What do you mean by viewing port in 2D.
19. What is layer?
20. What is filter?
21. Define scaling in 3D.
22. Define rotation in 3D.
23. Define translation in 3D.
24. What do you mean by additive color?
25. What do you mean by raster graphics?
26. Define JPEG.
27. Define TIFF.
28. Define BMP.
29. Define amplifier.
30. What are the light sources used.
31. What is clipping in 2D?

32. Define line clipping.

33. Define 2D viewing.

34. Define SCAME.

35. Define NTSC.

36. Define PAL.

37. What is aspect ratio?

38. Define 2D viewing pipeline.

39. Define vector graphics.

40. Define raster graphics.

41. Define clipping.

42. Define MPEG.

<u>Long question (6 marks)</u>

1. What do you mean by line & point? Explain DDA line drawing algorithm.

2. Explain mid point circle algorithm with neat diagram.

3. Differentiate between raster scan display & vector scan display?

4. Explain translation, rotation & scaling in 2D transformation briefly.

5. Explain rotation & translation in 3D transformation.

6. Define layers. Explain it briefly.

7. What is color palate? Explain additive & subtraction color theory.

8. What is projection? Explain prospective projection.

9. What do you mean by 2D viewing? Explain window to view transformation.

10. What is clipping? Explain polygon clipping?

11. Explain flood fill & boundary fill algorithm.

12. Explain cubic Bezier curve.

13. What is viewing in 3D? Explain viewing pipeline.

14. Explain transformation from world to viewing coordinate in 3D.

15. Explain motion video.

16. What are the sources of motion video?

17. Differentiate between JPEG & MPEG?

18. Explain color depth.

19. Differentiate between raster graphics and vector graphics.

20. Explain illumination model with diagram.

Long question (8 marks)

1. Explain brashenham line drawing algorithm briefly.
2. What are the graphics hardware available? Explain each.
3. Explain graphics used in different sector.
4. Explain 2D transformation briefly with neat diagram.
5. Explain 2D homogeneous transformation with neat diagram.
6. Explain 3D transformation with neat diagram.
7. What is 2D viewing? Explain window to view port transformation.
8. What is clipping? Explain Cohen Sutherland line clipping algorithm briefly with neat diagram.
9. What do you mean by spline representation? Define interpolation spline & approximation spline.
10. Explain spline specification with the neat diagram.
11. Explain Bezier curve & surfaces with properties of Bezier curve.
12. Explain B. spline curves & surface.
13. What is projection? Explain parallel & prospective projection.
14. Explain basic illumination model briefly.
15. What are the characteristics of color? Explain color theory.
16. What is layer? Explain image manipulation.
17. Explain television broadcast standards briefly.
18. Explain MPEG compression.
19. Explain graphics input devices.
20. Explain midpoint circle algorithm briefly.