Semester-4

(Computer Graphics & Animation)

(According to Purvanchal University Syllabus)

Unit – 1

Graphics Primitives

- Computer graphics is an art of drawing pictures on computer screens with the help of programming. It involves computations, creation, and manipulation of data. In other words, we can say that computer graphics is a rendering tool for the generation and manipulation of images.

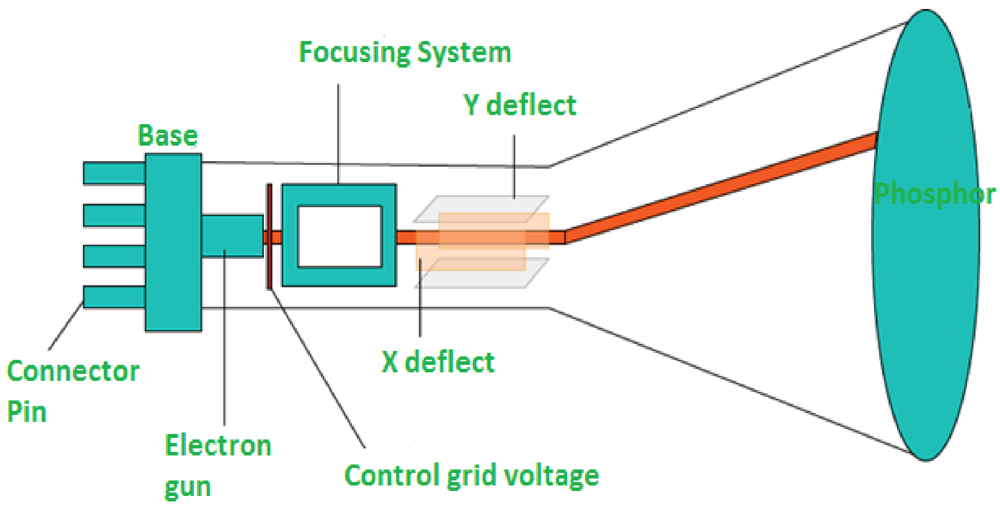
Display Devices :

Refresh cathode ray tube –

The primary output device in a graphical system is the video monitor. The main element of a video monitor is the Cathode Ray Tube (CRT), shown in the following illustration.

The operation of CRT is very simple −

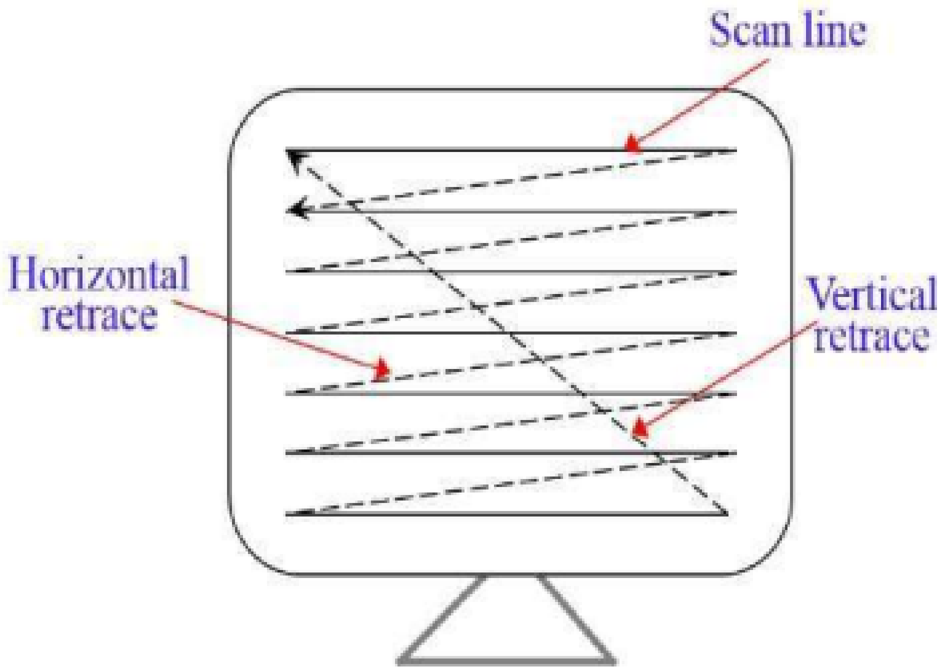
- The electron gun emits a beam of electrons (cathode rays).
- The electron beam passes through focusing and deflection systems that direct it towards specified positions on the phosphor-coated screen.
- When the beam hits the screen, the phosphor emits a small spot of light at each position contacted by the electron beam.
- It redraws the picture by directing the electron beam back over the same screen points quickly.



CATHODE RAT TUBE

Raster Scan display –

- 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.
- Each screen point is referred to as a pixel (picture element) or pel. At the end of each scan line, the electron beam returns to the left side of the screen to begin displaying the next scan line.



Plasma display –

- A plasma display is a computer video display in which each pixel on the screen is illuminated by a tiny bit of plasma or charged gas, somewhat like a tiny neon light. Plasma displays are thinner than cathode ray tube (CRT) displays and brighter than liquid crystal displays (LCD). Plasma displays are sometimes marketed as "thin-panel" displays and can be used to display either analog video signals or display modes digital computer input.

Liquid crystal display –

- LCD (liquid crystal display) is the technology used for displays in notebook and other smaller computers. Like light-emitting diode

(LED) and gas plasma technologies, LCDs allow displays to be much thinner than cathode ray tube (CRT) technology. LCDs consume much less power than LED and gas-display displays because they work on the principle of blocking light rather than emitting it.

Plotters –

- A plotter is a computer hardware device much like a printer that is used for printing vector graphics. Instead of toner, plotters use a pen, pencil, marker, or another writing tool to draw multiple, continuous lines onto paper rather than a series of dots like a traditional printer.

Printers –

Printer is an output device, which is used to print information on

paper. **There are two types of printers −**

- **Impact Printers**
- **Non-Impact Printers**

Impact Printers-

Impact printers print the characters by striking them on the ribbon, which is then pressed on the paper.

Characteristics of Impact Printers are the following −

- Very low consumable costs
- Very noisy
- Useful for bulk printing due to low cost
- There is physical contact with the paper to produce an image

  These printers are of two types −

- Character printers
- Line printers

Character Printers-

Character printers are the printers which print one character at a time.

These are further divided into two types:

- **Dot Matrix Printer(DMP)**
- **Daisy Wheel**

Dot Matrix Printer-

In the market, one of the most popular printers is Dot Matrix Printer. These printers are popular because of their ease of printing and economical price.

Each character printed is in the form of pattern of dots and head consists of a Matrix of Pins of size (5*7, 7*9, 9*7 or 9*9) which come out to form a character which is why it is called Dot Matrix Printer.

Advantages

- Inexpensive
- Widely Used
- Other language characters can be printed

Disadvantages

- Slow Speed
- Poor Quality

Daisy Wheel

Head is lying on a wheel and pins corresponding to characters are like petals of Daisy (flower) which is why it is called Daisy Wheel Printer. These printers are generally used for word-processing in offices that require a few letters to be sent here and there with very nice quality.

Advantages

- More reliable than DMP
- Better quality
- Fonts of character can be easily changed

Disadvantages

- Slower than DMP
- Noisy
- More expensive than DMP

Line Printers-

Line printers are the printers which print one line at a time.

These are of two types −

- Drum Printer
- Chain Printer

Drum Printer

This printer is like a drum in shape hence it is called drum printer. The surface of the drum is divided into a number of tracks. Total tracks are equal to the size of the paper, i.e. for a paper width of 132 characters, drum will have 132 tracks. A character set is embossed on the track. Different character sets available in the market are 48 character set, 64 and 96 characters set. One rotation of drum prints one line. Drum printers are fast in speed and can print 300 to 2000 lines per minute.

Advantages

- Very high speed

Disadvantages

- Very expensive

- Characters fonts cannot be changed

Chain Printer-

In this printer, a chain of character sets is used, hence it is called Chain Printer. A standard character set may have 48, 64, or 96 characters.

Advantages

- Character fonts can easily be changed.
- Different languages can be used with the same printer.

Disadvantages

- Noisy

Non-impact Printers

Non-impact printers print the characters without using the ribbon. These printers print a complete page at a time, thus they are also called as Page Printers.

These printers are of two types −

- Laser Printers
- Inkjet Printers

Characteristics of Non-impact Printers

- Faster than impact printers
- They are not noisy
- High quality
- Supports many fonts and different character size

Laser Printers

These are non-impact page printers. They use laser lights to produce the dots needed to form the characters to be printed on a page.

Advantages

- Very high speed
- Very high quality output
- Good graphics quality
- Supports many fonts and different character size

Disadvantages

- Expensive
- Cannot be used to produce multiple copies of a document in a single printing

Inkjet Printers

Inkjet printers are non-impact character printers based on a relatively new technology. They print characters by spraying small drops of ink onto paper. Inkjet printers produce high quality output with presentable features.

They make less noise because no hammering is done and these have many styles of printing modes available. Color printing is also possible. Some models of Inkjet printers can produce multiple copies of printing also.

Advantages

- High quality printing
- More reliable

Disadvantages

- Expensive as the cost per page is high
- Slow as compared to laser printer

Input Devices :

Keyboard –

- Keyboard is the most common and very popular input device which helps to input data to the computer. The layout of the keyboard is like that of traditional typewriter, although there are some additional keys provided for performing additional functions.

Keyboards are of two sizes 84 keys or 101/102 keys, but now keyboards with 104 keys or 108 keys are also available for Windows and Internet.

Trackball –

- Track ball is an input device that is mostly used in notebook or laptop computer, instead of a mouse. This is a ball which is half inserted and by moving fingers on the ball, the pointer can be moved.

Since the whole device is not moved, a track ball requires less space than a mouse. A track ball comes in various shapes like a ball, a button, or a square.

Joystick –

- Joystick is also a pointing device, which is used to move the cursor position on a monitor screen. It is a stick having a spherical ball at its both lower and upper ends. The lower spherical ball moves in a socket. The joystick can be moved in all four directions.

The function of the joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.

Mouse –

Mouse is the most popular pointing device. It is a very famous cursor-control device having a small palm size box with a round ball at its base, which senses the movement of the mouse and sends corresponding signals to the CPU when the mouse buttons are pressed.

Generally, it has two buttons called the left and the right button and a wheel is present between the buttons. A mouse can be used to control the position of the cursor on the screen, but it cannot be used to enter text into the computer.

Advantages

- Easy to use
- Not very expensive
- Moves the cursor faster than the arrow keys of the keyboard.

<u>Light pen –</u>

- Light pen is a pointing device similar to a pen. It is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube.

When the tip of a light pen is moved over the monitor screen and the pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the CPU.

Tablet –

- A graphics tablet (also known as a digitizer, drawing tablet, drawing pad, digital drawing tablet, pen tablet, or digital art board) is a computer input device that enables a user to hand-draw images, animations and graphics, with a special pen-like stylus, similar to the way a person draws images with a pencil and paper. These tablets may also be used to capture data or handwritten signatures. It can also be used to trace an image from a piece of paper which is taped or otherwise secured to the tablet surface. Capturing data in this way, by tracing or entering the corners of linear poly-lines or shapes, is called digitizing.

Digitizing camera –

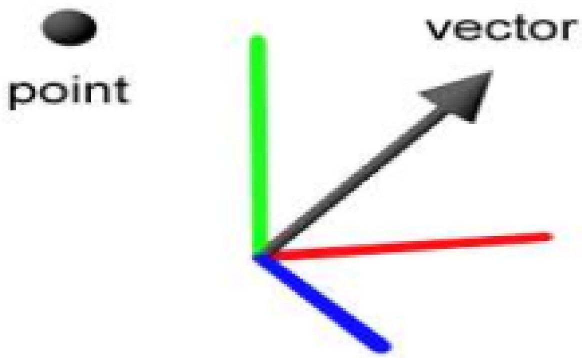
- A digital camera uses an electronic image sensor to create still photographs and record video. The optical system of a digital camera works like a film camera, in which a typical lens and diaphragm are used to adjust electronic image sensor lighting.

Unit – 2

Mathematics for Computer Graphics
Point representation –

Here, a point is a **position** in a three-dimentional space. A vector, on the other hand, usually means a **direction** (and some corresponding magnitude, or size) in three-dimensional space. Vectors can be thought of as arrows pointing various dimensional space.Three-dimensional Vectors can be thought of are both represented by the aforementioned tuple notation.

V=(x,y,z),
where (x, y, z) are again real numbers.

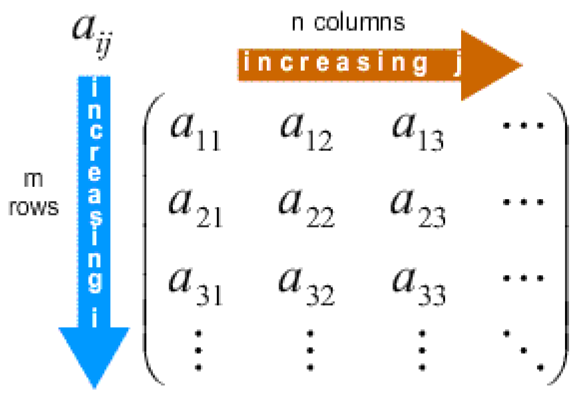


Matrix and operations related to matrices –

- The usefulness of a matrix in computer graphics is its ability to convert geometric data into different coordinate systems. A matrix is composed of elements arranged in rows and columns. In simple terms, the elements of a elements of a matrix are coefficients that represents the scale or rotation a vector will undergo during a transformation.

Matrix-

A matrix is an entity composed of components arranged in rows and columns.Mathematically, a matrix is represented as:



The rows and columns of a matrix determines the dimension of a matrix. A matrix containing 2 rows and 3 columns is of dimension 2x3. Here is an

example matrices with different dimensions:

$$M_{3x2}=\begin{vmatrix} 2 & 3 \\ 1 & 2 \\ 5 & 3 \end{vmatrix} \quad M_{2x3}=\begin{vmatrix} 1 & 4 & 2 \\ 2 & 3 & 4 \end{vmatrix} \quad M_{2x2}=\begin{vmatrix} 1 & 4 \\ 2 & 3 \end{vmatrix} \quad M_{1x3}=\begin{vmatrix} 1 & 4 & 5 \end{vmatrix}$$

Matrices-

The use of matrices in computer graphics is widespread. Many industries like cartoon, automotive that were formerly done by hand drawing now are done routinely with the aid of computer graphics. Video gaming industry, are done routinely with the aid of computer graphics. Video gaming industry, maybe the earliest industry to rely heavily on computer graphics, is now representing rendered polygon in 3- Dimensions. In video gaming industry,matrices are major mathematic tools to construct and manipulate a realistic animation of a polygonal figure.

Vector addition and vector multiplication –

Addition

In vector addition, each vector component are individually add added to the corresponding component in the second vector. Vector addition is represented mathematically as:

You will often find it useful to represent a vector $\mathbf{u} = (u_1, u_2, \ldots, u_n)$ in R^n as either a $1 \times n$ row matrix (row vector) or an $n \times 1$ column matrix (column vector). This approach is valid because the matrix operations of addition and scalar multiplication give the same results as the corresponding vector operations. That is, the matrix sums

$$\begin{aligned}\mathbf{u} + \mathbf{v} &= [u_1 \quad u_2 \quad \cdots \quad u_n] + [v_1 \quad v_2 \quad \cdots \quad v_n] \\ &= [u_1 + v_1 \quad u_2 + v_2 \quad \cdots \quad u_n + v_n]\end{aligned}$$

and

$$\mathbf{u} + \mathbf{v} = \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_n \end{bmatrix} + \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{bmatrix} = \begin{bmatrix} u_1 + v_1 \\ u_2 + v_2 \\ \vdots \\ u_n + v_n \end{bmatrix}$$

yield the same results as the vector operation of addition,

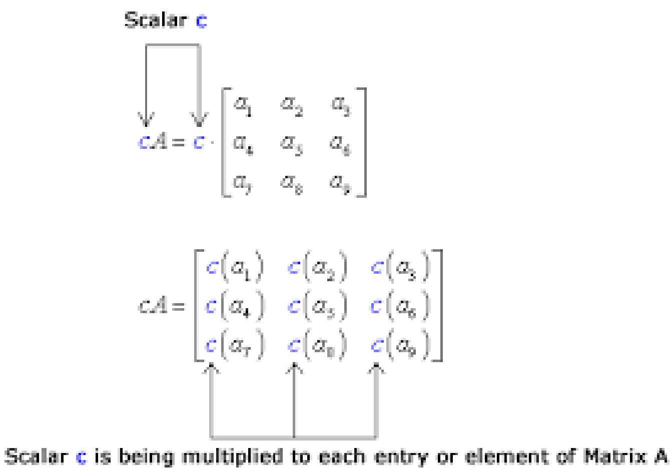
$$\begin{aligned}\mathbf{u} + \mathbf{v} &= (u_1, u_2, \ldots, u_n) + (v_1, v_2, \ldots, v_n) \\ &= (u_1 + v_1, u_2 + v_2, \ldots, u_n + v_n).\end{aligned}$$

The same argument applies to scalar multiplication. The only difference in the three notations is how the components are displayed.

Scalar multiplication/division-

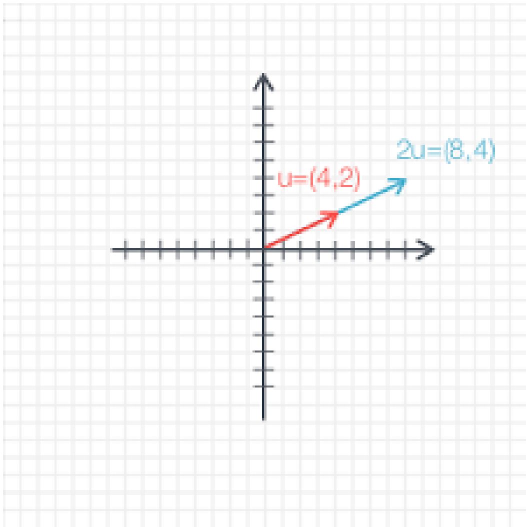
Geometrically, multiplying a vector with a scalar **streches** the length of a vector. Dividing a vector by a scalar has the opposite effect. To multiply a vector by a scalar, simply multiply each component by the scalar. Note that multiplying a vector by a positive scalar only affects its magnitude. However, multiplying

it by a negative scalar affects its magnitude and reverses its direction. Scalar negative scalar affects its magnitude and reverses its direction. Scalar multiplication is represented mathematically as:



For example, scaling a vector by 3 is done as follows:

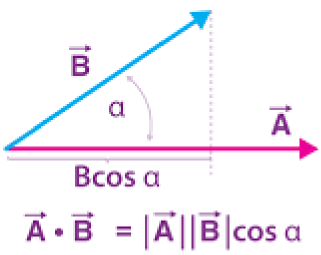
Graphically, vector scalar multiplication is represented as follows:



Scalar product of two vector –

The scalar product and the vector product are the two ways of multiplying vectors, which see the most application in physics and astronomy. The scalar product of two vectors can be constructed by taking the component of one vector in the direction of the other and multiplying it times the magnitude of the other vector.

This can be expressed in the form:



If the vectors are expressed in terms of unit vectors i, j, and k along the x, y, and z directions, the scalar product can also be expressed in the form:

The scalar product is also called the "inner product" or the "dot product" in some mathematics texts.

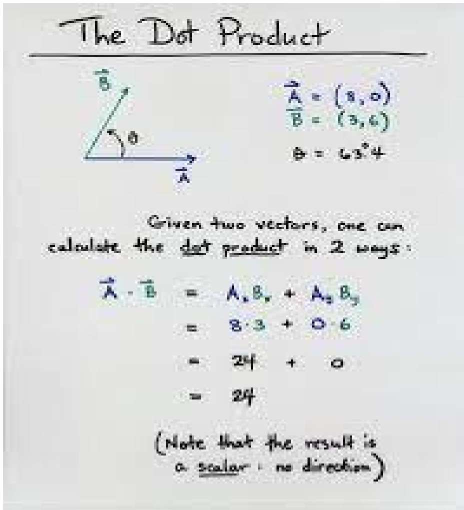
Vector product of two vector –

Unlike real numbers, vectors do not have a single multiplication operation. They have two distinct type of product operations; the dot product and cross product. The _dot product_produces a scalar and is mainly use to determine the angle between vectors.Thecross product produces a vector perpendicular to the multiplicand and multiplier vectors.

Dot Product-

The Dot Product is a vector operation that calculates the angle between two The The dot product is calculated in two different ways

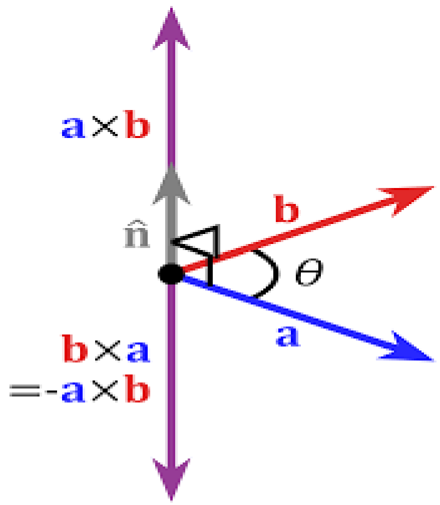
Version 1



In the above equation, information about the angle between the vectors is missing. However, the result from this equation can tell us the direction of each vector. For example, if the dot product is equal to 1, it means that both vectors have the same direction. If the dot product is 0, it means that both vectors are perpendicular on each other. Finally, if the dot product is -1, it means that both vectors are heading in opposite directions.

Cross Produ-

Two vectors produces a plane. A cross product operation
vectors is
perpendicular to both vectors. The cross product of two vectors is calculated as follows:



It is important to remember that a cross product can only be calculated with can only be calculated with vectors in three-dimensions. If vectors res

Line Drawing Algorithm

DDA Algorithm –

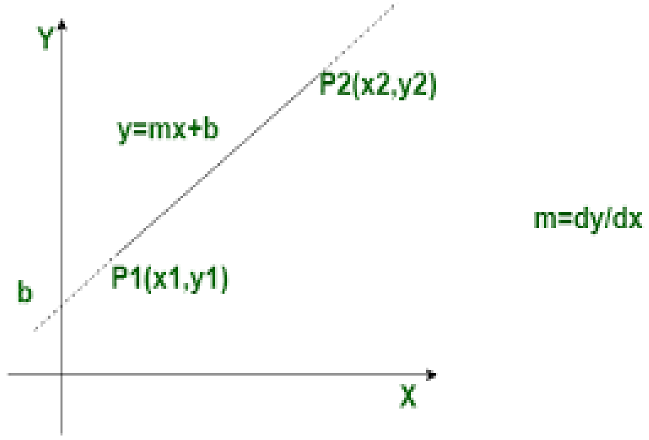
In any 2-Dimensional plane if we connect two points (x0, y0) and (x1, y1),

we get a line segment. But in the case of computer graphics we can not two

coordinate points, for that we should calculate intermediate point's

coordinate and put a pixel for each intermediate point, of the desired color

help of functions like putpixel(x, y, -ordinate and
K) in C
putpixel(x, y, K) in C, where (x,y) is our co
denotes some color.
Examples:



Scan Converting line Using DDA Algo.

In a Simple Way - for generating any line segment we need intermediate points and for calculating them we have can use a basic algorithm called DDA(Digital differential analyzer) line generating algorithm.

DDA Algorithm:

Consider one point of the line as (X0,Y0) and the second point of the line as (X1,Y1).

So, by equation of line $(y = mx + c)$ we have

$$y = \frac{5}{7}x + \frac{18}{7}$$

DDA Algorithm Two case:	
Case 1: $m < 1$	$x_{i+1} = x_i + 1$
	$y_{i+1} = y_i + m$
Case 2: $m > 1$	$x_{i+1} = x_i + (1/m)$
	$y_{i+1} = y_i + 1$

As $0 < m < 1$ so according to DDA algorithm case 1

$$x_{i+1} = x_i + 1 \qquad\qquad y_{i+1} = y_i + m$$

given $(x_0, y_0) = (2, 4)$

1) $x_1 = x_0 + 1 = 3$

$$y_1 = y_0 + m = 4 + \frac{5}{7} = \frac{28+5}{7} = \frac{33}{7} = 4\frac{5}{7}$$

put pixel (x_0, round y, colour)

i.e., put on (3, 5)

2) $x_2 = x_1 + 1 = 3 + 1 = 4$

$$y_2 = y_1 + m = (33/7) + \frac{5}{7} = 38/7 = 5\frac{5}{7}$$

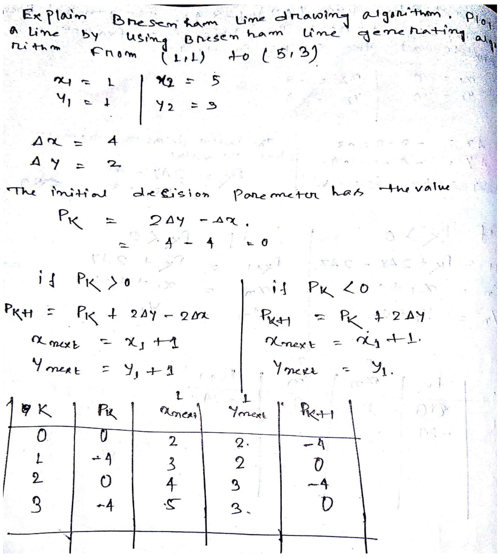
put on (4, 5) ?

Similarly go on till (9, 9) is reached.

Bresenharm’s Algorithms –

Given coordinate of two points A(x1, y1) and B(x2, y2). The task to find all the intermediate points required for drawing line AB on the computer screen of pixels. Note that every pixel has integer coordinates.

Examples:



Explain Bresenham line drawing algorithm. Plot a line by using Bresenham line generating algorithm from (1,1) to (5,3)

$x_1 = 1$ | $x_2 = 5$
$y_1 = 1$ | $y_2 = 3$

$\Delta x = 4$
$\Delta y = 2$

The initial decision parameter has the value

$P_K = 2\Delta y - \Delta x$.
$= 4 - 4 = 0$

if $P_K > 0$
$P_{K+1} = P_K + 2\Delta y - 2\Delta x$
$x_{next} = x_1 + 1$
$y_{next} = y_1 + 1$

if $P_K < 0$
$P_{K+1} = P_K + 2\Delta y$
$x_{next} = x_1 + 1$.
$y_{next} = y_1$.

K	P_K	x_{next}	y_{next}	P_{K+1}
0	0	2	2.	-4
1	-4	3	2	0
2	0	4	3	-4
3	-4	5	3.	0

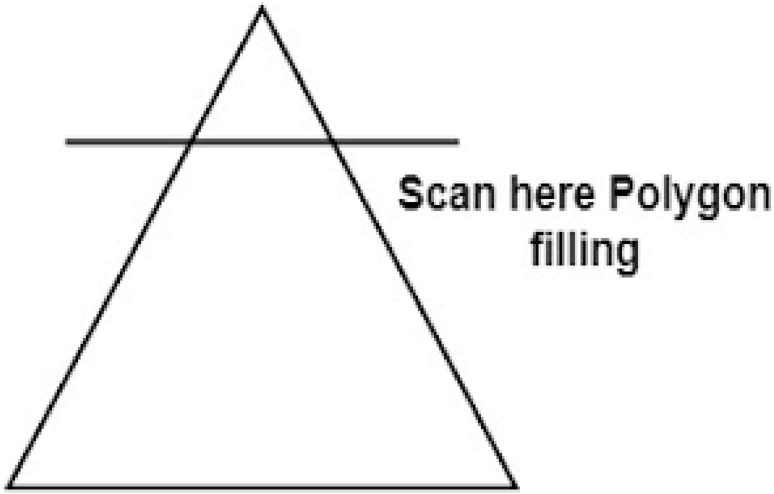
Polygons

Polygons Representation –

Polygons are used in computer graphics to compose images that are three dimensional in appearance. Usually (but not always) triangular, polygons arise when an object's surface is modeled, vertices are selected, and the object is rendered in a wire frame model. This is quicker to display than a shaded model; thus the polygons are a stage in computer animation. The polygon count refers to the number of polygons being rendered per frame.

Filling polygons –

Polygon is an ordered list of vertices as shown in the following figure. For filling polygons with particular colors, you need to determine the pixels falling on the border of the polygon and those which fall inside the polygon.


Scan here Polygon
filling

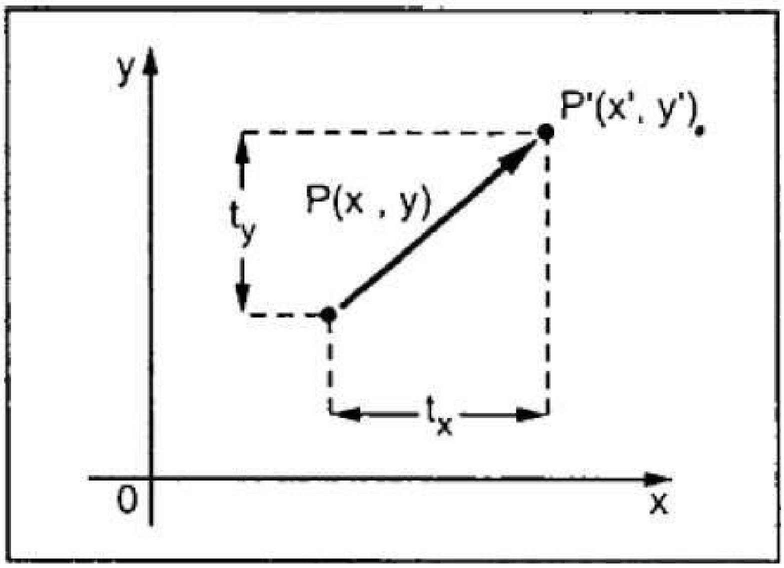
Unit-3

Transformations

Transformation means changing some graphics into something else by applying rules. We can have various types of transformations such as translation, scaling up or down, rotation, shearing, etc. When a transformation takes place on a 2D plane, it is called 2D transformation.
Transformations play an important role in computer graphics to reposition the graphics on the screen and change their size or orientation.

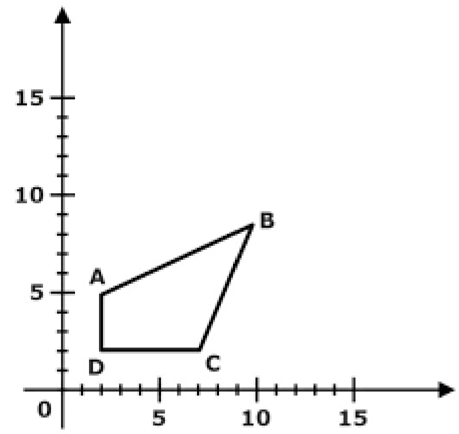
Translation –

A translation moves an object to a different position on the screen. You can translate a point in 2D by adding translation coordinate (tx, ty) to the original coordinate (X, Y) to get the new coordinate (X', Y').



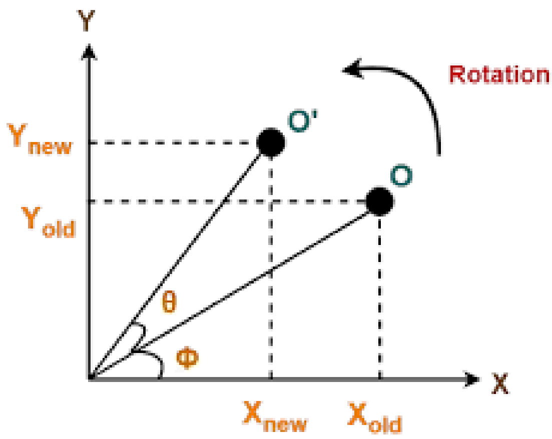
Scaling –

To change the size of an object, scaling transformation is used. In the scaling process, you either expand or compress the dimensions of the object. Scaling can be achieved by multiplying the original coordinates of the object with the scaling factor to get the desired result.
The scaling process is shown in the following figure.



Rotation –

In rotation, we rotate the object at particular angle θ (theta) from its origin. From the following figure, we can see that the point P(X, Y) is located at angle φ from the horizontal X coordinate with distance r from the origin. Let us suppose you want to rotate it at the angle θ. After rotating it to a new location, you will get a new point P' (X', Y').

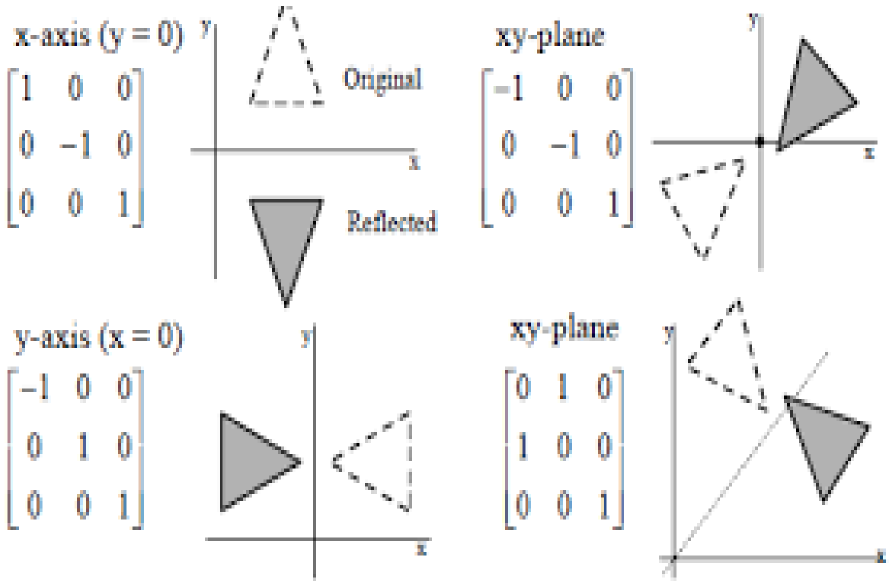


2D Rotation in Computer Graphics

Reflection –

Reflection is the mirror image of original object. In other words, we can say that it is a rotation operation with 180°. In reflection transformation, the size of the object does not change.

The following figures show reflections with respect to X and Y axes, and about the origin respectively.



Metrics transformation-

Transformation matrix is a basic tool for transformation. A matrix with n x m dimensions is multiplied with the coordinate of objects. Usually 3 x 3 or 4 x 4 matrices are used for transformation. For example, consider the following matrix various operation.

Row Method

1. Translation

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ t_x & t_y & 1 \end{bmatrix}$$

2. Scaling

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

Column Method

1.Translation

$$\begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 1 \end{bmatrix}$$

2. Scaling

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

Routines –

- In computer programming, routine and subroutine are general and nearly synonymous terms for any sequence of code that is intended to be called called and used repeatedly during the
and used repeatedly during the executable of a program.
- This makes the program shorter and easier to write (and also to read when necessary).

- The main sequence of logic in a program can branch off to a common routine when necessary. When finished, the routine branches back to the next sequential instruction following the instruction that branched to it.

- A routine may also be useful in more than one program and save other programmers from having to write code than can be shared.

Composite transformation –

If a transformation of the plane T1 is followed by a second plane transformation T2, then the result itself may be represented by a single transformation T which is the composition of T1 and T2 taken in that order. This is written as T = T1·T2.

Composite transformation can be achieved by concatenation of transformation matrices to obtain a combined transformation matrix.

A combined matrix −

[T][X] = [X] [T1] [T2] [T3] [T4] …. [Tn]

Where [Ti] is any combination of

- Translation
- Scaling
- Shearing
- Rotation
- Reflection

The basic purpose of composing transformations is to gain efficiency by applying a single composed transformation to a point, rather than applying a series of transformation, one after another.

For example, to rotate an object about an arbitrary point (X_p, Y_p), we have to carry out three steps −

- Translate point (X_p, Y_p) to the origin.
- Rotate it about the origin.
- Finally, translate the center of rotation back where it belonged.

Unit-4

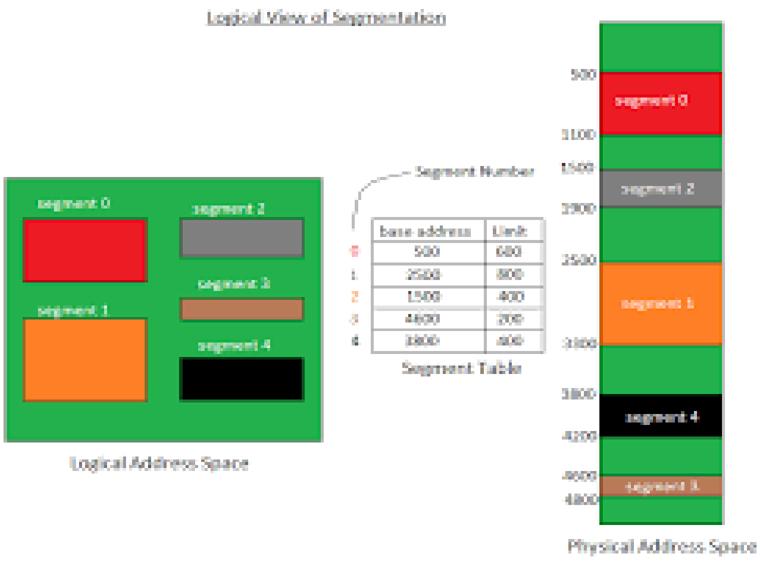
Segments

Segmentation means to divide the marketplace into parts, or segments, which are definable, accessible, actionable, and profitable and have a growth potential. In other words, a company would find it impossible to target the entire market, because of time, cost and effort restrictions.

Segments Table –

It maps two-dimensional Logical address into one-dimensional Physical address. It's each table entry has:

- **Base Address:** It contains the starting physical address where the segments reside in memory.
- **Limit:** It specifies the length of the segment.



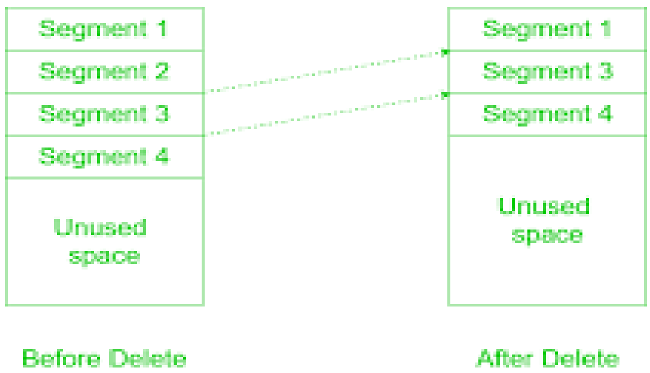
Creating, Deleting & Renaming a segments vigibility –

Segment Creation : Segment must be created or opened when no other segment is open, since two segments can't be opened at the same time because it's difficult to assign drawing instruction to particular segment. The segment created must be given a name to identify it which must be a valid one and there should be no segment with the same name. After this, we initialize items in segment table under our segment name and the first instruction of this segment is allocated at next free storage in display file and attributes of segments are initialized to default.

Algorithm :

1. If any segment is open, give error message : "Segment is still open" and go to step 8.
2. Read the name of the new segment.
3. If the segment name is not valid, give error message : "Segment name not a valid name" and go to step 8.
4. If given segment name already exists, give error message : "Segment name already exists in name list" and go to step 8.
5. Make next free storage area in display file as start of new segment. 6. Initialize size of new segment to 0 and all its attributes to their default values. 7. Inform that the new segment is now open.
8. Stop.

Deleting a Segment : To delete a particular segment from display file, we must just delete that one segment without destroying or reforming the entire display and recover space occupied by this segment. Use this space for some other segment. The method to achieve this depends upon the data structure used to represent display file. In case of arrays, the gap left by deleted segment is filled by shifting up all the segments following it.



Display file contents before and after deleting Segment 2

Unit-5

Animation

Introduction to Animation –

- Animation means giving life to any object in computer graphics. It has the power of injecting energy and emotions into the most seemingly inanimate objects. Computer-assisted animation and computer-generated animation are two categories of computer animation. It can be presented via film or video.
- The basic idea behind animation is to play back the recorded images at the rates fast enough to fool the human eye into interpreting them as continuous motion.

Principles of Animation –

1. SQUASH AND STRETCH

This action gives the illusion of weight and volume to a character as it moves. Also squash and stretch is useful in animating dialogue and doing facial expressions. How extreme the use of squash and stretch is, depends on what is required in animating the scene. Usually it's broader in a short style of picture and subtler in a feature. It is used in all forms of character animation from a bouncing ball to the body weight of a person walking. This is the most important element you will be required to master and will be used often.

2. ANTICIPATION

This movement prepares the audience for a major action the character is about to perform, such as, starting to run, jump or change expression. A dancer does not just leap off the floor. A backwards motion occurs before the forward action is executed. The backward motion is the anticipation. A comic effect can be done by not using anticipation after a series of gags that used anticipation. Almost all real action has major or minor anticipation such as a pitcher's wind-up or a golfers' back swing. Feature animation is often less broad than short animation unless a
develop a characters personality.

3. STAGING

A pose or action should clearly communicate to the audience the attitude, mood, reaction or idea of the character as it relates to the story and continuity of the story line. The effective use of long, medium, or close up shots, as well as camera angles also helps in telling the story. There is a limited amount of time in a film, so each sequence, scene and frame of film must relate to the overall story. Do not confuse the audience with too many actions at once. Use one action clearly stated to get the idea across, unless you are animating a scene that is to depict clutter and confusion. Staging directs the audience's attention to the story or idea being told. Care must be taken in background design so it isn't obscuring the animation or competing with it due to excess detail behind the animation. Background and animation should work together as a pictorial unit in a scene.

4. STRAIGHT AHEAD AND POSE TO POSE ANIMATION

Straight ahead animation starts at the first drawing and works drawing to drawing to the end of a scene. You can lose size, volume, and proportions with this method, but it does have spontaneity and freshness. Fast, wild action scenes are done this way. Pose to Pose is more planned out and charted with key drawings done at intervals throughout the scene. Size, volumes, and proportions are controlled better this way, as is the action. The lead animator will turn charting and keys over to his assistant. An assistant can be better used with this method so that the animator doesn't have to draw every drawing in a scene. An animator can do more scenes this way and concentrate on the planning of the animation. Many scenes use a bit of both methods of animation.

5. FOLLOW THROUGH AND OVERLAPPING ACTION

When the main body of the character stops all other parts continue to catch up to the main mass of the character, such as arms, long hair, clothing, coat tails or a dress, floppy ears or a long tail (these follow the path of action). Nothing stops all at once. This is follow through. Overlapping action is when the character changes direction while his clothes or hair continues forward. The character is going in a new direction, to be followed, a number of frames later, by his clothes in the new direction. "DRAG," in animation, for example, would be when Goofy starts to run, but his head, ears, upper body, and clothes do not keep up with his legs. In features, this type of action is done more subtly. Example: When Snow White

starts to dance, her dress does not begin to move with her immediately but catches up a few frames later. Long hair and animal tail will also be handled in the same manner. Timing becomes critical to the effectiveness of drag and the overlapping action.

6. SLOW-OUT AND SLOW-IN

As action starts, we have more drawings near the starting pose, one or two in the middle, and more drawings near the next pose. Fewer drawings make the action faster and more drawings make the action slower.

Slow-ins and slow-outs soften the action, making it more life-like. For a gag action, we may omit some slow-out or slow-ins for shock appeal or the surprise element. This will give more snap to the scene.

7. ARCS

All actions, with few exceptions (such as the animation of a mechanical device), follow an arc or slightly circular path. This is especially true of the human figure and the action of animals. Arcs give animation a more natural action and better flow. Think of natural movements in the terms of a pendulum swinging. All arm movement, head turns and even eye movements are executed on an arcs.

8. SECONDARY ACTION

This action adds to and enriches the main action and adds more dimension to the character animation, supplementing and/or re-enforcing the main action. Example: A character is angrily walking toward another character. The walk is forceful, aggressive, and forward leaning. The leg action is just short of a stomping walk. The secondary action is a few strong gestures of the arms working with the walk. Also, the possibility of dialogue being delivered at the same time with tilts and turns of the head to accentuate the walk and dialogue, but not so much as to distract from the walk action. All of these actions should work together in support of one another. Think of the walk as the primary action and arm swings, head bounce and all other actions of the body as secondary or supporting action.

9. TIMING

Expertise in timing comes best with experience and personal experimentation, using the trial and error method in refining technique. The basics are: more drawings between poses slow and smooth the action. Fewer drawings make the action faster and crisper. A variety of slow and fast timing within a scene adds texture and interest to the movement. Most animation is done on twos (one

drawing photographed on two frames of film) or on ones (one drawing photographed on each frame of film). Twos are used most of the time, and ones are used during camera moves such as trucks, pans and occasionally for subtle and quick dialogue animation. Also, there is timing in the acting of a character to establish mood, emotion, and reaction to another character or to a situation. Studying movement of actors and performers on stage and in films is useful when animating human or animal characters. This frame by frame examination of film footage will aid you in understanding timing for animation. This is a great way to learn from the others.

10. EXAGGERATION

Exaggeration is not extreme distortion of a drawing or extremely broad, violent action all the time. Its like a caricature of facial features, expressions, poses, attitudes and actions. Action traced from live action film can be accurate, but stiff and mechanical. In feature animation, a character must move more broadly to look natural. The same is true of facial expressions, but the action should not be as broad as in a short cartoon style. Exaggeration in a walk or an eye movement or even a head turn will give your film more appeal. Use good taste and common sense to keep from becoming too theatrical and excessively animated.

11. SOLID DRAWING

The basic principles of drawing form, weight, volume solidity and the illusion of three dimension apply to animation as it does to academic drawing. The way you draw cartoons, you draw in the classical sense, using pencil sketches and drawings for reproduction of life. You transform these into color and movement giving the characters the illusion of three-and four-dimensional life. Three dimensional is movement in space. The fourth dimension is movement in time.

12. APPEAL

A live performer has charisma. An animated character has appeal. Appealing animation does not mean just being cute and cuddly. All characters have to have appeal whether they are heroic, villainous, comic or cute. Appeal, as you will use it, includes an easy to read design, clear drawing, and personality development that will capture and involve the audience's interest. Early cartoons were basically a series of gags strung together on a main theme. Over the years, the artists have learned that to produce a feature there was a need for story continuity, character

development and a higher quality of artwork throughout the entire production. Like all forms of story telling, the feature has to appeal to the mind as well as to the eye.

Types of Animation –

1. Traditional animation
2. 2D Vector-based animation
3. 3D computer animation
4. Motion graphics
5. Stop motion

Traditional animation

Traditional animation, sometimes referred to as cel animation, is one of the older forms of animation, in it the animator draws every frame to create the animation sequence. Just like they used to do in the old days of Disney. If you've ever had one of those flip-books when you were a kid, you'll know what I mean. Sequential drawings screened quickly one after another create the illusion of movement.

2D Vector-based animation

2D animation is the term often used when referring to traditional hand-drawn animation, but it can also refer to computer vector animations that adopts the techniques of traditional animation.

Vector-based animations, meaning computer generated 2D animations, uses the exact same techniques as traditional animation, but benefits from the lack of physical objects needed to make traditional 2D animations, as well as the ability to use computer interpolation to same time.

3D computer animation

3D animation, also referred to as CGI, or just CG, is made by generating images using computers. That series of images are the frames of an animated shot.

The animation techniques of 3D animation has a lot of similarities with stop motion animation, as they both deal with animating and posing models, and still conforms to the frame-by-frame approach of 2D animation, but it is a lot more controllable since it's in a digital work-space.

Motion graphics

Think animated logos, explainer videos, app commercials, television promos or even film opening titles.

The skills for motion graphics don't necessarily translate to the other types of animation, since they don't require knowledge of body mechanics or acting, but they do have some attributes in common such as understanding good composition and the all important camera motion.

The process of creating Motion Graphics depends on the programs used, since video editing softwares often have different UI or settings, but the idea is the same. Motion Graphics usually involves animating images, texts or video clips using key framing that are tweened to make a smooth motion between frames.

Stop motion

Stop motion is done by taking a photo of an object, and then moving it just a little bit and taking another photo. The process is repeated and when the photos are played back one after another they give the illusion of movement. This is similar to traditional animation but it uses real life materials instead of drawings.

Types of Animation System :

Scripting –

Scripting Systems were the earliest type of motion control systems. The animator writes a script in the animation language. Thus, the user must learn this language and the system is not interactive. One scripting system is ASAS (Actor Script Animation Language), which has a syntax similar to LISP. ASAS introduced the concept of an actor, i.e., a complex object which has its own animation rules. For

example, in animating a bicycle, the wheels will rotate in their own coordinate system and the animator doesn't have to worry about this detail. Actors can communicate with other actors be sending messages and so can synchronize their movements. This is similar to the behavior of objects in object-oriented languages.

Procedural –

Procedures are used that define movement over time. These might be procedures that use the laws of physics (Physically - based modeling) or animator generated methods. An example is a motion that is the result of some other action (this is called a "secondary action"), for example throwing a ball which hits another object and causes the second object to move.

Representational –

This technique allows an object to change its shape during the animation. There are three subcategories to this. The first is the animation of articulated objects, i.e., complex objects composed of connected rigid segments. The second is soft object animation used for deforming and animating the deformation of objects, e.g. skin over a body or facial muscles. The third is morphing which is the changing of one shape into another quite different shape. This can be done in two or three dimensions.

Stochastic –

This uses stochastic processes to control groups of objects, such as in particle systems. Examples are fireworks, fire, water falls, etc.