Computer Graphics — Computer Graphics refers to the creation, storage & manipulation of pictures of drawing using a digital computer.

By graphics we will refer to any sketch, drawing special artwork or other material to pictorially depict and object as pictures otherwise convey information, as a supplement to or instead of written discription. The sketch may be cartoon or land scape building, the sketch may be cartoon. electrical n/w or human anatomy. It may be just a few irregular line or 2D or 3D drawing.

Pixels — Pixel are the basic building block of the graphical display we can also call it picture element.

'Pixel' is a smallest size object or color spot that can be displayed or addressed on a screen. Any image that can be displayed on the monitor is made of thousands of pixel.

Note — Pixel is the minimum area on the screen can computer display screen which can ignite.

Dot — The internal surface of the monitor screen is coated with red blue & green phosphorous material that glow when struck by the stream of the electron. The coated material is arranged into an array of millions of tiny cells. Red-

blue & green. These coloured cells are usually called dots.

1- Advantage of Computer Graphics-
It provides tools for producing pictures not only of concrete real world objects but also of abstractions, synthetic objects such as mathematical surface in 4D & of data that have no inherent geometry such as survey result.

2- It has the ability to show moving pictures & thus it is responsible to produce & animation with computer graphics

3- The third advantage with computer graphics user can also control any animation speed position of the view, the "goniometric" relationship the object in the same to one another.

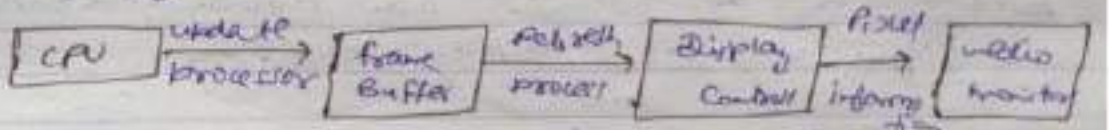
4- In computer graphics provide tool called "motion dynamics". With this tool user can move object with respect to stationary object observer.

5- The computer graphics also provides facility called "update dynamics". With the help of update dynamics it is responsible to change the type, colour or other properties of object.

6- With the recent development of digital signal processing (DSP) & audio synthesis chips the interactive graphic cannot provide feedback along with the graphical feedbacks to make simulated environment even more realistic.

Component of computer Graphics:—
Interactive computer Graphics is consist of three components such as—

1. Digital memory Buffer
2. TV monitor
3. Display controller.



Frame Buffer (Digital memory Buffer) — This is place where image or pictures are stored as an array (matrix of 0 & 1) 0 represent darkness & 1 represent the image or pictures.

Frame Buffer is the video RAM (VRAM) that is used to hold or make the image displayed on the screen the amount of memory required to store the image depends primarily on the resolution of the screen image & also the colour or the screen image is also the colour depth used per pixel the formula to calculate how much video memory is required at a given resolution & width.

memory in MB = X-Resolution × Y-Resolution × 8 × bit per pixel / 8 × 1024 × 1024

Display controller — It is the interface b/w memory buffer & TV monitor. The main fun^c of this is the content of frame buffer to the monitor. The display / controller reads each successive bit of data from the frame buffer memory & convert 0's & 1's into corresponding video signal. This signal is then fed to the TV monitor to produce black & white picture on the screen. Now display controller is recognised as display card.

T.V monitor (video monitor) :— monitor helps to view the display & make use of CRT.

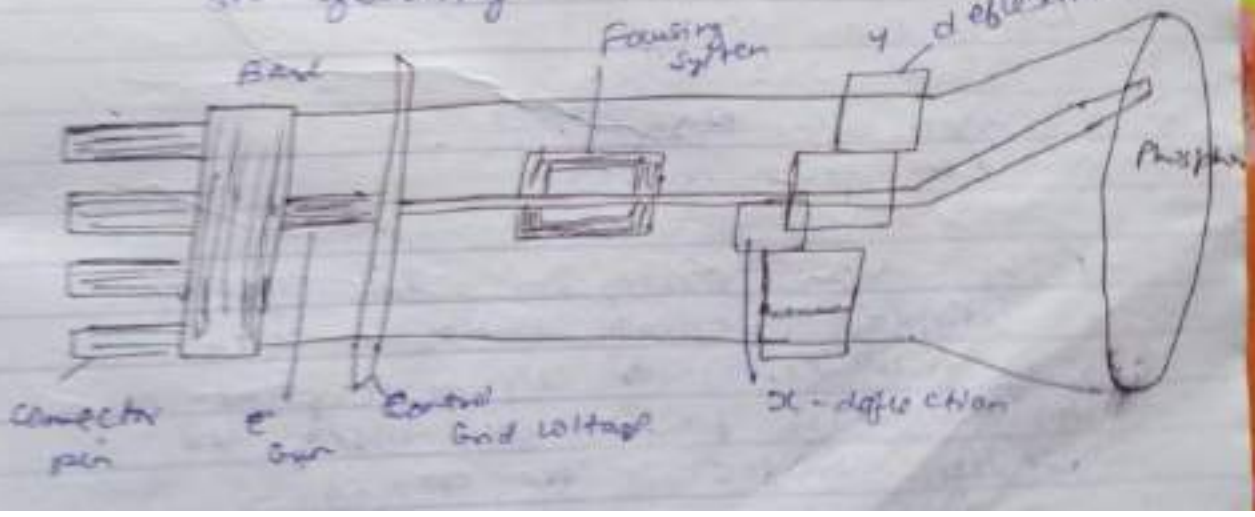
Application of Computer Graphics :—

1) Computer aided design for graphics (CAD / CADD)
2) Present recent graphics
3) Entertainment
4) Computer added learning (CAL)
5) Computer Art
6) Office automation & desktop publishing
7) Medical applications
8) Internet
9) Simulation & virtual reality
10) Geographical information system (GIS)

Resolution — Resolution is a measure used to describe the sharpness & clarity of an image or picture & is often used as a metric for judging the quality of monitor, printer, digital image & various other display technologies.

The term is especially applicable & also in the entertainment media to distinguish the visual quality of movies & to distinguish the high definition & standard definition movies.

CRT (Cathode Ray Tube) :- The primary output device in the graphical system is the video monitor. The main element of the video monitor is the cathode ray tube shown in the following -



Operation of CRT :-

1- The electron gun emits the electron
2- The electron beam passes through focusing & deflection system that direct it towards specified position on the Phosphor coated screen.
3) When the beam strikes the screen, the phosphor emit the small spot of light at each position contacted by the electron beam.
4) It redraw the pictures by directing the electron beam back over the same screen points quickly.

There are four ways by which can display an object on screen

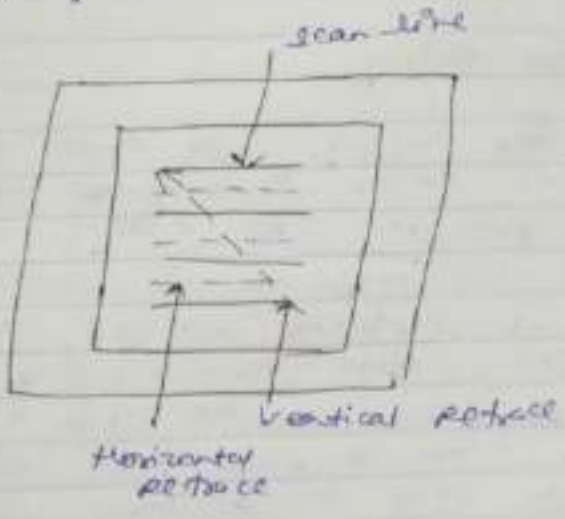
1 Raster scan display
2 Random scan display
3 direct view storage tube
4 Flat panel display

Raster scan display :- This type of display basically employes a cathode ray tube (CRT) or liquid crystal display (LCD) panel for display the viewing surface of the CRT is coated with a layer of array phosphor dots. At the back of CRT a set of

the vertical deflection for the both horizontal & vertical plates the electron emission is stopped.

Note- Electron gun is controlled by the video card & attached in the circuit. All these happen extremely quickly & the entire screen is drawn in a fraction (1/60) of a second.

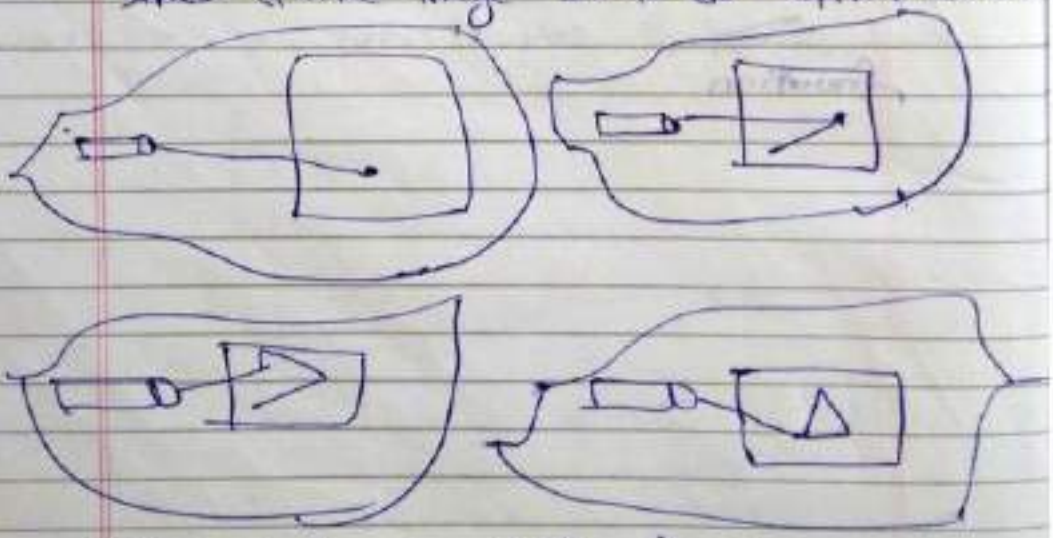
electron guns (cathode) which produce controlled stream of objects. The phosphor dots glow when struck by high energy electrons to produce a picture on the screen, these deflected electron beams start at the top of the screen & scan speedily from left to right along the row of phosphor dots. At the end of line it means it moves to the left most dots of the next line.



Thus, it covers the entire screen & start scanning again after completing each line, when moves to next line is called horizontal retrace. Scanning each line, when the beam reaches at the right bottom corner it move to starting point to scan the screen again & again. when it is moves to the first line it is called

Random Scan display

Random scan display also known as vector scan Technique. 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 redraw all the lines of the image 30 to 60 time each.



NOTE: Random scan display also known as stroke-writting display or calligraphic display

Point and Lines —

We can specify the point with an ordered pair of numbers (x, y where x is the horizontal distance from the origin & y is the vertical distance from the origin).

To specify a line, we need two such points.

DDA (Digital Differential Analyzer) Algorithm —

The vector generation addition algorithm (curve generation algorithm) which step along the line or (curve) to determine the pixel to which should be turned on are sometime called digital differential analyzer. The name comes from the fact that we use the same technique as a numerical method for solving differential equation.

We know the equation of the straight line is $y = mx + c$ where m = slope, c = intercept

The slope btw (x_1, y_1) and (x_2, y_2) is =

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

or,

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

Now, if the points are (x_F, y_F) and (x_{End}, y_{End})

Drawing a line starting from (x_S, y_S) and ending (x_e, y_e), so initially we have to calculate the slope of straight line, starting & ending points

$$m = \frac{y_e - y_s}{x_e - x_s}$$

For the different value of m, different calculation are required —

Case-1 For the value of $(m < 1)$, then the X-coordinate will change in unit intervals (i.e. increment in x axis only)

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

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

$x_{k+1} - x_k = 1$ — unit increment

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

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

Case-2 For the value of $(m > 1)$, then the y-coordinate will change in unit intervals, so

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

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

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

$$\boxed{x_{k+1} = \left(\frac{1}{m}\right) + x_k}$$

Case 3 For the value of $(m = 1)$, then the X & Y coordinate will change in unit intervals, so

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

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

Note - Sometimes the value of x & y may Result fractional values, but we have to select a pixel from the display with an integer. To convert real values to integers in each iterations ground function (Round ()) are needed. It will take the real values of the pixel co-ordinate & change the values of the nearest integer value, so that it can be seen.

1/8/19 * Example of DDA Line Algorithm —

Draw a straight line from (0,0) to (4,5)

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

$$m = \frac{5-0}{4-0} = 1.25$$

$1.25 > 1$

greater than

The slope of m > 1 then y moves in unit intervals & x moves $x_k + \frac{1}{m}$, so the next point is

$$(x_{k+1}, y_{k+1}) = (x_k + \frac{1}{m}, y_k + 1)$$

$$m = \frac{5}{4} = \frac{1}{m} = 0.8$$

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X	Y	X-plot	Y-plot	(x,y)	Actual value of X
0	0	0	0	(0,0)	X=0
.8	1	1	1	(1,1)	ceil (0.8)
1.6	2	2	2	(2,2)	ceil (1.6)
2.4	3	2	3	(2,3)	floor(2.4)
3.2	4	3	4	(3,4)	floor (3.2)
4.0	5	4	5	(4,5)	X=4

Advantage of DDA algorithm

> DDA algorithm is faster than the direct use of line equation since it calculates points on the line without any floating point multiplication.

> It is simplest algorithm and does not require special skills for implementation.

Disadvantage of DDA algorithm -

> It is orientation dependent, due to this the point accuracy is poor.

> A floating point addition is still needed in determining each successive point which is time consuming. Further more, cumulative error due to limited precision in the floating point representation may cause calculated

Circle generating algorithm:

Circle: A circle is locus of all points equidistance from a central point

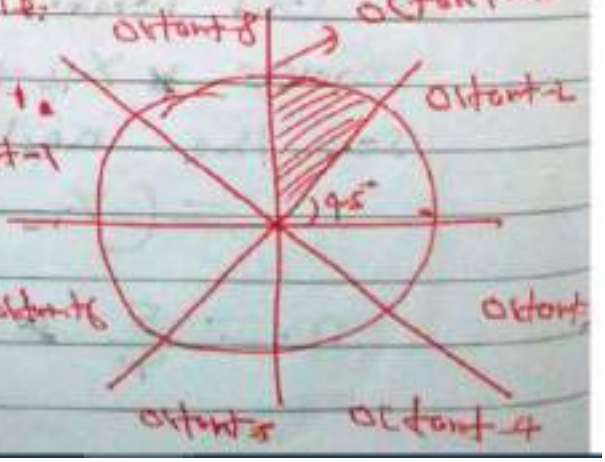
Definition Related to circle:

Chord: A line segment within a circle that touches 2 points on the circle.

Arc: A curved line that is the part of the circumference of a circle.

Circumference: The distance around the circle

Mid point circle Algorithm:



In the diagram we can divide a circle into 8 different octants.

- Here we have to find points for the first octant, until $X >= Y$ then it indicates the end of octant 1.
- The first coordinate point is $(r, 0)$ to draw the circle, the x increasing at unit interval, then y always decreasing along the value of x.

The next point we either $(x_k + 1, y_k - 1)$ and (x_{k+1}, y_k) so the mid point of these two points (x_m, y_m) $x_m = \frac{x_{k+1} + x_{k+1}}{2}$

$$y_m = \frac{y_{k-1} + y_k}{2}$$

$$x_m, y_m = \left(x_{k+1}, y_k - \frac{1}{2}\right)$$

We know that the equation of circle is

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

putting the (x_m, y_m) in the circle equation we get, decision parameter

$$P_k = (x_k + 1)^2 + \left(y_k - \frac{1}{2}\right)^2 - r^2$$ initial coordinate

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and next coordinate

$$P_{k+1} = (x_{k+1} + 1)^2 + \left(y_{k+1} - \frac{1}{2}\right)^2 - r^2$$

Therefore

$$P_{k+1} - P_k = (x_{k+1} + 1)^2 + \left(y_{k+1} - \frac{1}{2}\right)^2 - r^2 - (x_k + 1)^2 - \left(y_{k+1} - \frac{1}{2}\right)^2 + r^2$$

$$= (x_{k+1} + 1)^2 + \left(y_{k+1} - \frac{1}{2}\right)^2 - (x_{k+1})^2 - (y_{k+1})$$

$$= (x_k+1)+1)^2 + (y_{k+1}-\tfrac{1}{2})^2 - (x_k+1)^2 - (y_k-\tfrac{1}{2})^2$$

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

$$P_{k+1} - P_k = 2(x_k+1) + [(y_{k+1})^2 - y_k^2] - [y_{k+1} - y_k] + 1$$

$$P_{k+1} = P_k + 2(x_k+1) + [(y_{k+1})^2 - (y_k)^2] - (y_{k+1} - y_k) + 1$$

Now the starting point is $(0, r)$ so,

$x_k = 0$ & $y_k = r$ for the initial decision parameter

$$P_0 = (0+1)^2 + (r - \tfrac{1}{2})^2 - r^2$$

$$P_0 = 1 + r^2 + \tfrac{1}{4} - r^2 - r$$

$$P_0 = \left(\tfrac{5}{4} - r\right)$$

$$P_0 = (1.25 - r)$$

$P_0 = (1-r)$ (avoid fractional part)

Now, if $P_k \geq 0$ then —

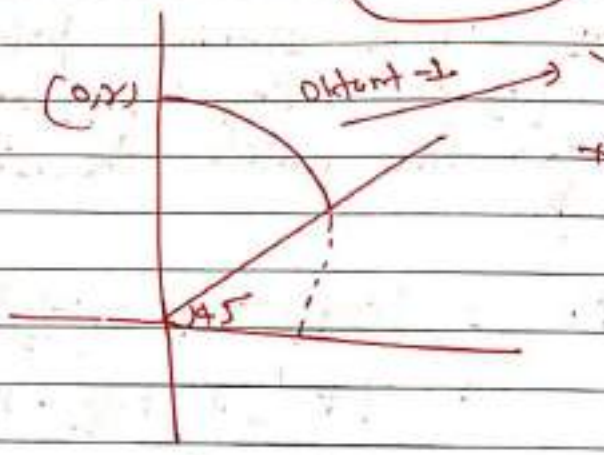
$$y_{k+1} = y_k - 1$$

Next point is (x_k+1, y_k-1)

else $P_k < 0$ then

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

Next point is (x_k+1, y_k)



Example: Problem on midpoint circle Drawing Algorithm.

Solution- Draw a circle with radius 8-unit.

$P_k = 1-r$

$P_{k+1} = P_k + 2(x_k+1) + [(y_{k+1})^2 - (y_k)^2] - (y_{k+1} - y_k) + 1$

Iteration	x_k, y_k	P_k	x_{k+1}, y_{k+1}	P_{k+1}
0	(0,8)	-7	(1,8)	-4
1	(1,8)	-4	(2,8)	1
2	(2,8)	1	(3,7)	-6
3	(3,7)	-6	(9,7)	3
4	(4,7)	3	(5,6)	2
5	(5,6)	2	(6,5)	5

Terminated

$x_{k+1} > y_{k+1}$

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(1) $-7+2(0+1)+(64-49)$
$= 8-8+1 = -4$

(2) $-4+2(1+1)+(64-64)+(8-8)+1 = 1$

(3) $1+2(2+1)+(64-49)-(9-8)+1 = 6$

(4) $-6+2(3+1)+(49-49)-(7-7)+1 = 3$

(5) $3+2(4+1)+(36-49)-(6-7)+1$
$= 2$

1- Quadrant (+,+)	2- Quadrant (-,+)	3- Quadrant (-,-)	4- Quadrant
(0,8)	(0,8)	(0,8)	(0,-8)
(1,8)	(-1,8)	(-1,-8)	(1,-8)
(2,8)	(-2,8)	(-2,-8)	(2,-8)
(3,7)	(-3,7)	(-3,-7)	(3,-7)
(4,7)	(-4,7)	(-4,-7)	(4,-7)
(5,6)	(-5,6)	(-5,-6)	(5,-6)
(6,5)	(-6,5)	(-6,-5)	(6,-5)
(7,4)	(-7,4)	(-7,-4)	(7,-4)
(7,3)	(-7,3)	(-7,-3)	(7,-3)
(8,2)	(-8,2)	(-8,-2)	(8,-2)
(8,1)	(-8,1)	(-8,-1)	(8,-1)
(8,0)	(-8,0)	(-8,0)	(8,0)