⇒ What is Computer Graphics?

* Computer graphics is concerned with producing images and animations (or sequences of images) using a computer.

* This includes the hardware and software systems used to make these images.

* Many software ~~image~~ systems have been developed for generating computer graphics.

* This can include systems for producing 3-dimensional models of the scene to be drawn, the rendering software for drawing the images, and the associated user-interface software and hardware.

⇒ Computer Graphics Applications

1) Graphs and charts:

A type of information graphic that represent tabular numeric data. They are used to:

- make it easier to understand large quantities of data.
- make it easier to show relationships. Can be 2-D or 3-D.

2) Computer Aided Design (CAD):-

- Most products are now computer designed.
- CAD or CADD (Computer-aided drafting and design) methods used in design.
- Allow to see the effects of interactive adjustments
- Application areas:

Design of automobiles, computers, textiles.--

Architecture design: floor plan, wiring or electronic outlets, lighting simulations----

Engineering

Circuit design and network design

3) Virtual Reality Environment (VR)

- Interact with the objects in a three-dimensional environments.
- Based on animation
- Animations in virtual reality environments helps in analyzing interactive effects.
- Used in games and training.

4) Data Visualization:

> Scientific Visualization:
producing presentation for scientific, engineering and medical data sets (ex: DNA, Human Body)

> Business Visualization:
Visual presentation for data sets related to commerce, industry and other nonscientific areas.

- Analyzing very amount of information.
- Study the behaviour of highly complex processes.
- Ex: analyzing satellite images, pollution over earth, modeling ocean floor.

Scanned with CamScanner

5) Education and Training

- Educations aids: computer-generated models of physical, financial and economic systems
- Special hardware devices are designed

Examples:
- Training of ship captains, aircraft points, heavy-equipment operators....

6) Computer Art:

- Including ~~set~~ special S/W & H/W (ex: paintbrush)

★ Fine art: pictures are produced by computers using stylus (simulate paint stroke, brush width, colors type (oily, pasteel, etc...)).

★ Commercial art: logos, advertizing

- Can use visualization and other techniques.
- Morphing: transforming a shape into another.

7) Entertainment:

TV programs use animation, to combine computer generated figures of people, animals, and cartoon characters with actors in the scene.

- Use morphing and other utilities like VR.
- Ex:- Computer games, ---

8) Image processing:

- Concerns with improving image quality, analyzing images, recognize visual patterns.
- Computer graphics methods are being used in image processing and vice versa.
- A photograph must be digitized before being used in Image Processing Applications.
- Ex: used to analyze satellite images.
- Used in medicine to improve x-rays quality.

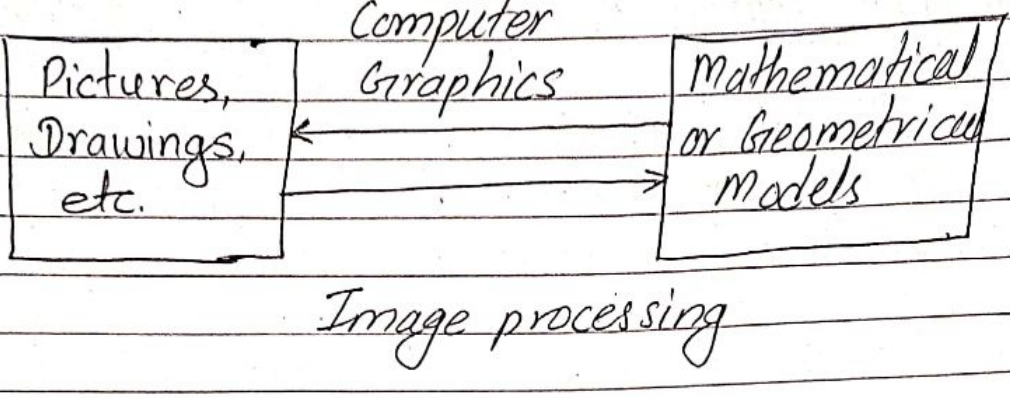


Image Enhancement

It is used to improve quality, remove noise from image.

9) Graphical User Interface (GUI):

- Contains windows, menus, icons.
- Icons are preferred over textual presentations because:

1) Use less space on the screen
2) Easier to ~~underst~~ understand.

How Computer Works?

input devices → CPU → frame buffer → display devices

CPU ↔ memory

input devices
- mouse
- keyboard
- data tablet
- haptic glove
- tracker
- joystick

CPU
- model graphics
- interaction
- rendering pipeline

memory
- model
- display list
- viewing parameters.

frame buffer
- stores ~~of~~ array of pixels
- VRAM/DRAM (high-end)
- standard memory (low-end)
- depth = nr of bits per pixels
- resolution = nr of pixels.

display devices
- CRT (monitor
- film recorder
- video
- plotter
- printer

(2) Write short note on CAD and CAM?

⇒

CAD:

Computer-aided design (CAD) is the use of computers to aid in the creation, modification, analysis or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations.

CAM:-

Computer aided manufacturing (CAM) is the use of software and computer controlled machinery to automate a manufactring process.

Need three components for a CAM system to function:

- **Software** that tells a machine how to make a product by generating toolpaths.
- **Machinery** that can turn raw material into a finished product.

- **Post Processing** that converts toolpaths into a language machines can understand.

Scanned with CamScanner

(3) Explain briefly the various I/O devices for Computer Graphics.

⇒ Input devices for computer graphics:-

Mouse:-

A mouse is an external computer hardware device which allows a user to control the motion of a computer cursor. The mouse works on the basic principle that the movement of the device is translated into the movement of the cursor.

Types of mouse:-

- OPTICAL MOUSE
- MECHANICAL MOUSE

Optical mouse:

Optical mouse is a computer mouse which uses a light source, typically a light-emitting diode (LED), and a light detector, such as an array of ~~po~~ photodiodes, to detect movement relative to a surface.

Mechanical mouse:

Mechanical mouse is a computer mouse that contains a metal or rubber ball on its under side. When the ball is rolled in any direction, sensors inside the mouse

Date
Page

detect the motion and move the on-screen mouse pointer accordingly.

(4) Differentiate between Raster scan display and Vector scan display.

⇒

Raster scan display	Vector Scan Display
~~1) It has high resolution.~~	~~1) Its~~
1) It has low resolution.	1) It has high resolution.
2) It is less expensive.	2) It is more expensive.
3) Modification is tough.	3) Any modification if needed.
4) Solid pattern is easy to fill.	4) Solid pattern is tough to fill.
5) Refresh rate does not depend on the picture.	5) Refresh rate depends on resolution.
6) Whole screen is scanned.	6) Only screen with view on an area is displayed.
7) Shadow mark technology came under this	7) Beam Penetration technology come under it.

8) It ~~does not~~ uses interlacing method.	8) It does not use interlacing method.
9) It is suitable for realistic display.	9) It is restricted to line drawing applications.

Keyboard :-

A computer keyboard is an input device that allows a person to enter letters, numbers, and other symbol into a computer. It is one of the most used input devices for computers. Using a keyboard to enter lots of data is called typing.

Light-pen :-

A handheld pen-like photosensitive device held to the display screen of a computer terminal for passing information to the computer.

A light pen detects a change of brightness of nearby screen pixels when scanned by cathode ray tube election beam and commu~~nication~~nicates the timing of the event of the computer.

Touch panel:-

A touch panel is a piece of equipment that lets users interact with a computer by touching the screen directly. Incorporating features into the monitor like sensors that detect touch actions makes it possible to issue instructions to a computer by having it sense the position of a finger or stylus.

Types of touch panel:

- Optical touch panel
- Electrical touch panel
- Resistive touch panel

Optical touch panel:-

Optical touch panels are a relatively modern development in touchscreen technology, in which two or more image sensors are placed around the edges of the screen. Infrared backlights are placed in the sensor's field of view on the opposite side of the screen.

Date
Page

Electrical Touch Panel:

An electrical touch panel is constructed with two transparent plates separated by a small distance. One of the plate is coated with a conduction material and other plate is coated with a resistive material.

When the outer plate is touched, it is forced to contact the inner plate. This contact creates a voltage drop across the resistive plate that is converted to the coordinate values of the selected screen position.

Acoustic touch panel:

In Acoustic type similar to the light rays, sonic beams are generated ~~to~~ from horizontal and vertical edges of the screen. The sonic beam is obstructed or ~~obstructed~~ reflected by putting a finger in the desire location on the screen.

From the tive of travel of the beams the location of finger tip is determined.

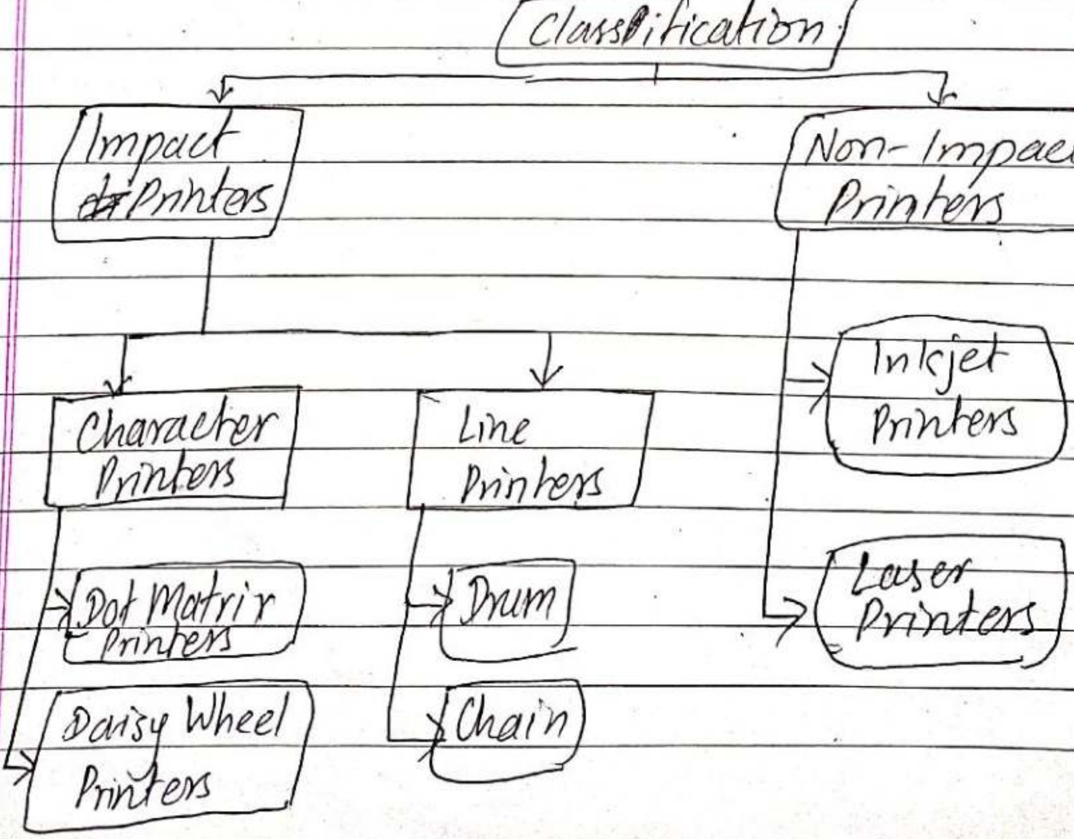
Scanner :-

A scanner is an input device that scans documents such as photographs and pages of text. When a document is scanned it is converted into a digital format. Most scanners are flatbed devices, which means they have a flat scanning surface.

Output device for computer graphics :-

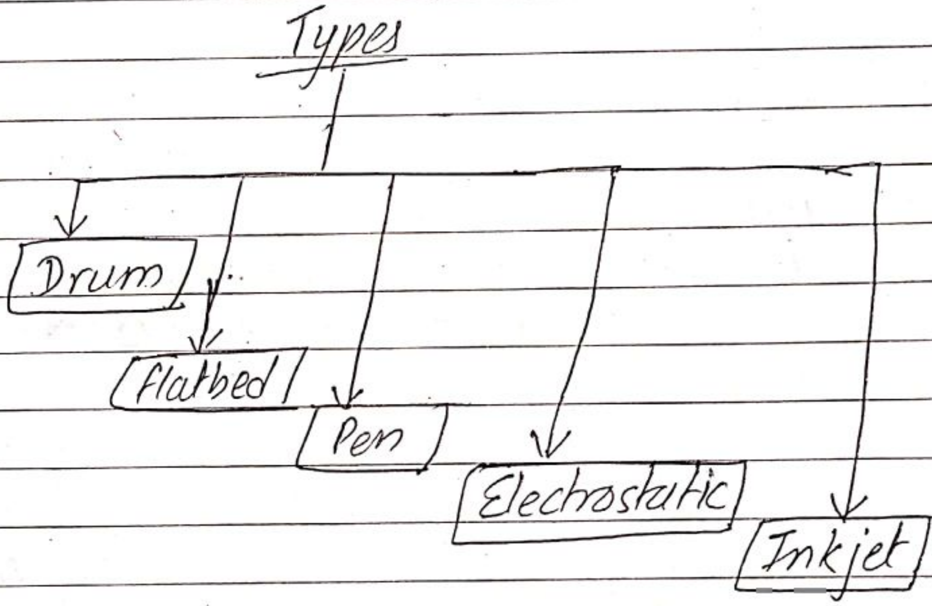
Printers:

This allows you to print off the graphics you create and edit on the computer. You can print them off in color, black and white or gray scale in various sizes.



Plotter :-

A plotter is a printer designed for printing vector graphics. Instead of printing individual dots on the paper, plotters draw continuous lines. By combining these two directions, lines can be drawn in any direction. Flatbed plotters have a large horizontal surface on which the paper is placed.



Monitors :-

Monitor allows us to see the images produced by the computer. The quality of the graphics that you see depends on the size and the resolution of the monitor.

Types
1) CRT 2) LCD 3) LED

1) CRT:

A cathode ray tube (CRT) is a specialized vaccum tube in which images are produced when an electron beam strikes a phosphorescent surface. It modulates, accelerates and deflects electron beam(s) onto the screen to create the images. Most desktop computer displays make use of CRT for image displaying purposes.

2) LCD:

Luquid Crystal display (LCD) is a flat panel display technology commonly used in TV's and computers monitors.

LCD is not bulk like ~~a~~ CRT monitor and instead of firing electrons at a glass screen, an LCD has backlight that provides light to individual pixels arranged in a rectangular grid. Each pixel has a red, green and blue RGB sub-pixel that can be turned on or off. When the all light turns on then it produce white colour and all ~~colour~~ light turns off then it produce black ~~colour~~ colour. By the adjusting some levels of red, green and blue then million of colour combinations are possible.

3) LED:

A Light emitting diodes (LED) display is a flat panel that uses an array of light-emitting diodes for a video display. Their brightness allows them to be used outdoors where they are visible in the sun for store signs and billboards.

★ Define, Pixel, Resolution and Refresh Rate

⇒ Pixel:

A pixel is the smallest unit of a digital image or graphic that can be displayed and represented on a digital display device.

A pixel is the basic logical unit in digital graphics. Pixels are combined to form a complete image, video, text or any visible thing on a computer display.

A pixel is also known as a picture element.

Resolution:-

Resolution is a measure used to describe the sharpness and clarity of an image or picture. It is often used as a metric for judging the quality of monitors, printers, digital images and various other hardware and software technologies.

The term is popular in the mobile industry for describing a mobile device's display capabilities and also in the entertainment media to distingush the visual quality of movies to distingush between high definition and standard definition movies. It is also used to determine the resolution of a screen, monitor or TV.

Resolution is also referred to as screen resolution.

Refresh Rate:-

Refresh rate is a characteristic of computer display monitors and projection devices that defines the frequency and ability of the device to repaint or redraw the entire visible display on the screen each second.

Refresh rate is measured in hertz and will vary according to the architechure of the display device.

Refresh rate is also known as vertical refresh rate or vertical scan rate.

Scanned with CamScanner

Date
Page

★ Explain Computer animation. Define the terms key frame, tweening and morphing.

⇒ Computer animation is a general term for a kind of visual digital display technology that simulates moving objects on-screen. Mordern forms of computer animation envolved from more primitive computer graphics over the last few decades, as huge advances in computer technology led to much more sophisticated imaging methods. Modern computer animation can achieve dazzling results with three dimensional figures acting against a three-dimensional background.

Keyframe:

Animation requires showing the changing states of an object. Key frame in animation refers to the beginning and end point for the transition of an object. Simply put, the beginning keyframe is where the object is right now and the ending keyframe is where you want the object to be after transition. Animation that needs to be done within a decided upon time frame uses key frames to ensure that the transition stays within this timeline.

Tweening:-

Tweening is the process of creating transitional frames between two separate objects in order to show the appearance of movement and evolution of the first object into the second object. It is a common technique used in many types of animation. The frames between the key frames (the first and last frames of the animation) are called tweening or inbetween and they help make the illusion of fluid motion.

Morphing:-

Morphing is a special effect in motion pictures and animations that changes (or morphs) one image or shape into another through a seamless transition. Traditionally such a depiction would be achieved through dissolving techniques on film.

★ Discuss the difference between stop motion animation and computer animation?

Stop motion animation	Computer animation
1) It is create by using still pictures.	1) It is created by computer created graphics.
2) It required all still pictures frame to make one animation.	2) It not required all frame to create, some can be tweening by the computer software.
3) Much time consuming then computer animation.	3) less time consuming then stop motion animation.

★ Breif History of Computer Graphics

⇒ 1885- CRT (Cathode Ray Tube)
1887- Edison patents motion picture camera
1926 - J.L Baird invents the television
1959- First industrial CAD system
1960- William Fetter, a graphic designer for Boeing, coined the pharse "computer graphics".
1961- Sketchpad developed by Ivan Sutherland (light pen based)
1962- Space War (game) created by Steve Russel

1963- IBM creates the 360 models. The mouse is invented by Dout Englebeart at the Stanford Research Institute (SRI)

1965- The digital line drawing algorithm for raster devices developed.

1966- Baer creates the 1st consumer CG product

1967- First full Color real time fight simulator for NA.

19171- Gourand shading is developed by Utah student Henri Gourand.

1973- The entertainment feature film West world makes the first use of 2D animation.

1977- Star Wars wins Oscar for special effects.

1979- Alien wins Oscar for visual effects.

1989- The Abyss is the first movie to include convincing 3D Character animation.

1995- Pixar Animation Studios produce Toy story, the first computer-animated full-length feature film.

2000s- Video games and CGI cinema had speard the reach of computer graphics to the mainstream by the late 1990's.

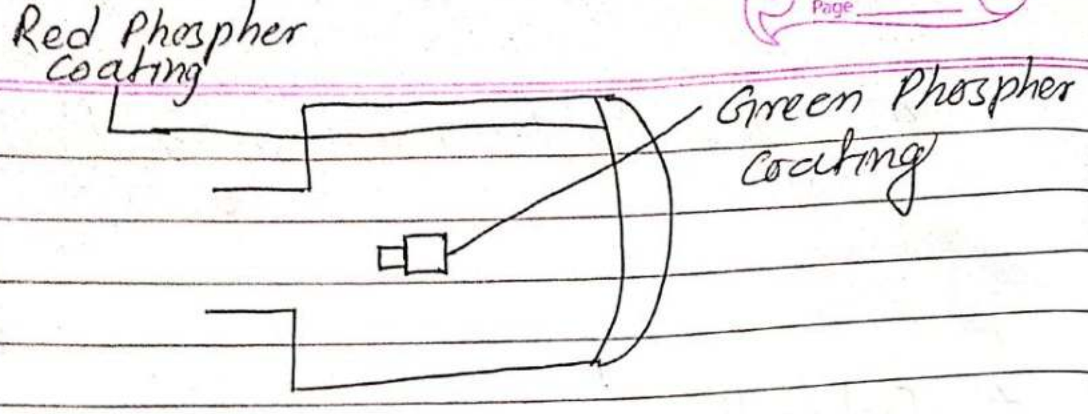
* Explain the color production methods used in CRT with necessary diagrams.

⇒ The CRT Monitor display by using a combination of phosphors. The phosphors are different colors. There are two popular approaches for producing color displays with a CRT are:-

1) Beam penetration method
2) Shadow Mask method

Beam Penetration method :-

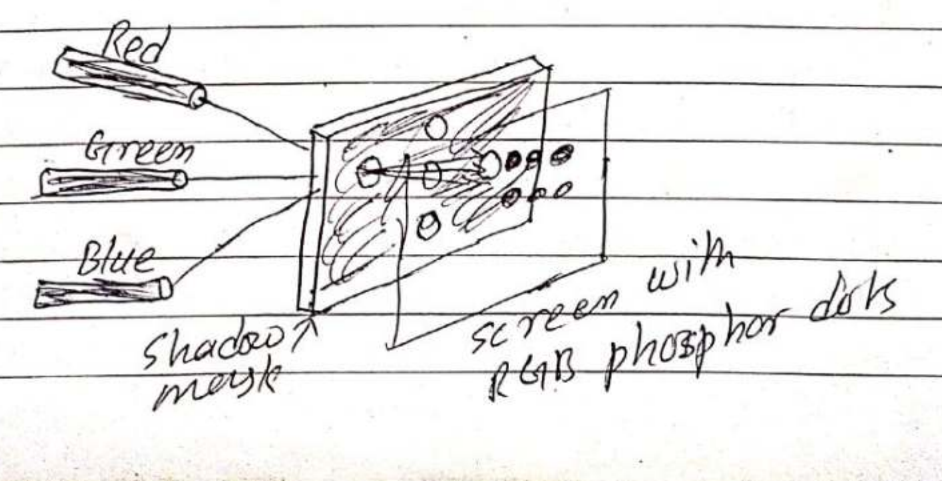
The Beam penetration method has been used with random-scan monitors. In this method, the CRT screen is coated with two layers of phosphor, ~~and~~ red and green and the displayed color depends on how far the electron beam penetrates the phosphor layers. This method produces four colors only, red, green, orange and yellow. A beam of slow electrons excites the outer red layer only; hence screen shows red color only. A beam of high-speed electrons excites the inner green layer. Thus screen shows a green color.



Shadow-Mask Method:-

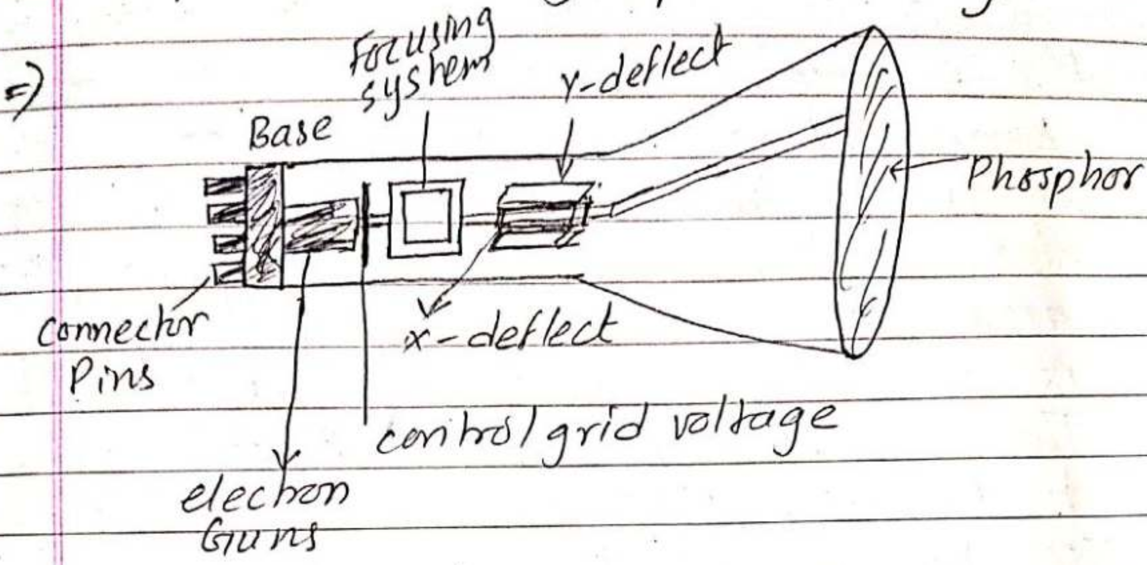
Shadow mask method is commonly used in Raster-Scan System because they produce a much wider range of colors than the beam penetration method. It is used in the majority of color TV sets and monitors.

This type of CRT has 3 electron guns, one for each ~~other~~ color dot and a shadow mask grid just behind the phosphor coated screen. Shadow mask grid is pierced with small round holes in a triangular pattern.
Figure shown the delta-delta shadow mask method commonly used in color CRT System.



★ Draw a neat line diagram of CRT and Explain each major parts briefly.

=)



Electro Gun:-

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

Control Electrode:

It is used to turn the electron beam on and off.

Focusing system:-

It is used to create a clear picture by focusing the electrons into a narrow beams.

Scanned with CamScanner

Date
Page

Deflection Yoke:

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

Phosphorus-coated screen:-

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

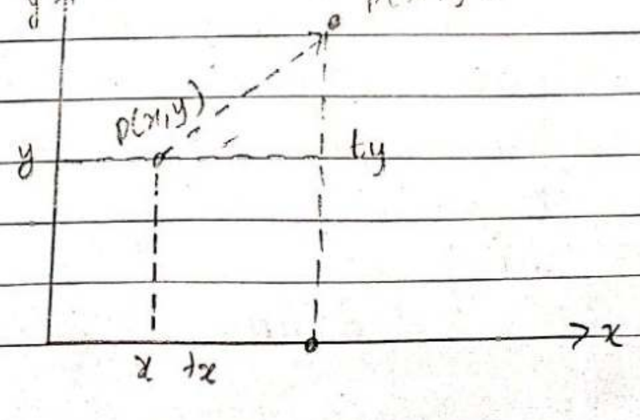
2D Transformation:-

In computer graphics, transformations of 2D objects are essential to many graphics applications. The transformation are used directly by application programs and within many graphics subroutines in application programs. Many ~~graphics~~ applications use the geometric transformation s to change the position, orientation and size or shape of the objects in drawing. Rotation, translation and scaling are three major transformations that are extensively used by all almost all graphical packages or graphical subroutines in applications. Other than these, reflection and shearing transformations are also used by some graphical packages.

2D Translation:-

A translate is applied to an object by representing it along a straight line path from one co-ordinate location to another. We translate a two-dimensional point by adding translation distance t_x, t_y to the respective co-ordinate values of original co-ordinate position (x,y) to move point to a new position (x', y') as:

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



The translation distance pair (t_x, t_y) is known as translation vector or shift vector. We can express translation equations as matrix representations as

$$P = \begin{bmatrix} x \\ y \end{bmatrix} \quad P' = \begin{bmatrix} x' \\ y' \end{bmatrix} \quad T = \begin{bmatrix} T_x \\ T_y \end{bmatrix}$$

$$\therefore \; P' = P + T$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

Sometimes matrix transformation are represented co-ordinate rows vector instead of column vectors as:

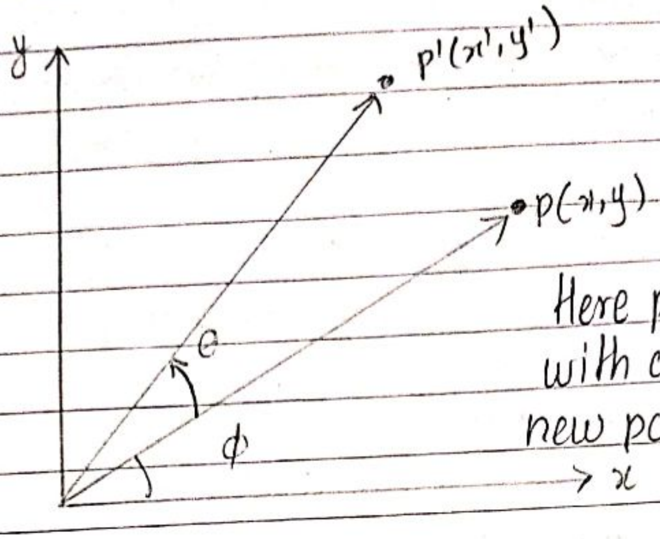
$$P = (x, y) \quad T = (t_x, t_y) \quad P' = P + T$$

2D Rotation:-

The 2D rotation is applied to reposition the object along a circular path in XY-plane. To generate rotation, we specify a rotation angle θ through which the co-ordinates are to be rotated. Rotation can be made by angle θ either clockwise or anticlockwise direction. Besides the angle of rotation θ, there should be a pivot point through which the object is to be rotated. The positive θ rotates object in anti-clockwise direction and the negative values of θ rotates the object in clockwise direction.

A line perpendicular to rotating plane

and passing through pivot point is called axis of rotation.



Here point $p(x,y)$ is rotated with angle θ to get new point $p'(x',y')$.

From the figure,

$$\cos\phi = \frac{b}{h} = \frac{x}{r}$$

$$x = r\cos\phi \quad \text{--- (i)}$$

$$\sin\phi = \frac{p}{h} = \frac{y}{r}$$

$$y = r\sin\phi \quad \text{--- (ii)}$$

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

$$\begin{aligned} x' &= r\cos(\theta+\phi) \\ &= r\cos\theta\cos\phi - r\sin\theta\sin\phi \\ &= x\cos\theta - y\sin\theta \quad \text{--- (iii)} \ [\because \text{From eqn (i) \& (ii)}] \end{aligned}$$

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

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

Scanned with CamScanner

$y' = r\sin\theta\cos\phi + r\cos\theta.\sin\phi$

$y' = x\sin\theta + y\cos\theta$ — (iv) [$\because$ From eqn (i) & (ii)]

Representing the eqn (iii) & (iv) in matrix form we get:

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

OR

$$P' = P.R$$

where R is called Rotation matrix.

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

The rotation angle can be positive & negative (anticlockwise = +ve, clockwise = -ve)

For negative rotation angle

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

③ Rotate a line A(4,2) B(6,6) by angle 45° anticlockwise from a point P(2,2) in 2D plane.

Solution Rotation angle = 45° (clockwise)

Rotation matrix = $\begin{bmatrix} \cos 45 & \sin 45 \\ -\sin 45 & \cos 45 \end{bmatrix}$

$= \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix}$

Here we have to rotate the line from pivot from P(2,2).

Step① translating the line towards origin with $t_x = -2$ & $t_y = -2$

$A_1 = (2,0)$ $B_1 = (4,4)$

Now Applying Rotation From origin

$A_2 = [2\ 0] \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix}$

$= [2/\sqrt{2}\ \ 2/\sqrt{2}]$

$B_2 = [4.4] \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} \\ -1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix}$

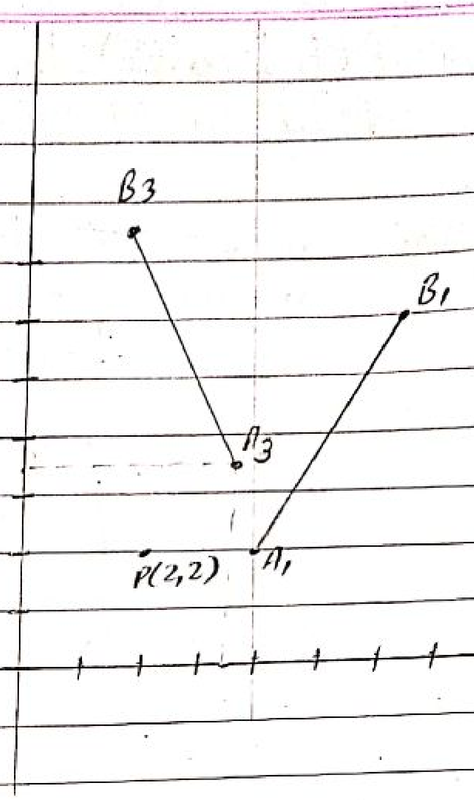
$= [0\ \ 4\sqrt{2}]$

Step③ Retranslating the line using $t_x = 2$ & $t_y = 2$

we get $A_3 = [3.41\ \ 3.41]$

$B_3 = [2\ \ \ 7.66]$

Scanned with CamScanner



2D Scaling:

A scaling transformation alters the size of the object. This operation can be carried out for polygon by multiplying the co-ordinate value (x, y) of each vertex by scaling factor S_x and S_y to produce transformed co-ordinates (x', y').

i.e $x' = x \cdot S_x$ & $y' = y \cdot S_y$

Scaling factor S_x scales objects in x-direction and S_y scales in y-direction. If the scaling factor is less then 1, the size of object is decreased and if it is greater thom 1 the size of the object is increased. If both scaling factors have same value then the scaling is known as uniform scaling. If the value of S_x and S_y are different, then the scaling is known as differential scaling. The differential scaling is mostly used in the graphical package to change the shape of the object.

The matrix equation for scaling is:-

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} Sx & 0 \\ 0 & y \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \quad \text{ie } P' = S.P$$

2D Reflection:-

A reflection is a transformation that produce ~~that~~ a mirror image of an object. In 2D-transformation, reflection is generated relative to an axis of reflection. The reflection of an object to an relative axis of reflection is same as 180° rotation about the reflection axis.

1) Reflection about x-axis:

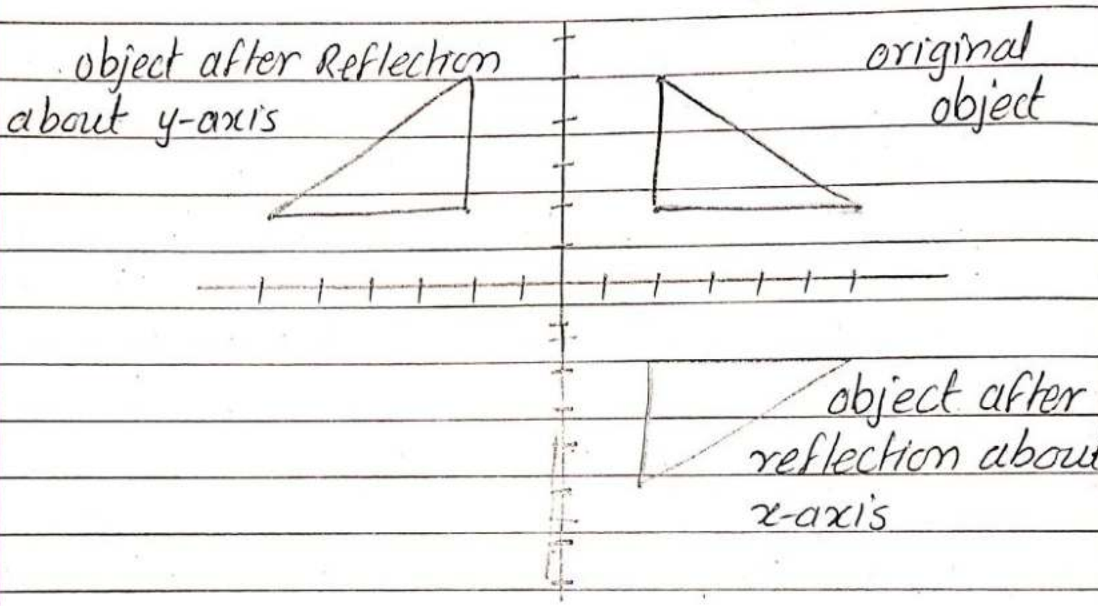
The line representing x-axis is $y=0$. The reflection of a point $P(x,y)$ on axis, changes the y-co-ordinate sign i.e. Reflection about x-axis, the reflected position of $P(x,y)$ will be $P'(x,-y)$. Hence, reflection in x-axis is accomplished with transformation equation.

$$[x' \; y'] = [x \; y] \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

2) Reflection about Y-axis:

The line representing y-axis is $x=0$. The reflection of a point $P(x,y)$ on y-axis changes the sign of x-coordinate ie $P(x,y)$ changes to $P'(-x,y)$

$$[x' \; y'] = [x \; y] \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$$



3) Reflection on an arbitary axis:

The reflection on any arbitary axis of reflection can be achieved by sequence of rotation and co-ordinate axis reflection matrices.

- First, rotate the arbitary axis of reflection and one of the coordinate axis concide.
- Reflect the image on the coordinate axis to which the axis of reflection concides.

- Rotate the axis of reflection back to its original position.

④ Reflection about Origin:- The reflection on the line perpendicular to xy-plane and passing through flips x and y co-ordinates both. So sign of x and y coordinate value changes. The equivalent matrix equation for the point is:

$$[x' \; y'] = [x \; y] \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$$

Q. For a sequence P(1,1) Q(1,5) R(5,1) T(5,5). Applying the following transformation & plot after each.

1) Scale 2 unit along x-axis & 0.5 unit along y-axis.

P(1,1) Q(1,5) R(5,1) T(5,5)

= P'(2, 0.5) Q' = (2, 2.5) R' = (10, 0.5) T' = (10, 2.5)

2) Rotate clockwise about origin by angle 60°

$$R = \begin{bmatrix} \cos 60 & -\sin 60 \\ \sin 60 & \cos 60 \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix}$$

$$P_R = [1 \; 1] \begin{bmatrix} \frac{1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & \frac{1}{2} \end{bmatrix}$$

$$= \left[\frac{1}{2} + \frac{\sqrt{3}}{2} \quad -\frac{\sqrt{3}}{2} + \frac{1}{2} \right] = \left[\frac{1+\sqrt{3}}{2} \quad \frac{1-\sqrt{3}}{2} \right]$$

$$= [1.36 \quad -0.36]$$

$$Q_R = [1, 5] \begin{bmatrix} 1/2 & -\frac{\sqrt{3}}{2} \\ \frac{\sqrt{3}}{2} & 1/2 \end{bmatrix}$$

$$= \begin{bmatrix} 1/2 + \frac{5\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} + \frac{5}{2} \end{bmatrix}$$

$$= \begin{bmatrix} \frac{1+5\sqrt{3}}{2} & \frac{5-\sqrt{3}}{2} \end{bmatrix}$$

$$= [4.83 \quad 1.63]$$

$$R_R = [5\ 1] \cdot \begin{bmatrix} 1/2 & -\frac{\sqrt{3}}{2} \\ \sqrt{3}/2 & 1/2 \end{bmatrix}$$

$$= [5/2 + \sqrt{3}/2 \quad -5\sqrt{3}/2 + 1/2]$$

$$= \begin{bmatrix} \frac{5+\sqrt{3}}{2} & \frac{1-5\sqrt{3}}{2} \end{bmatrix}$$

$$= [3.36 \quad -3.83]$$

$$T_R = [5\ 5] \begin{bmatrix} 1/2 & -\sqrt{3}/2 \\ \sqrt{3}/2 & 1/2 \end{bmatrix}$$

$$= \begin{bmatrix} 5/2 + \frac{5\sqrt{3}}{2} & -5\sqrt{3}/2 + 5/2 \end{bmatrix}$$

$$= \begin{bmatrix} \frac{5+5\sqrt{3}}{2} & \frac{5-5\sqrt{3}}{2} \end{bmatrix}$$

$$= [6.83 \quad -1.83]$$

3) Reflect from x-axis & Scale uniformly with scaling factor 1.5.

$$P_{Re} = [1\ 1]\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$$

$$= [1\ \ -1] \quad P_s = [1.5\ \ -1.5]$$

$$Q_{Re} = [1\ 5]\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$$

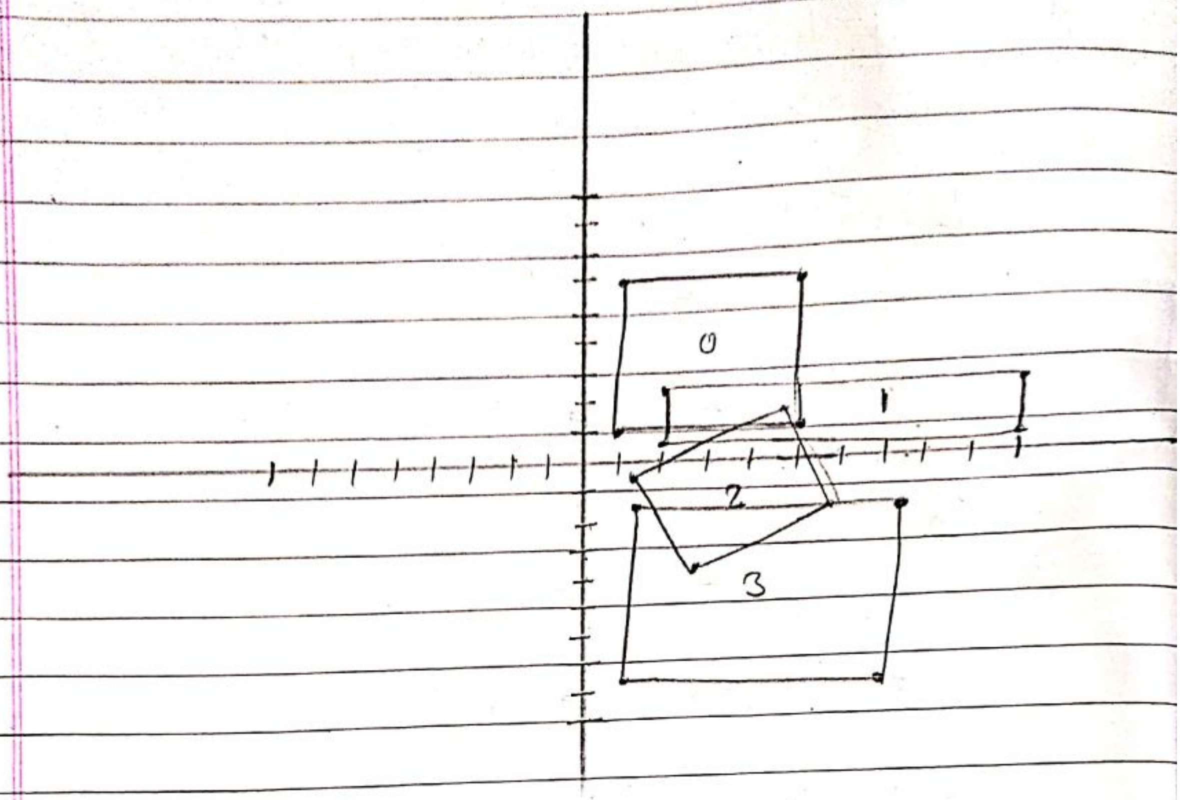
$$= [1\ \ -5] \quad Q_s = [1.5\ \ -7.5]$$

$$R_{Re} = [5\ 1]\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$$

$$= [5\ \ -1] \quad R_s = [7.5\ \ -1.5]$$

$$T_{Re} = [5\ 5]\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$$

$$= [5\ \ -5] \quad T_s = [7.5\ \ -7.5]$$



Shearing:

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

X direction shear:

An x direction shear relative to x-axis is produced ~~to~~ with transformation matrix equation.

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} 1 & sh_x \\ 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} \quad \text{ie } x' = x + sh_x \cdot y, \quad y' = y$$

Scanned with CamScanner

y-direction Shear:

An y-direction shear relative to y-axis is produced by following equations.

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

i.e $x' = \cancel{x + Sh_x \cdot y}\ \cancel{y} \ x$

$y' = y + Sh_y \cdot x$

Homogenous co-ordinate representation of 2D Transformation:

The homogenous co-ordinate system provides uniform framework for handling different geometric transformation simply as multiplication of matrices. It extension to 3D is straight forward which also helps to produce 3D perspective projections by use of matrix multiplication.

We simply add a 3rd coordinate to 2D graphics. Homogenous coordinate are generally used in design and construction application. To combine the 2D transformations rotation, translation and scaling into a single transformation homogenous coordinate are used. We perform 2D presentation by triple coordinates.

Following are the matrices for 2D transformation in homogenous coordinate:-

Date
Page

① <u>Translation:-</u>

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ tx & ty & 1 \end{bmatrix} \text{ or } \begin{bmatrix} 1 & 0 & t_x \\ 0 & 1 & t_y \\ 0 & 0 & 0 \end{bmatrix}$$

② <u>Scaling:-</u>

$$\begin{bmatrix} Sx & 0 & 0 \\ 0 & Sy & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

③ <u>Rotation:</u>

Clockwise: $\begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

Anticlockwise: $\begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$

④ <u>Reflection:</u>

Against x-axis: $\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

&

Against y-axis: $\begin{bmatrix} -1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

V.V.I

Date
Page

DDA (Digital Differential Analyzer) Line drawing Algorithm

In computer graphics, the first ~~time~~ line drawing graphics is DDA Algorithm. To draw line we need two points between which we can draw line.

In computer graphics, DDA is hardware or software, used for interpolation of variables over an interval between start and end point. DDA are used for rasterization of lines, triangles and polygons

Let (x_1, y_1) & (x_2, y_2) are the points between which we need to draw the line then,

$$dx = x_2 - x_1$$

$$dy = y_2 - y_1$$

$$slope(m) = \frac{dy}{dx}$$

Case 1, $m < 1$ (i.e x is incrementing faster)

Perform,

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

$$y_{k+1} = y_k + m$$

Case 2, $m > 1$ (ie y is incrementing faster)

Perform

$$x_{k+1} = x_k + 1/m$$

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

Case 3 $m = 1$

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

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

These equations are under the assumption that the lines are processed from left to right i.e. left end is starting point & right end is ending point.

If the line is processing from light to left then we can use, -ve sign for the above equations.

case ① $m<1$

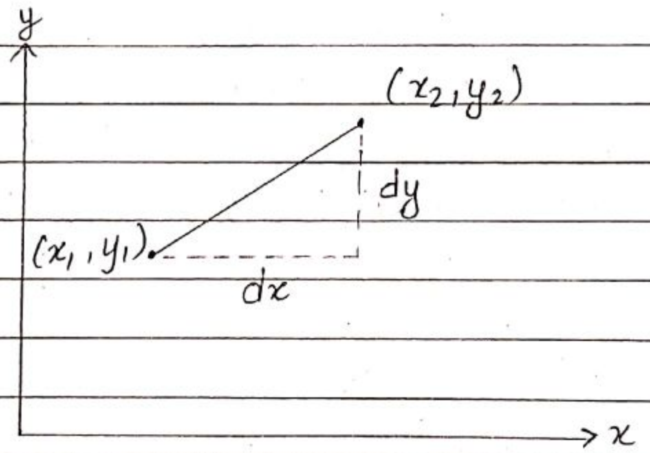
$$x_{k+1} = x_k - 1$$
$$y_{k+1} = y_k - m$$

case ② $m>1$

$$x_{k+1} = x_k - 1/m$$
$$y_{k+1} = y_k - 1$$

case ③ $m=1$

$$x_{k+1} = x_k - 1$$
$$y_{k+1} = y_k - 1$$



Advantages:-

- Its is faster method of ~~living~~ using, direct use of line equation.
- This method doesnot use multiplication theorem.
- It allow us to detect the change in value of x & y. So plot a same point twice is impossible.
- Each steps involves only two additions.

Disadvantage:-

- It involves floating point additions.
- Accumulation of round off error can cause huge error.
- Rounding off operation & floating point operations consumes a lot of time.
- More suitable using software but less suitable using hardware.

Q. Plot a line between points (2,3) to (6,15) using DDA Algorithm. How many points we will be needed to generate such line.

soln

The given points are:-

$$(x_1, y_1) = (2, 3)$$
$$(x_2, y_2) = (6, 15)$$

Now, $dx = x_2 - x_1 = 6 - 2 = 4$

$dy = y_2 - y_1 = 15 - 3 = 12$

& $m = \frac{dy}{dx} = \frac{12}{4} = 3$

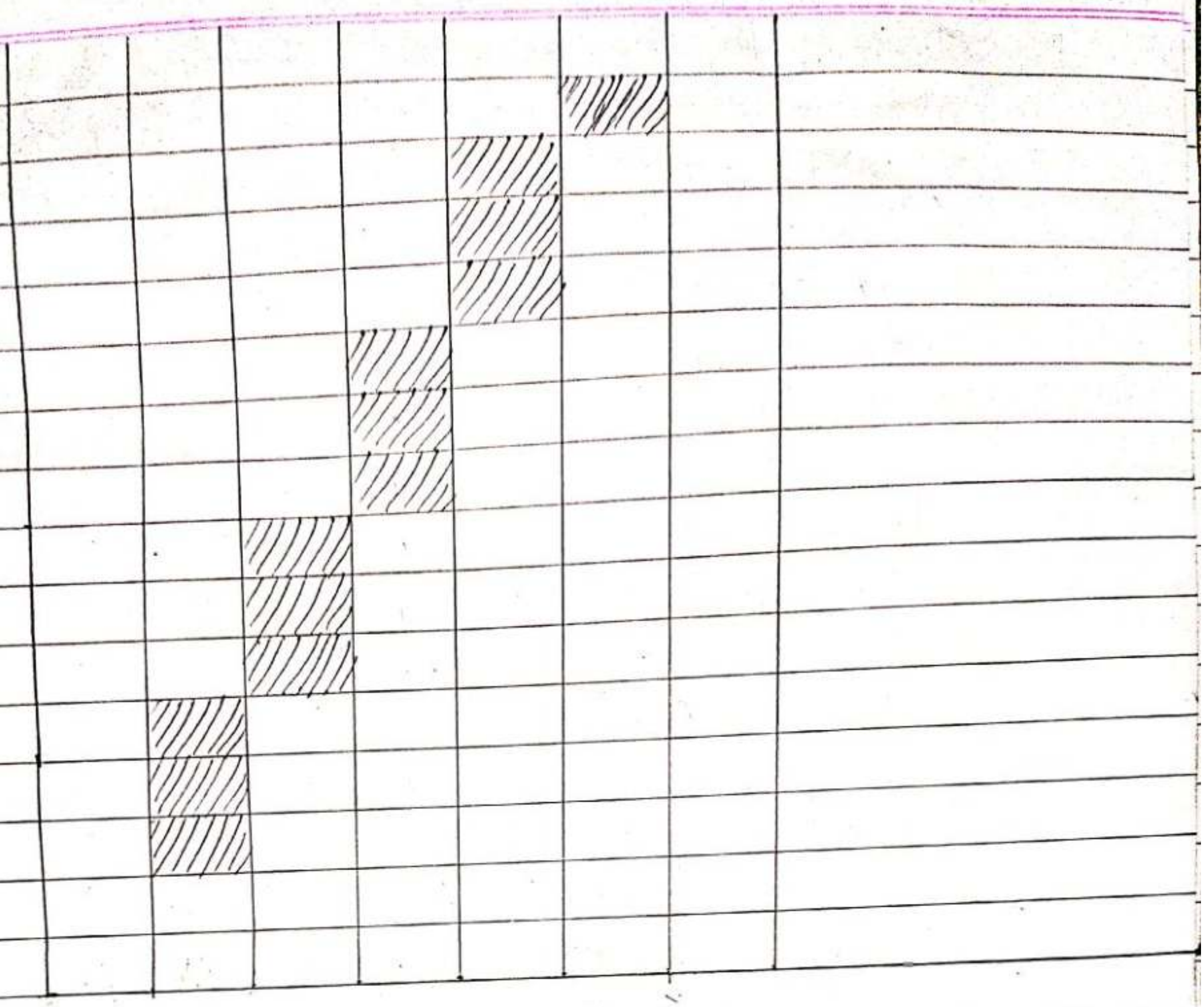
Since $m > 1$ we use:

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

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

We obtain the required points of line in tabular form as follows:-

SN	x	y	(x_{plot}, y_{plot})
1	2	3	(2,3)
2	2.33	4	(2,4)
3	2.67	5	(2,5)
4	3	6	(3,6)
5	3.33	7	(3,7)
6	3.67	8	(3,8)
7	4	9	(4,9)
8	4.33	10	(4,10)
9	4.67	11	(4,11)
10	5	12	(5,12)
11	5.33	13	(5,13)
12	5.67	14	(5,14)
13	6	15	(6,15)



Bresenham's Line Drawing Algorithm :-

It is an accurate and effective line generating algorithm developed by Bresenhan that scan converts lines by using integer calculation to find next (x,y) position to plot. It avoids incremental error accumulation.

Advantages :-

1. It involves only integer arithmetic, so it is simple.
2. It avoids the generation of duplicate points.
3. It can be implemented using hardware because it doesn't use multiplication & division.
4. It is faster as compared to DDA because it doesnot involve floating point calculations.

Assuming that line is growing from left to right, to draw a straight line between starting point (x_1, y_1) & ending point (x_2, y_2) we can perform the following.

$dx = x_2 - x_1$

$dy = y_2 - y_1$

$m = \frac{dy}{dx}$

When $m < 1$

$I_1 = 2dy$

$I_2 = 2dy - 2dx$

$P_0 = 2dy - dx$

Case (I): When $P_K < 0$ performs

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K$

$P_{K+1} = P_K + I_1$

Case (II) When $P_K \geq 0$ Perform

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K + 1$

$P_{K+1} = P_K + I_2$

When $m \geq 1$.	Case (I) When $P_K < 0$ Perform
$I_1 = 2dx$	$x_{K+1} = x_K$
$I_2 = 2dx - 2dy$	$y_{K+1} = y_K + 1$
$P_0 = 2dx - dy$	$P_{K+1} = P_K + I_1$

Case (II) When $P_K \geq 0$ Perform

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K + 1$

$P_{K+1} = P_K + I_2$

(Q) Rasterize a straight line between points (2,4) & (10,9) using Bresenham's Line drawing algorithm.

Soln Using Bresenham's line drawing algorithm, we can find the points to draw the line as follows:-

Given that, $(x_1, y_1) = (2,4)$

$(x_2, y_2) = (10,9)$

$dx = x_2 - x_1 = 10 - 2 = 8$

$dy = y_2 - y_1 = 9 - 4 = 5$

$m = \frac{dy}{dx} = \frac{5}{8} < 1$

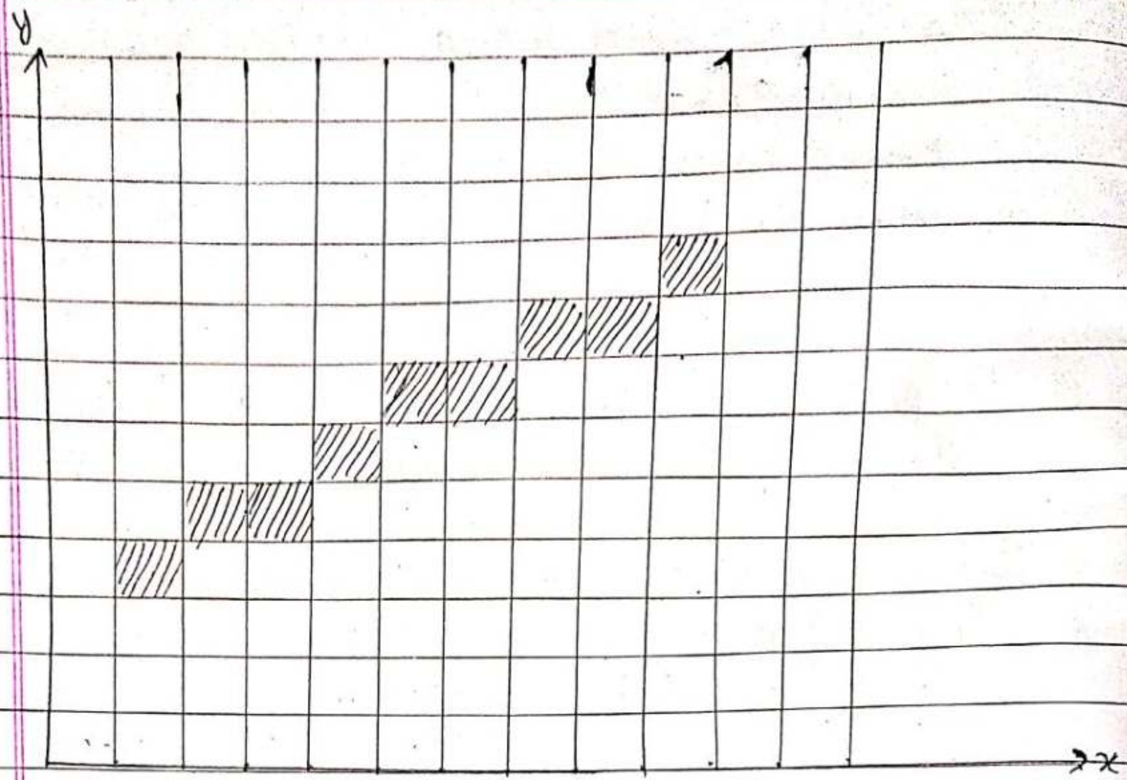
$P_0 = 2dy - dx$

$= 2 \times 5 - 8 = 2$

$I_1 = 2dy = 2 \times 5 = 10$

$I_2 = 2dy - 2dx = 2 \times 5 - 2 \times 8 = -6$

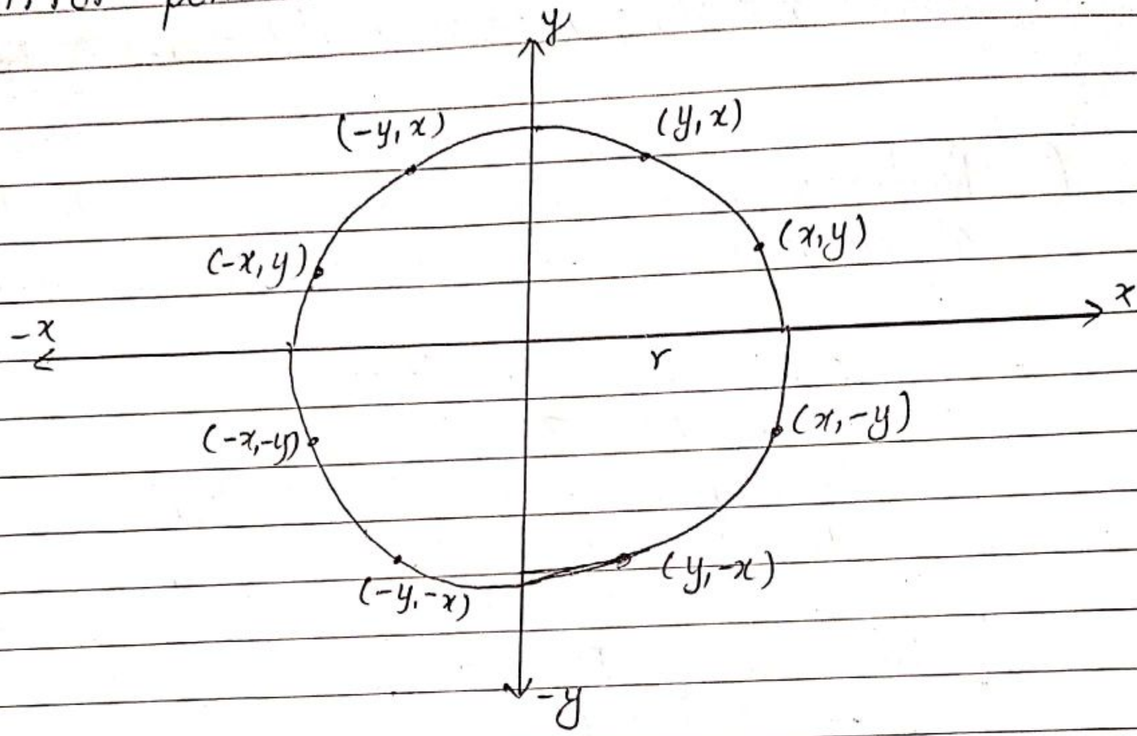
SN	P	x	y	Plot (x,y)
1	-	2	4	(2,4)
2	2	3	5	(3,5)
3	-4	4	5	(4,5)
4	6	5	6	(5,6)
5	0	6	7	(6,7)
6	-6	7	7	(7,7)
7	4	8	8	(8,8)
8	-2	9	8	(9,8)
9	8	10	9	(10,9)


y
x

Date
Page

Midpoint Circle drawing algorithm:

We use midpoint algorithm to calculate all the perimeter points of all the circle in the first octant and then print them along with their mirror points in the other octants.



For a circle having center at origin (0,0) & radius $= r$. Suppose the current point is (x_K, y_K) and the point next to plot is (x_{K+1}, y_{K+1}).

$P_0 = 1 - r$

First point $= (0, r)$

Then we can find the next point of the first octant depending upon the value of decision parameter P_K as follows:-

Date ______ Page ______

Case (I)

$P_K \leq 0$

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K$

$P_{K+1} = P_K + 2x_{K+1} + 1$

Case (II) $P_K \geq 0$

$x_{K+1} = x_K + 1$

$y_{K+1} = y_K - 1$

$P_{K+1} = P_K + 2x_{K+1} + 1 - 2y_{K+1}$

keep repeating process until $x_{plot} \geq y_{plot}$

Q) Rasterize a circle using midpoint circle drawing algorithm whose center is at (0,0) & radius = 8 unit.

center of circle = (0,0)

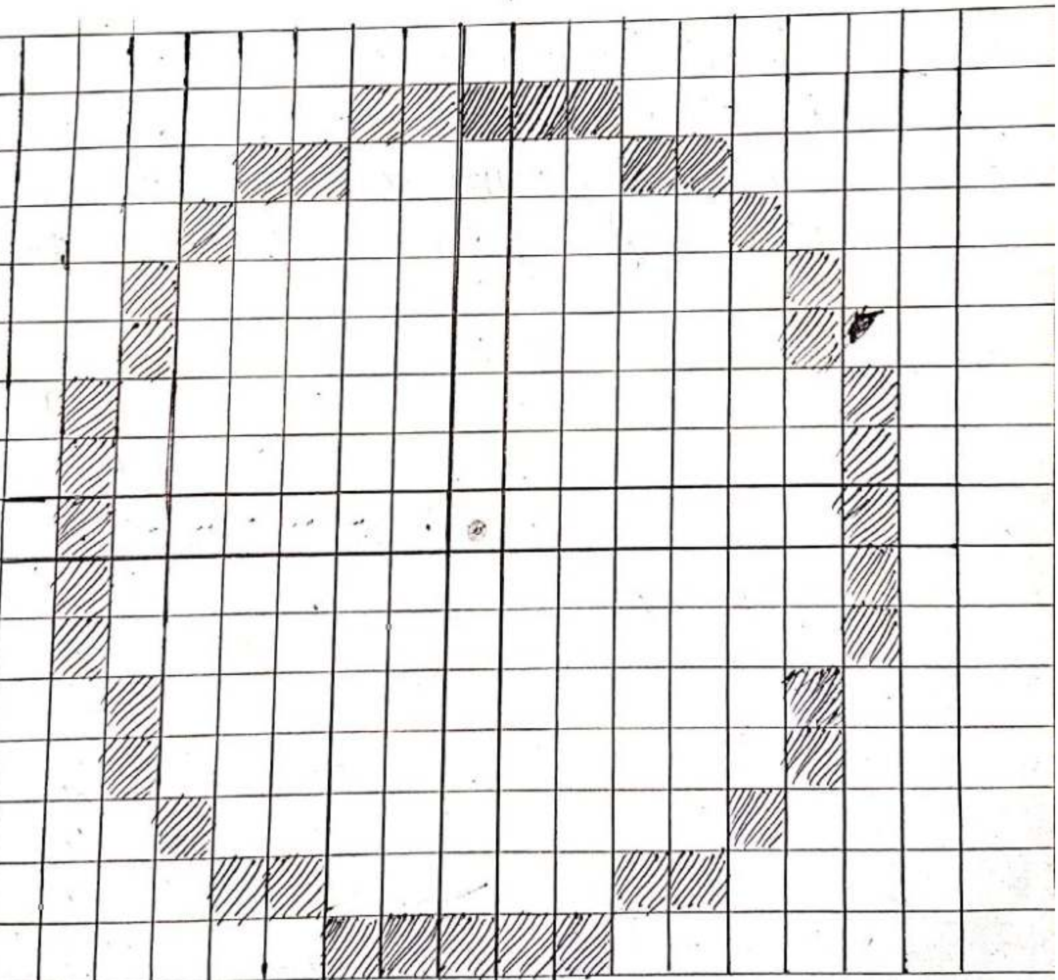
Radius (r) = 8

First point to plot = (0, r) = (0,7)

$P_0 = 1 - r = 1 - 7 = -7$

P_K	Plot (x,y)
—	(0,7)
-7	(1,7)
-4	(2,7)
1	(3,6)
-4	(4,6)
5	(5,5)

(x, y) 1st	(-x, y) 2nd	(-x, -y) 3rd	(x, -y) 4th
(0,7)	(0,7)	(0,-7)	(0,-7)
(1,7)	(-1,7)	(-1,-7)	(1,-7)
(2,7)	(-2,7)	(-2,-7)	(2,-7)
(3,6)	(-3,6)	(-3,-6)	(3,-6)
(4,6)	(-4,6)	(-4,-6)	(4,-6)
(5,5)	(-5,5)	(-5,-5)	(5,-5)
(6,4)	(-6,4)	(-6,-4)	(6,-4)
(6,3)	(-6,3)	(-6,-3)	(6,-3)
(7,2)	(-7,2)	(-7,-2)	(7,-2)
(7,1)	(-7,1)	(-7,-1)	(7,-1)
(7,0)	(-7,0)	(-7,0)	(7,0)



Error Note: In this figure, One point ~~is~~ should required. Here, Instead of 8 radius, 7 radius is used.

Scanned with CamScanner

Midpoint Ellipse Drawing Algorithm:-

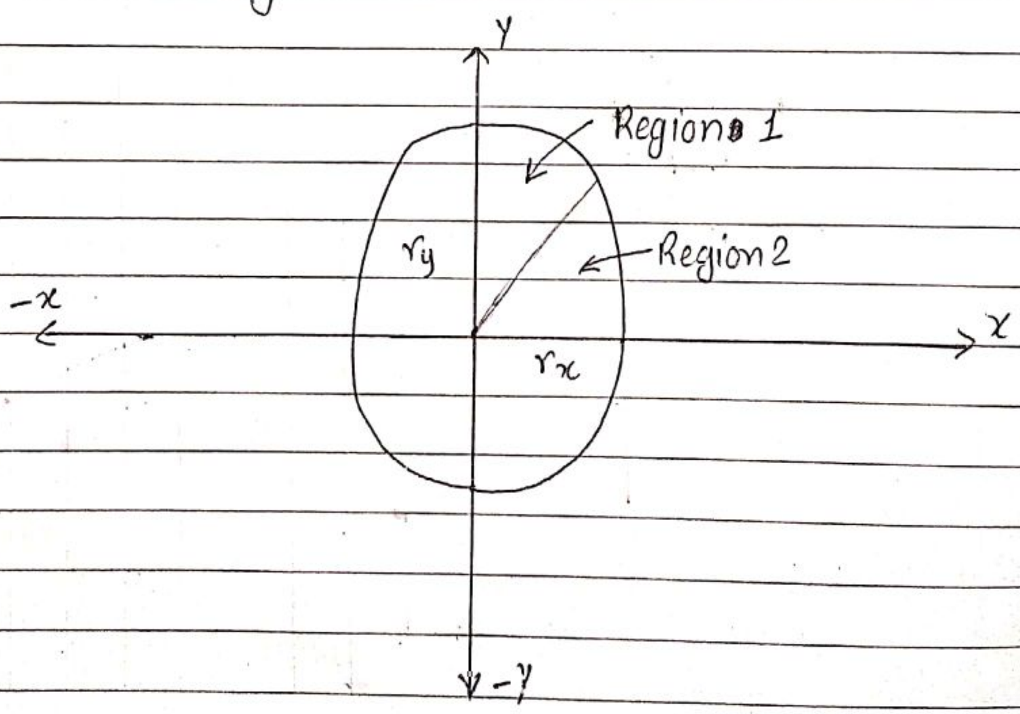
Ellipse is defined as the geometric figure which is the set of all point on a plane whose distance from two point to fixed point known as foci remains a constant.

It consists of two axes: major axis and minor axis.

The major axis is longest diameter and minor axis is the shortest diameter.

Unlike circle, the ellipse has four way symmetry property.

In computer graphics, the midpoint ellipse algorithm is an incremental method of drawing an ellipse. This is very similar to the midpoint algorithm used in the generation of a circle.



For a Ellipse having center at (0,0), x-axis radius = r_x and y-axis radius = r_y. we can obtain the points required to draw ellipse as follows:-

Region ①:

Initial point = $(0, r_y)$

$$P_0 = r_y + \frac{1}{4} r_x^2 - y_x^2 \cdot y$$

case Ⅰ : If $P_k < 0$ —
- Plot (x_k+1, y_k)
- $P_{k+1} = P_k + r_y^2 + 2x_k \cdot r_y^2 + 2r_y^2$

case Ⅱ : If $P_k \geq 0$ —
- Plot (x_k+1, y_k-1)
- $P_{k+1} = P_k + r_y^2 + 2x_k r_y^2 + 2r_y^2 + 2r_x^2 - 2r_x^2 y_k$

Region ②:

Initial point = last point of region ① let (x_0, y_0)

~~Case Ⅰ: If $P_k < 0$ — Plot (x_k+1, y_k-1) — $P_{k+1} =$~~

$$P_0 = r_y^2 \left(x_0 + \frac{1}{2}\right)^2 + r_x^2 (y_0-1)^2 - r_x^2 r_y^2$$

case Ⅰ : If $P_k < 0$ —
- Plot (x_k+1, y_k-1)
- $P_{k+1} = P_k + 2r_y^2 (x_k+1) + r_x^2 [1-2(y_k-1)]$

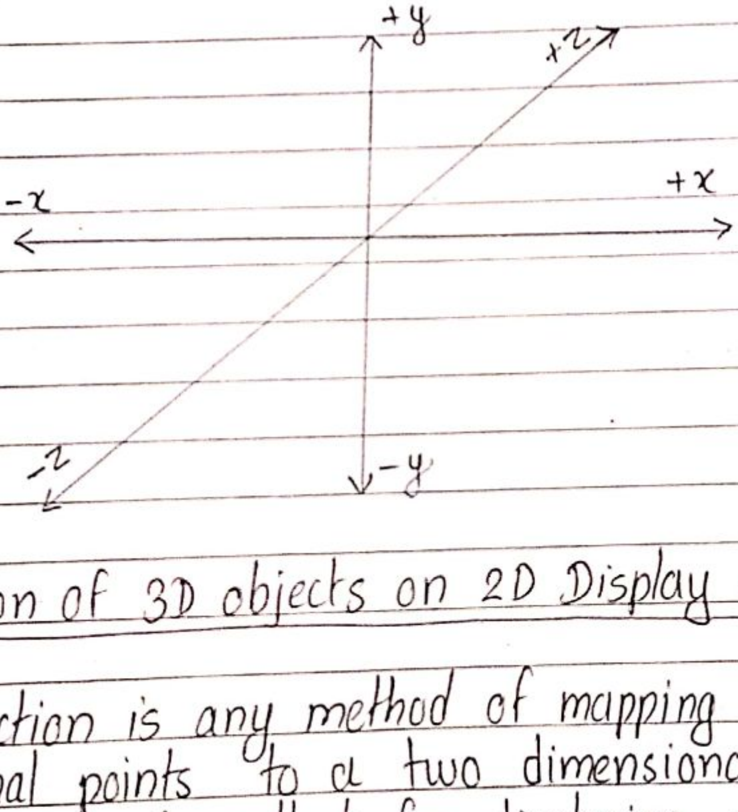
Case Ⅱ : If $P_k \geq 0$ —
- Plot (x_k, y_k-1)
- $P_{k+1} = P_k + r_x^2 - 2r_x^2 y_x + 2r_x^2$

Three Dimensional Graphics (3D)

In 2D system, We use only two coordinates x & y but in 3D an extra co-ordinate z is added.

3D graphics technics and there application are fundamental entertainment, games & computer aided design industries. It is continuous area of search in a scientific visualization.

Furthermore 3D graphics components are now part of almost computer every personal computer and allthough traditional intended for graphics intense software such as games.



Projection of 3D objects on 2D Display devices :-

1) 3D projection is any method of mapping three dimensional points to a two dimensional plane. As most current methods for displaying graphicals data are based on planer (Pixel information from several bit planes) two dimensional media.

2) The use of this type of projection is wide spread, specially in computer graphics, engineering & drafting.

3) The easier way to think converting 3D world into 2D ~~range~~ image is the way we do it in real life with a comma.

4) There are mainly two types of projections:
1) Parallel Projection
2) Perspective Projection

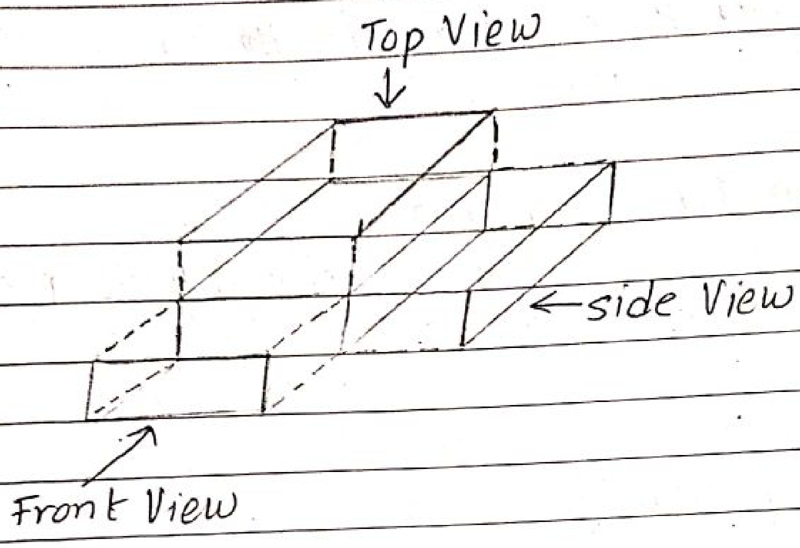
1) Parallel Projection:-

- Center of projection is infinite far from the view panel.
- Projections will be parallel to each other.
- Need to define the direction of projection (vector).
- Better for drafting & CAD application.

2 Sub types are:-
a) orthographics projection
b) Oblique projection.

@ Orthographic projection:
In ~~at~~ orthographics projection, the direction of projection is normal to the projection plane. There are three types of orthographics ~~ori~~ projection.

i) Front View / Projection
ii) Top View / Projection
iii) Side View / Projection



② Oblique Projection:
In a oblique projection, the direction of projection is not normal to the projection of plane. We can view the object better than orthographic projection.
There are 2 types of oblique ~~tran~~ projections:
- Cavalier
- Cabinet

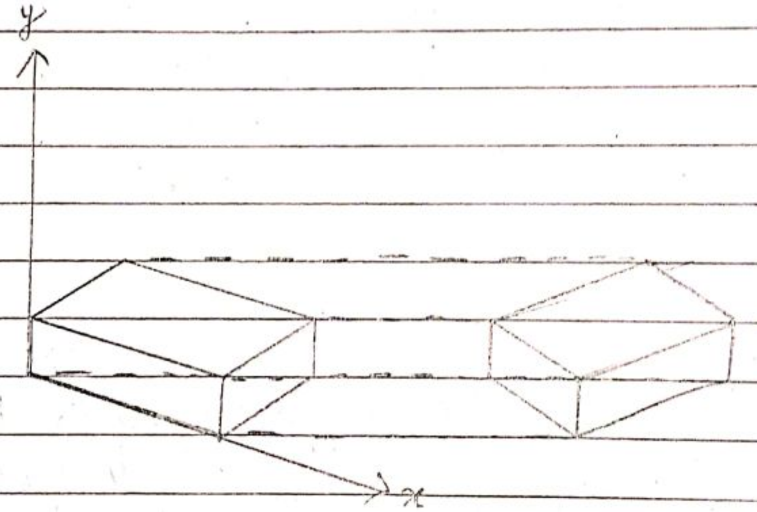
↳ Cavalier:
The cavalier projection makes 45° angle with the projection of plane. The projection of a line perpendicular to the view plane has the same length as the ~~plane~~ line itself in the cavalier projection.

↳ Cabinet:

The cabinet projection angle 63.4° angle with the projection plane. In this projection, line perpendicular to the viewing surface are projected at 1/2 of their actual length.

Isometric projection:-

Orthographic projection that shows more than one side of object are called axnometric orthographic projection. The most common axnometric projection is an isometric projection where the projection plane interset each co-ordinate in the model co-ordinate system at an equal distance. In this projection, parallelism of lines ~~distance~~ are preserved but angle are not preserved. The following shows isometric projection.



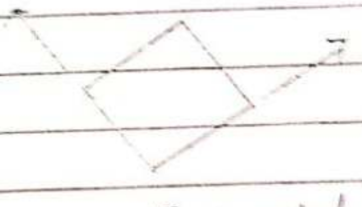
Perspective projection:-

- Center of projection is finitely far from view plane.
- Projectors will ~~be~~ not be parallel to each other
- We need to define the location of center of projection
- More visually realistic i.e. objects furtherway appear smaller.

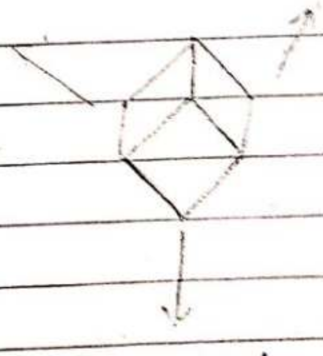
The distance and angle are not preserved and parallel line do not remain parallel. Instead they all coverage at a single point called center of projection or projection reference point. There are three types of perspective projection.

1) One point:- It is simple to draw.
2) Two point:- Gives better impression of depth
3) Three point:- Are most difficult to draw.

One point



Two point



Three point

Date
Page

Perspective Projection Summary:-

- Size varies inversely with distance i.e. looks ~~rel~~ realistics.
- Distance and angle are not preserved
- Parallel line donot remain parallel.

Parallel Projection summary:-

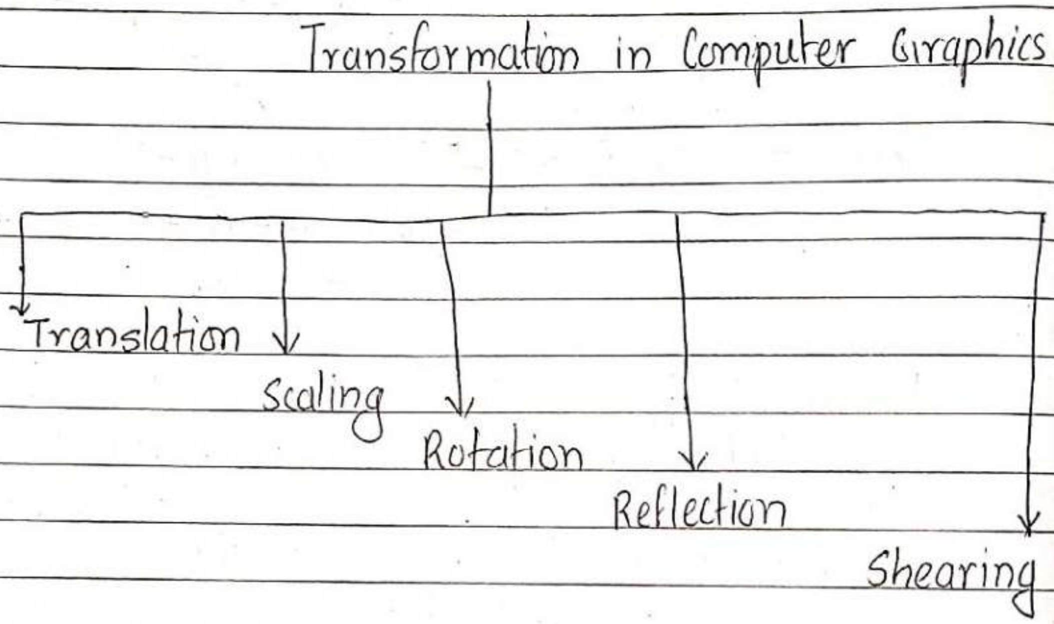
- Less realistic looking
- Good for exact measurement
- Parallel line remains parallel
- Angle are preserved.

3D Transformation:

3D transformation takes place in a three dimensional plane. 3D Transformation are important and a bit more complex then 2D Transformation.

Transformations are helpful in changing the position, size, orientation, shape etc of the object.

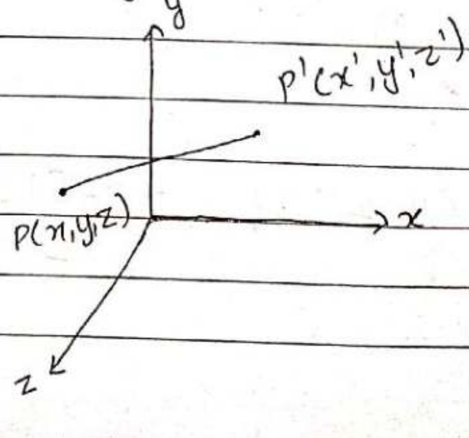
In computer graphics, there are various transformation techniques.



① **3D- Translation:**

The translation is achived by adding the translation co-ordinates to the old- cordinates of the object.

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



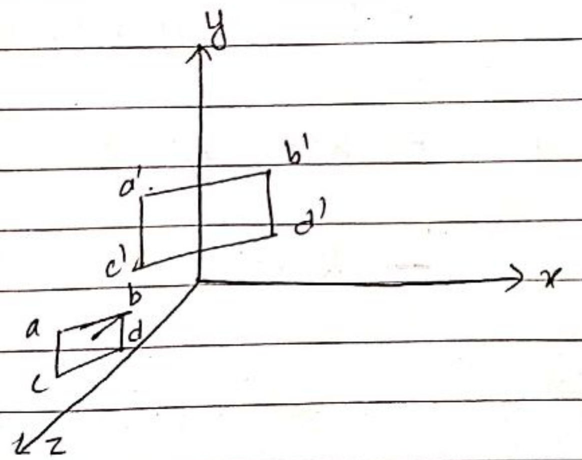
where t_x, t_y, t_z are called translation vector.

In matrix form,

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

② 3D Scaling:- Scaling is used to increase or decrease the size of object. It subjects the co-ordinate points of the original object to change. Scaling factors determine wheather the object size is to be reduced or increased.

If scaling factor is greater then 1. The object size will be increased. Similarly, if scaling factor is less than 1 then the object size will be decreased and if all scaling factor is 1 then the object size will be same.



$x' = x \cdot S_x$
$y' = y \cdot S_y$
$z' = z \cdot S_z$

Note: if $S_x = S_y = S_z$, the scaling is called uniform scaling

In matrix form:-

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

③ 3D Reflection:

Reflection is a kind of rotation where the angle of rotation is 180°. The reflected object is always the mirror object of original object. The size of reflected object is always same as the size of original object.

In 3D graphics, there are thoree possible types of reflection.

Types of reflection
- → Reflection relative to XY plane
- → Reflection relati~~on~~ve to XZ plane
- → Reflection relative to YZ plane

Scanned with CamScanner

① Reflection relative to xy plane.

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

In matrix form;

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

② Reflection relative to yz-plane

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

In matrix form;

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

③ Reflection relative to XZ-plane

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

In matrix form;

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

(*) 3D Transformation :-

Rotation:

In three dimensional, there are 3 possible type of rotations.

① X-axis rotation:-

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

In matrix form:-

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

② Y-axis rotation

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

In matrix form:

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

③ z-axis ~~t~~rotation:

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

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

③ Given a point $(x,yz) = (2,3,4)$. Apply the rotation in x, y & z axis by $45°$ to obtain new coordinate.

Soln Given point is,

$(x,yz) = (2,3,4)$

Rotation angle$(\theta) = 45°$

$\therefore \sin 45 = \cos 45 = \frac{1}{\sqrt{2}} = 0.71$

Now,

① X-axis rotation

$x' = x = 2$

$y' = y\cos\theta - z\sin\theta = 3\cos 45 - 4\sin 45 = -0.71$

$z' = z\cos\theta + y\sin\theta = 4\cos 45 + 3\cos 45 = 4.95$

② Y-axis rotation:

$x' = x\cos\theta + z\sin\theta = 2\cos 45 + 4\sin 45 = 4.24$
$y' = y = 3$
$z' = z\cos\theta - x\sin\theta = 4\cos 45 - 2\cos 45 = 1.41$

③ Z-axis rotation

$x' = x\cos\theta - y\sin\theta = 2\cos 45 - 3\sin 45 = 0.71$
$y' = y\cos\theta + x\sin\theta = 3\cos 45 - \cancel{4} 2\cos 45 = 3.54$
$z' = \cancel{4} = z = 4$

(*) 3D Shearing:
In computer graphics three types of shearing is possible:

① Shearing in x-direction
$x' = x$
$y' = y + sh_x . z$
$z' = z + sh_x . x$

② Shearing in y-direction:-
$x' = x + shy . y$
$y' = y$
$z' = z + shy . y$

③ Shearing in z-direction:
$x' = x + shz . z$
$y' = y + shz . z$
$z' = z$

Date
Page

Introduction to GUI

Graphical User Interface allows the use of icons or other visual indicators to interact with electronic devices, rather than using only text via the command line. For example, all versions of Microsoft Windows utilize a GUI, whereas MS DOS does not. The GUI was first developed at Xeroc PARC by Alan kay, ~~Deutag~~glas Engelbart and a group of other researches in 1981.

A GUI uses windows, icons and menus to carry out commands, such as opening, deleting and moving files. Although may GUI operating systems are navigated through the use of a mouse, the GNOME, KDE, MS Word, Excel, Internet browsers are the examples of GUI.

Benefits of GUI :-

- Low skilled pepole can use
- High productivity
- Greater Accessibility
- Lower cognitive load
- More Interactive
- Easy for multitasking
- Remote access is easy

Disadvantages of GUI :-

- Need large hard disk
- Need more RAM
- Need more processing power
- Sometimes slow

Date
Page

What do Windows, Icons, Menus and Pointing Device (WIMP) mean?

⇒ Windows, icons, menus and pointing device (WIMP) denotes a style of computer-human interaction involving the aforementioned elements of the graphical user interface (GUI) which is the most common interaction method being used by desktop computers today. WIMP interaction was developed at Xerox PARC in 1973 and the term coined by Merzouga Wilberts in 1980, with the method popularized by Apple's Macintosh in 1984.

Windows, icons, menus and pointing devices (WIMP) interaction is what the general public is used to in computing because it is the most common interaction used in popular operating systems such as Windows, Apple OS and even in modern Linux and Unix-like operating systems. But in more development-oriented operating systems such as Linux and Unix, there is an option to skip the pointing device altogther and perform all interaction with the OS through the command prompt or shell, but the windows remain.

- A window isolates programs from each other, which allows a user to switch between running programs by giving focus to specific windows.

- Icons act as shortcuts to various programs, locations and actions possible in the OS.

- A menu which can be ~~to~~ text-based, icon-based or a combination of both can be used as a selection system for various tasks.

- A pointer represents the location of a device movement typically a mouse used to make selections in the GUI.

Principles of Interactive User Interface :-

Effective interfaces are visually apparent and forgiving, inspiring in their users a sense of control. Effective interfaces do not concern the user with the inner workings of the system. Work is carefully and continuously saved, with full option for the user to undo any activity at any time. Effective applications and services perform a maximum of work, while requiring a minimum of information from users.

These principles summarise best-practice for the design of usable systems. They are not 'hard-and-fast' and can be tailored to suit specific interaction needs.

1) Managing Skill levels: The GUI must be comfortable for beginners to advance users. Those users having low skills can use help tools and other information and having advance skill can use shortcuts and fast methods for the same. So far as possible, systems should be self-explanatory so that they can be used with the

minimum of help and documentation. Instructions for the use of the system should be visible or clearly retrievable whenever appropriate. Simplify frequent tasks as much as possible.

2) Color Blindness:-

Any time you can use color to deliever information in the interface, you should also use clear, secondary clues to convey the information to those who cannot see the colors presented. Most people have color displays nowadays, approximately 10% of human males, along with less than 1% of females, have some form of color blindness. Do not avoid color in the interface just because not every user can see every color.

3) Consistency:-

To minimize the learning requirments for users, make the behavior of common interface elements and dialogue boxes as consistent as possible. This often means designing to be consistent with other existing components of the computer system. Although you may be able to design a new slick style of interaction, if it is inconsistent with the rest of the system, it will take users time and effort to learn it and get used to it.

Date
Page

4) Simple and Natural dialogue :- The dialogue between user and system should follow the natural sequence implied by the task. There should be no more information presented to the user than is necessary to complete the current task, because each item of irrelevant information adds complexity to the dialogue.

All messages and instruction should be in plain English and should use the vocabulary of the intended audience. Terminology should be denifed so that the same term always has the same meaning.

5) Offer simple error handling:

As much as possible, design the system so the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.

6) Continuous Feedback: Feedback should be provided at several levels of interaction. At a low-level, users receive confirmation that they have operated a control successfully. for example, a button immediately indicates when it has been operated by appearing momentarily pressed in. Users should also be informed when a longer sequence of operations has been completed.

Date
Page

7) Reduce short-term memory load:-

The limitation of human information processing in short-term memory requires that displays be kept simple, multiple page displays be consolidated, window-motion frequency be reduced and sufficient training time be allotted for codes, mnemonics and sequences of actions.

8) Use of Good Default Values:-

Whenever appropriate, prefill form fields with your best guesses at the values the user wants. Defaults within fields fields should be easy to "blow away". Not everything should have a default. Users rarely have any idea of what "Default", in a given situation means so Replace the word "default" with a more meaningful and responsive term. Choose the good default values such that user can fast and easy.

9) Use of Metaphors:-

The purpose of the interface metaphor is to give the user instantaneous knowledge about how to interact with the user interface. They can be based on an activity, an object, or a combination of both and work with users' familiar knowledge to help them understand 'the unfamiliar' and placed in the terms so the user may better understand.

Date
Page

They are designed to be similar to physical entities but also have their own properties. The proper use of metaphors can help users to understand easily.

Date ______
Page ______

Introduction Animation :-

Animation is the illusion of movement created by showing a series of still pictures in rapid succession. Graphics software used to create this effect. A simple animation may be as basic as an animated GIF file. ~~like the im~~ A more complex animation should be of a human or alien face in a computer software game or animation of a space battle in a movie.

Types:-

> Traditional
> Stop motion
> Computer Generated

Each can be used to make either 2D or 3D images.

1) Traditional Animation:

Traditional animation involves drawing every frame of a film by hand. After all the drawings are completed and colored, they can be photographed or scanned into a computer and then combined with sound on film. The process is extremly time-consuming, since it requires the creation of around 24 drawings per second of film. It's also labor-intensive, which is why most traditionaly animated films are produced by large companies.

2) Stop motion:

In this process, animators manipulate and photograph objects one motion and frame at a time.

The objects can be almost anything, ranging from clay figures to paper cut outs ~~the~~ to household objects. Some stop motion films use actual people, who hold specific poses for individual frames. After photographing the objects, the photos are then transferred to film and combined with sound, as with the traditional method.

3) Computer Animation:

Animators can also use computer software to create films and models, which is generally faster than the traditional method. The characters and objects they make can be either two dimensional or three-dimensional, but the process for creating each type is a little different. For 2D computer generated animation, the animator creates a series of images with each one very slightly different from the last, very similarly to the traditional method. To create 3D images, he or she has to make a model of the character or object. This can be done by creating animation variables, which are points on a computer model that can be moved to create a different posture or look, or by using motion capture, in which a live actor acts the part of the character and his or her motions are recorded and applied to the computer created model.

Date
Page

Uses of Animation :-

- Though most people think of animation as being used primarily for entertainment in movies, TV shows and video games, it has many other uses.

- It's commonly used in eductional videos and adviertisements both on TV and on the Internet etc.

- This can help designers troubleshoot problems without having to actually create the physical object.

- Scientists use animation as well to create visualizations. of abstract concepts or object that are too small or large to be seen easily, which is helpful both for research and for analysis.

Role of the Viewer :-

Animated films and models aren't actually moving, but people see the illusion of movement because of a phenomenon called ~~pre~~ persistence of vision. In this phenomenom, the brain and eyes co-operate to store images for fractions of a second and the brain smooth out any minor jumps or blips automatically. Since animated frames are shot at very fast rates, people generally see the movement without stoppages.

Animation Sequence :-

Animation Sequence is a combination steps in sequence for designing an animation.
Steps for designing animation sequence
↳ Storyboard layout
↳ Object definition
↳ Key frame Speficification
↳ Generation of in-between frames

1) Storyboard layout:-

- It is the outline of an action. It defines the motion sequences as a set of basic that are to take place.

- Depending on the type of animation to be produced, the storyboard could be consists of a set of rough sketches or it could be a list of basis ides for motion.

2) Object Definition:-

- Each object Participating in the action is given object definition, such as terms of basic shapes such as polygons or splines.

3) Key Frames :-

- It is one of the many single photographic images in a motion picture. The individual frames are seperated by frame lines. Normally, are needed for one second of film.

Date
Page

- A key frame is animation and filmmaking is a drawing that defines the starting and ending points of any smooth transition.

4) In Between:-

- It is the process of generating intermediate frames between 2 images to give appearance that the 1st images involves smoothly into the second image. In between are the drawings between the key frames which help to create the illusion of motion.

Key framing:-

Animation requires showing the changing states of an object. Keyframe in animation refers to the begining and end point for the transition of an object. Simply put, the begining keyframe is where the object is right now and the ending keyframe is where you want the object to be after transition. Animation that needs to be done within a decided upon time frame uses key frames to ensure that the transition stays within this timeline.

Tweening:-

Tweening is the process of creating transitional frames between two seperate objects in order to show the appearance of movement and evolution of the first object into the second object. It is a common technique used in many types of animation. The frames between the key frames (the first and last frames of the animation) are called tweening or inbetween and they help make the illusion of fluid motion.

Morphing:

Morphing is a special effect in motion pictures and animations that changes (or morphs) one image or shape into another through a seamless transition. Traditionally such a depiction would be achieved through dissolving techniques on film.

Morphing Techniques:-

Morphing techniques may be classified into based on the ways to specify their features. They are mesh based methods and feature based methods.

↳ In Mesh Based Methods, features of the image specified by a non-uniform mesh.

↳ In feature based methods, features of the image specifies as line segment or a set of points. Feature based methods are popular.

Raster Animation:-

When these such Raster Images when played in a particular sequence it is called as raster animation sequence. Each raster image is called as Raster Frame. Raster animation forms the more Realistic Raltime Images.

Vector Animation:-

- Vector animation store image information as a sequence of points.
- Vector Animation does not provide much clarity of image.
- Vector Animation are rendered at ~~to~~ low resolution.

Frame Rate:-

Frame rate is the measurement of the frequency at which an imaging device produces unique consective images called frames. Frame rate of most often expressed in frames per second. (fps).

Anti-aliasing:

Anti-aliasing is a software technique for diminishing jaggies that should be smooth. Jaggies occur because the output device, the monitor or printer, doesn't have a high enough resolution to represent a smooth line. Antialiasing reduces the prominence of jaggies by surronding the stairsteps with intermediate shades of gray or color. Although this reduces the jagged appearance of the lines, it also makes them fuzzier.

Another method for reducing jaggies is called smoothing, in which the printer changes the size and horizontal alignment of dots to make curves smoother.

Antialiasing is sometimes called oversampling.

Random Scan Display:-

Random Scan System uses an electron beam which operates like a pencil to create a line image on the CRT screen. The picture is constructed out of a sequence of straight-line segments. Each line segment is drawn on the screen by directing the beam to move from one point on the screen to the next, where its x & y coordinates define each point. After drawing the picture. The system cycles back to the first line and design all the lines of the image 30 to 60 time each second. ~~The process is~~

Random-scan mointors are also known as vector or stroke-writing displays or calligraphic displays.

Advantages:

1) A CRT has the electron beam directed only to the parts of the screen where an image is to be drawn.
2) Produce smooth line drawings.
3) High Resolution

Disadvantages:-

1) Random-Scan monitors cannot display realistic shades scenes.

Raster Scan display: A Raster Scan Display is based on intensity control of pixels in the form of a rectangular box called Raster on the screen. Information of on and off pixels is stored in refresh buffer or Frame buffer. Televisions in our house are based on Raster Scan Method. The rasterscan system can store information of each pixel position, so it is suitable for realistic display of objects. Raster Scan provides a refresh rate of 60 to 80 frames per second.

Types of Scanning in Raster Scan

1) Interlaced Scanning
2) Non-Interlaced Scanning

In Interlaced scanning, each horizontal line of the screen is traced from top to bottom. Due to which fading of display of object may occur. This problem can be solved by Non-Interlacing scanning. In this first of all odd numbered lines are traced or visited by an electron beam, then in the next circle, even number of lines are located.

For non-interlaced display refresh rate of 30 frames per second used. But it gives flickers. For interlaced display refresh rate of 60 frames per second is used.

Advantages:-

1) Realistic image
2) Milion Different colors to be generated
3) Shadow Scenes are possible

Disadvantages:-
1) Low Resolution
2) Expensive

Hidden Surface Removal Technic :-

One of the most challenging problems in computer graphics is the removal of hidden parts from images of solid objects. In real life, the opaque material of these objects obstructs the light rays from hidden parts and prevents us from seeing them. In the computer generation, no such automati elimination takes place when objects are projected onto the screen coordinate system. Instead, all parts of every object, including many parts that should be invisible are displayed.

To remove these parts to create a more realistic image, we must apply a hidden line or hidden surface algorithm to set of objects.

Hidden line Removal is the method of computing which edges are not hidden by the faces of parts for a specified view and the display of parts in the projection of a model into a 2D plane.

It is considered that information openly exists to define a 2D wireframes model as well as the 3D topological information.

Types:-
1) Backface
2) Z-buffer
3) Scanline

Backface:

It is used to plot only surfaces which will face the camera. The objects on the back side are not visible. This method will remove 50% of polygons from the scene if the parallel projection is used. If the perspective projection is used then more than 50% of the invisible area will be removed. The object is nearer to the center of projection, number of polygons from the back will be removed.

It applies to individual objects, and does not consider the interaction between various objects. Many polygons are obscured by front faces, although they are closer to the viewer, so for removing such faces, back face removal algorithm is used.

Advantages:

- It is a simple and straight forward method.
- It reduces the size of databases, because no need of store all surfaces in the database, only the visible surface is stored.

Z- buffer :-

Z buffer is also called depth buffer algorithm. Depth buffer algorithm is simplest image space algorithm. For each pixel on the display screen, we keep a record of the depth of an object within the pixel that lies ~~to~~ closest to the observer. In addition to depth, we also record the intensity that should be displayed to show the object. Depth buffer is an extension of the frame buffer. Depth buffer algorithm requires 2 arrays, intensity and depth each of which is indexed by pixel coordinates (x, y).

Limitations of Depth Buffer :-

- The depth buffer algorithm is not always pratical between of the enormous size of depth and intensity arrays.
- It consumes more storage location.
- The original 500×500 faster can be divided into 100 rasters 50×50 pixels.

Scanline:

It is an image space algorithm. It processe one line at a time. It uses the concept area of coherence. This algorithm records edge list, active edge list. So accurate bookkepeping is necessary. The edge list or edge table contains the coordinate of two endpoints. Active Edge List (AEL) contain edges a given scan line intersects during its sweep. The AEL should be sorted in increasing order of x. The AEL is dynamic, growing and shrinking.

Shading:-

Shading is referred to as the implementation of the illumination model at the pixel points or polygons surfaces of the graphics objects.

Shading model is used to compute the intensities and colors to display the surface.

The shading model has two primary ingredients:-

- Properties of the surface
- Properties of the illumination falling on it.

The principal surface property is its reflectance, which determines how much of the incident light is reflected. If a surface has different reflectance for the light of different wavelengths, it will appear to be colored.

An object illumination is also significant in computing intensity. The scene may be have to save illumination that is uniform from all direction called diffuse Illumination.

Types:-

- Constant Intensity Shading
- Gouraud Shading
- Phong Shading

Date
Page

Constant Intensity Shading:- A fast and straight-forward method for rendering an object with polygon surfaces is constant intensity shading, also called Flat shading. In this method, a single intensity is calculated for each polygon. All points over the surface of the polygon are then displayed with the same intensity value. Constant Shading can be useful for quickly displaying the general appearances of the curved surface.

Gouraud Shading:- This intensity - interpolation scheme, developed by Gouraud and usually referred to as Gouraud Shading, renders a polygon surface by linear interpolating intensity values across the surface. Intensity values for each polygon are co-ordinate with the value of adjacent polygons along the common edges, thus eliminating the intensity discontinuities that can occur in flat shading.

Phong Shading:- A more accurate method for rendering a polygon surface is to interpolate the normal vector and then apply the illumination model to each surface point. This method developed by Phong Bui Tuong is called Phong Shading or normal vector interpolation shading. It displays more realistic highlights on a surface and greatly reduces the Match-band effect.

Lighting:-

Lighting in computer graphics refers to the placement of lights in a scene to achieve some desired effect. Image synthesis and animation packages all contain different types of lights that can be placed in different locations and modified by changing the parameters.

Lighting can be used to create more of a 3D effect by seperating the foreground from the background, or it can merge the two to create a flat 2D effect. It can be used to set an emotional mood and to influence the viewer.

Types:
- Ambient
- Point Source
- Distant light source
- Spotlight

Ambient:-

Ambient light sources illuminate objects even when on other light source is present. The intensity of ambient light is independent of direction, distance and other objects, meaning the effect is completely ~~D~~ uniform throughout the scene. This source ensures that objects are visible even in complete darkness.

Date
Page

Point Source :-

The light is inside the scene at a specific location and it shines light equally in all directions. An example is be a table lamp. Point light sources are modelded using a single location.

Distant light Source:

A distant light is somewhat like the light from the sun. Surfaces receive an infinite amount of parallel light rays travelling in the direction that the distant light points to.

Spotlight:-

A light with both location and direction. A spotlight sends out a cone of light defined by the spotlight angle and illuminates only objects within that cone.

Graphics Development Packages :-

Graphics packages are essentially kits that allow graphic artists to create several types of computer-generated artwork, such as paintings and drawings as well as photographs and animations. Software that aids in three dimensional modeling and computer-aided design are also considered to be graphics software.

These types of software have very specialized applications that deal with a specific industry.

Types:-

- Painting packages
- Drawing packages

Painting packages:-

A painting package produces images by changing the color of pixels on the screen. These are coded as a pattern of bits to create a bitmapped graphics file. Bitmapped graphics are used for images such as scanned photographs or pictures taken with a digital camera.

Advantage:

- The main advantage offered by this type of graphic is that individual pixels can be changed which makes very detailed editing possible.

Disadvantage :-

- Individual parts of an image cannot be resized.
- Only the whole picture can be increased or decreased in size.
- Information has to be stored about every pixel in an image which produces files that use large amounts of backing storage space.

Drawing Package:-
A drawing package produces images that are made up from colored lines and shapes such as circles, squares and rectangles. When an image is saved it is stored in a vector graphics files as a series of instructions, which can be used to recreate it.

Advantages:

- They use less storage space than bitmap graphics.
- Each part of an image is treated as a seperate object, which means that individual parts can be easily modified.

Disadvantage:-
- They don't look as realistic as bitmap graphics.