COMPUTER GRAPHICS & MULTIMEDIA

Graphics → still images

Animation → artificially moving objects.

Morphing → one object will be changed into another object

(6m) 1) (2m) Survey of computer graphics: Application of Graphics

⇒ 1. CAD → Computer Aided Design. (To design machine, textiles, buildings, aircraft,

⇒ 2. wireframe displays (To see internal layers of particular objects)

↓

Advantage: * we can see the effects of interactive adjustments.

* we can also use for personalized symbols.

⇒ Animation can be used in CAD applications.

* can be used in vechille monitoring.

* virtual reality ⇒ by giving lightning effects, we can walk through. see the final project.

CAD → defn
usage

wireframe ⇒ animation in virtual reality
walk through.

2) Presentation Graphics → imp applⁿ is illustrate the report :: representing cricket scores in bar charts, histograms

Eg: (runs secured in respective overs)

↓

in bar chart

* represented / displayed 35mm slide & projector.

Eg:- bar charts, pie charts

★ To represent reports.

3. computer art (or) art :-

i) fine-art ⇓ ii) Commerical art

artists will be using paint brush program to draw picture in paint monitor screen.

Animation :- Paint-brush will be using stylus.

this uses pressure sensitive stylus for electronic painting

★ Animation used in advertising. (frame by frame)

★ Each frame is saved as image file.

★ When all the frames are stored, it will be

★ changed to film or video in buffer.

24 → film animation per second → 24 frames/sec.

30 → frames for playback. → 30 frames/sec.

↓ in video monitor

4. Entertainment :-

It is used in movies, television, making motion pictures, videos etc.,

Morphing :- Transformation of one person or object into another.

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5) Education and Training:

* used for pilot training, airtraffic control.
* will have flight simulators

⇒ uses Keyboard ... as input portal

⇒ Help to understand system in better way.

⇒ modelling of physical system

6) Visualization:

There are two types of visualization:

* scientific visualization ⇒ medical, engg data
* business (non scientific) ⇒ commerce, industries.

It is used to handle large amount of data.

⇒ effective visualization ⇒ collection of data
↓ depends on
Characteristics of data.

characteristics:

* noise (unwanted signal) → remove noise

⇒ collection of data is represented in scalars & vectors.

color coding → way to visualize dataset.

Image processing techniques are combined with computer graphics

7) Image Processing : (2m)

Computer graphics ⇒ we will create pictures. use computer to

applying techniques to modify or interrupt the existing pictures. interpret

advantages / applications :

* improving image quality.
* image perception.

robotic (machine perception)

To apply image processing :

Steps :

⇒ Digitize the photo (scan the photo and inserting it into a device)

⇒ we can rearrange parts of picture.

⇒ improve the quality of picture.

⇒ color can be added.

retouching, rearranging

medical application :

Tomography → similar to X-ray photography.

used for seeing the views for cross-sectional physiological system.

CT, PET

Computer / X-ray / Photography.

PET - Position Emission Tomography.

CT - Computer Tomography.

used in medicine, ultrasonic fields mainly in surgeries

can combine Image processing + computer graphics to design artificial limbs.

we can try-out different surgical Applications.

8) GUI - Graphical User Interface :-

* icon → graphical symbol is designed to easily interpret the application.

advantages :-

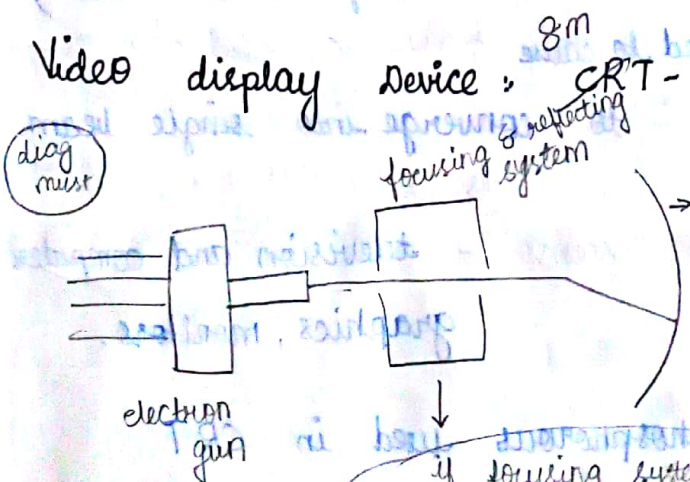
less screen space.

easily understandable.

menu → text description with icon.

* window manager :- managing multiple windows.

Video display Device :- CRT - cathode Ray Tube.



(phosphorous is +ve, electron is -ve ∴ it attracts & displays picture)

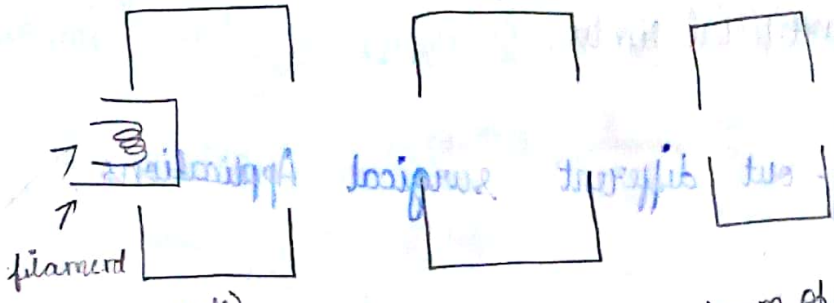
if focusing system is not there, electrons will scatter and repel each other

To keep phosphorous glowing :- i) redraw picture (or) ii) refresh CRT

Refresh CRT :

it keeps the phosphorous glowing to redraw the picture.

components of CRT :



filament (cathode) is heated so that it emits beam of electrons which passes through focusing system and reaches phosphorous.

Two components of electron gun :

* heated metal cathode. (cathode is +ve and electrons are negative they react and produces picture.
* Control grid (At high negative voltage applied to repel electron)

↓

control brightness of grid (if more electron passes, brightness is more)

Focusing system is needed to ~~cause~~ fore the electro beam as it strikes the phosphorous

Focusing electrons to converge into single beam

electrostatic focusing systems – television and computer graphics, monitors.

Different kinds of phosphorous used in CRT

2nd Persistence ⇒ even after the CRT beam is removed, how much long time the phosphorous screen is glowing.

refer book for defn of persistence:

Time it takes to decade the emitted light to $\left(\frac{1}{10}\right)^{th}$ of its original glow.

Low persistence phosphoreus is used to avoid flicker.

High persistence phosphoreus used in static ....

Resolution :-

maximum no of pixels can be displayed without overlapping in CRT is called resolution.

High Quality system resolution :- 1280 × 1024

Aspect ratio :- vertical as well as horizontal

$\left(\frac{3}{4}\right)$ → vertical

each screenpoint → PIXEL → element
↓
picture

plotted with 3 points & horizontal plotted with 4 points

8M

Rasterscan Display :-

↓

→ top to bottom scan

* most common form of graphics monitor which uses CRT technique
* we scan by top to bottom
* picure definition is stored in refresh buffer or frame buffer.
* Each screenpoint in graphics is known as pixels.

* Capabilities of Rasterscan is for realistic display.

Eg:- Home television set, printer are the example.

* provides intensity range ON or off.

* In black & white each screenpoint is on or off.

* 1 bit per pixel → [if its 1 → ON
0 → OFF]

In black & white,

One bit per pixel → BITMAP
multiple bits per pixel → PIXMAP.

Horizontal retrace & vertical retrace :- (retrace)

At the end of each scanline & (frame), electron beam returns to left side of the screen to begin with next scanline.

Interlaced refresh procedure :- (2m) (X)

Horizontal →

First pass :- beam will scan across every scanpoint

Second pass :- all the leftovers are scanned by vertical

Application :- To avoid flickering

Random scan display / Vector display / stroke writing / calligraphic display

Other names

Only the place where you are going to draw the picture is alone exposed to be spotted by beam of electrons.

Random scan display: Eg. pen plotter

Refresh display file :→ it is a picture defn [using set of line drawing commands]

display list / display file / refresh buffer.

Difference between rasterscan & randomscan

(2M) Rasterscan	Randomscan
* realistic display	* Used for line drawing applications
* Jagged lines ↓ Jagged ∈ (irregular shape)	* It is not realistic. ⇒ It cannot realistic shaded values.
* To remove this we use anti-aliasing	* it is not storing intensity value
* It stores intensity values	* smooth drawing.

Jagges → words or letters which are cut or damaged.

↓ to remove we use anti-aliasing.

color CRT monitor :⇒ used in color TV

RGB → 24 bits per pixel. CRT → needs refresh

DVST → no refresh needed

↓

Direct View Storage Tube

Depenetration method

Shadow mash "

(once picture is drawn, we can view them)

24 bits / pixel of RGB value.

DVST → no refresh is needed.

CRT → need "

flat panel → emissive → electrical energy to light energy (plasma panel, LED)

↘ non-emissive (LCD)

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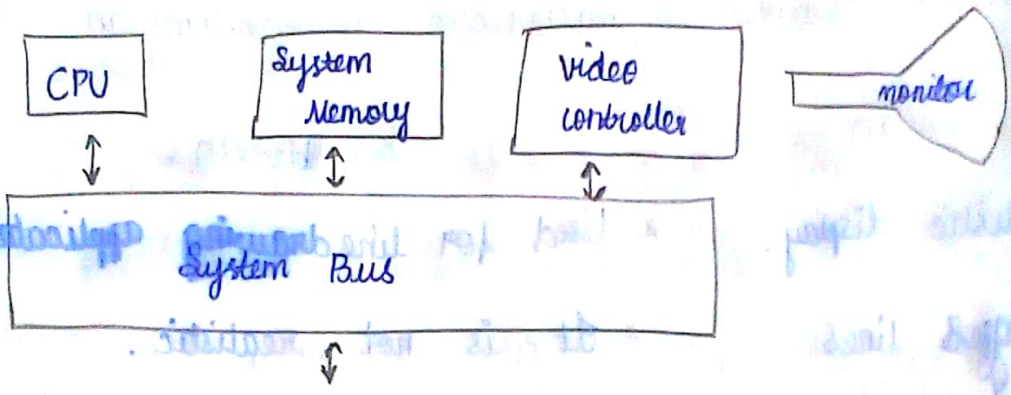
Raster Scan System:

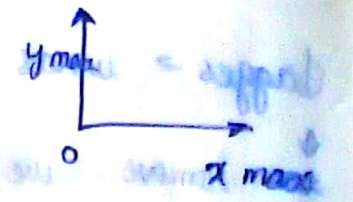


Video Controller : controls the operations of display device.
or
display controller

Frame buffer location → cartesian co-ordinates

↓

represents in x & y axis (2D)



x is positive values incremented to right

y is " " " from bottom to top.

Scan-lines : y max at top / y max to 0

0 → x max

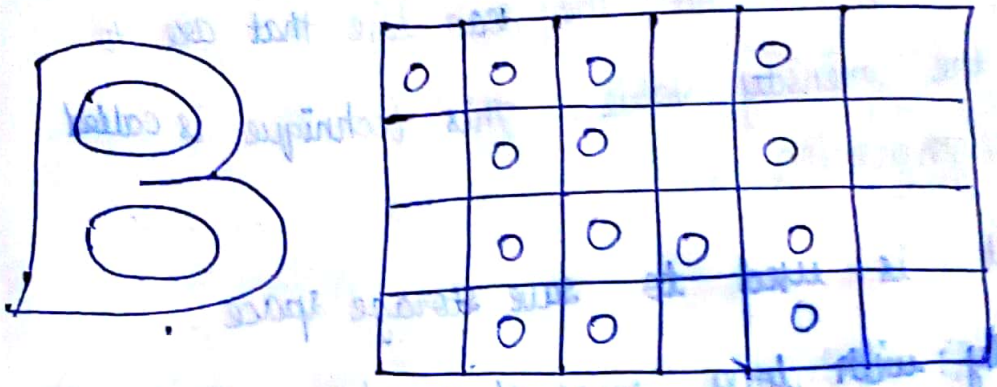
two register is used to store coordinates of x pixel.

x register - 0 → incremented by 1 when we are processing next pixel on the screen line

y " → y mod

↳ decremented by 1 ⇒ -1

fast mechanism for real time animation



Raster scan Display processor (or) Graphics controller (or) Display co-processor :-

To free CPU from graphic choices

a major task of display processor is digitizing the picture definition given in an application program into a set of pixel intensity values for store in the frame buffer.

The digitization process is called scan conversion

Line Styles :-

Solid ———————

Dotted - - - - - - - - - - - -

Dash — — — — — —

In an effort to reduce memory requirements of raster scan methods are linked list, encoding

* One way is to this is to store each scan line is set of integer pairs

* One no. of each pair indicates an intensity reduces & second number specifies the no. of adjacent pixels on the scan line that are to have the intensity value. This technique is called run-length encoding.

It is used to save storage space..

Mostly with long runs of a single color each.

A similar approach can be taken when pixel intensities change linearly

Another approach is to encode the raster as the set of rectangular areas is called cell encoding

Disadvantages :-

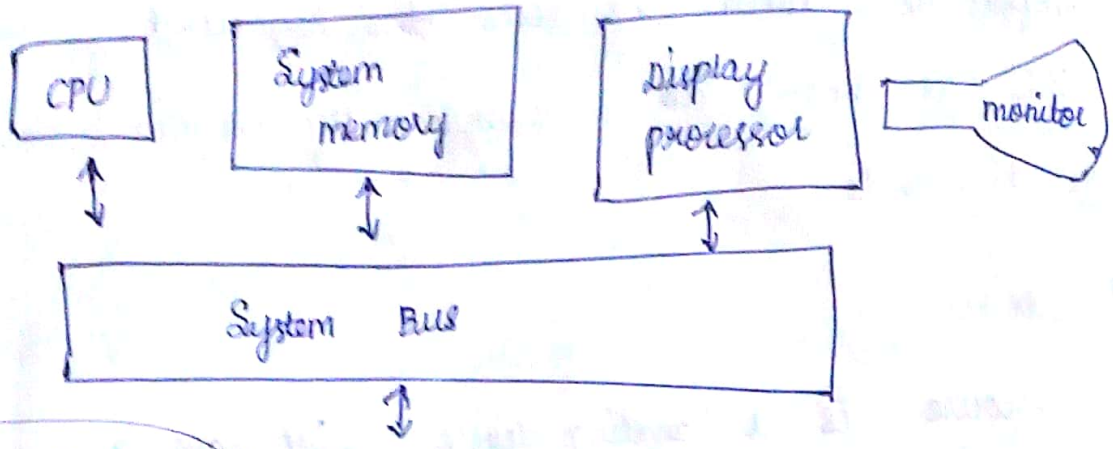
encoding runs are

Intensity changes are difficult

To make and storage requirements actually increase as the length of runs decreases.

It is difficult for the display controller to process the raster when many short runs are involved.

Random scan system :/ graphics controller / display processing unit



graphics I/O devices

other names → graphics controller or display processingunit

* Application program given as input.

20-12-17 * input is stored in system memory

* graphics commands are translated by graphic processor (packages) and is accessed by display processor and finally displays in the screen.

X media wall :- multiscreen is called media wall

Lines there are known as mullions and they are used to differentiate.

museum, Big Television display.

8m

Input devices :- i) Keyboard (X) (8m)

Alpha numeric Keyboard :- used for non graphical purpose cursor keys, Function keys, used to enter numerical values.

Ergonomic design Keyboard :- we will have numeric keypad.

user should feel comfortable

To design in such a way that user feels more comfortable when he uses the keyboard.

This is known as "ergonomically designed system" or keyboards.

ii) Mouse :-

Mouse is a handling device, will have a ball under which is used to for the motion

Z- mouse :- will be in z-shape with a ball used for motion. used in virtual reality, CAD, Animation movies

* will have track ball at bottom
* standard ball at the top.

Optical mouse :- It is used nowadays where it works without any physical connection

Trackball and space ball :- measured using strain guages.

* we can move track ball
* we cannot move space ball

⇒ Track ball is a ball which is rotated with finger which is mounted on a keyboard "two dimensional 2D"

⇒ Space ball is 3 dimensional "3D" used in virtual reality, CAD, modelling

Joystick: small levers mounted on the base to control the screen cursor.

pressure sensitive joystick is measured using strain guages. (measures amount of pressure).

Data glove: we can graph the virtual object

* will have series of sensors which works on hand and finger motions.
* will have transmitting & receiving antennas to capture electromagnetic waves.

Digitizers: * used to scan over a object or image
* input can be in both 2D & 3D.
* used in stylers (styleirs is a device used to position the tablet)
* Electromagnetic pulses
* Accaitic (acoustic) tablets (uses sound waves to work in ✓ stylers) used in drawing, painting to find tablet position

⇒ One type digitizer is graphics tablet

Image scanners:
* we will pass a optical beam.
* Information to be stored is passed under the beams.

Then we will apply Transformation :

(Translation , rotation , scaling)

Translation (moving) ⇒ moving object

rotation ⇒ rotating object

scaling ⇒ cutting or adding with other objects

Transformation is done in both 2D & 3D

2D ⇒ 2 axis x & y

3D ⇒ 3 axis x, y & z (imaginary)

Touch Panels :

allows to display objects by touch.

Finger touch

mainly used for selecting processing option.

* optical
* electrical or accoustical

} Touch input can be recorded by

optical ⇒ LED (using light)

Light Emitting Diode should be in AND Light detectors is used to detect.

Electrical :

Two plates ⇒ outer plate ⇒ conductive material

inner plate ⇒ resistive material

when outer plate is touch reacts with inner one and hence records pattern

accoustic : sound waves are recorded along with glass plate

Sound waves are reflected to the Emitters.

* Screen point of reflection is calculated by the distance of transformation .....

Light pen : it is a pencil shaped one.

used to select screen position, menus

Disadvantage :

* Based on the lightning of screen, readings will change
* Because of the usage, it is difficult for a user to handle and causes hand pain
* Hides the half screen because of the user
* Due to background lightning in the room (false readings are obtained)

Voice Systems :

* In Speech recognition, voice is given as input.
* Voice is stored in dictionary which stores all possible patterns and frequently used words.

Advantage :

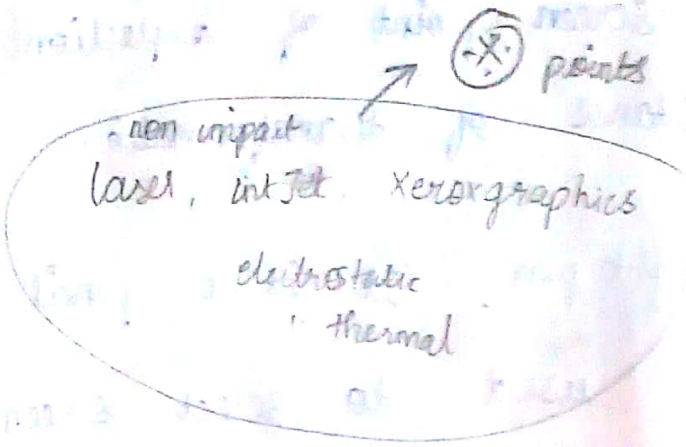
* No need to enter commands
* no need of attention to input device (we can just talk) no focus is needed here.
* don't need to switch from one device to another to enter command.

* we need dictionary, frequency pattern, headset, microphones etc.,

(8m) (X)

Hardcopy devices :-

Printers :-



* Pictures on the paper can be directed to printer or plotter

* Quality of pictures depends on dotsize (no. of dots per inch) or (lines per inch)

* printers produce o/p by either impact method or non impact method.

⇒ impact ⇒ traditional typewriters / characters faces the input ribbon. Eg:- line printer

⇒ non impact (X) ⇒ plotters

* will use laser technique in ink jet sprays, xero graphic process

* uses light beam to scan and then prints

* electrostatic and electrothermal method. are used in non-impact

Dotmatrix printers :- will have various pins for each 'l/p's.

Laser :- uses photoelectric material called selenium

Toner → supplied to the drum.

Inkjet :-

Laser beam will have some charges and is applied to rotating drum which has selenium when drum rotates the impression will be printed on paper.

electrostatic :- placing the magnetic charge on paper.

negative charge is on paper

Toner is +ve both reacts to produce impression.

electro thermal :- heat sensitive paper.

Disadvantages :-

In impact, coloured output is limited even though using different colour ribbons.

In non impact, three colour pigments is used (cyan, magneta, yellow)

(pen plotters ⇒ used in drawing, tip is used to ball point, writing, well tip when pen is moved back & forth it moves.)

Graphics Software:

* General programming packages.
* Special Purpose Application Packages.

* General purpose:

GL ⇒ Graphics library.

* It uses GL (we have to import GL file to work)

GL is used for:

* Straight line, polygon, color ... ⇒ Basic Functions for generating feature components
* we can select color, selecting views
* And to apply Transformation.

* Application Packages are designed for non-programmers.

* CAD application, Medical Applications ...
* User should be allowed to communicate with a program in his own terms.

Eg: artist painting programs, business Appln etc.

Coordinate

coordinate values for pictures

(2m) Modelling coordinates → we can construct the shape of individual objects →

=> such as trees, sea, furniture in a ~~screen~~ scene with a separate coordinate reference frames called modelling coordinates or local or master coordinates.

model coordinate —positioned→ world coordinate

world coordinate —viewed with→ device coordinate

device coordinate —normalise (adjust)→ normalized device coordinate

Once individual objects shapes have been specified we can place the objects into appropriate positions within the scene using the reference frame called world coordinate.

Finally world coordinate description of scene is transferred to one / more output device reference frames for display. These display coordinate systems are referred to as device coordinates or screen coordinates in the case of ~~screen~~ video monitors.

Graphics system first converts world coordinates positions to normalized device coordinates in the range from 0 to 1, before final conversion to specific device coordinates this makes the system independent of various devices that might be used at a particular workstation.

$xmc = ymc \Rightarrow wmc = y$

$(x_{mc}, y_{mc}) \rightarrow (x_{wc}, y_{wc}) \rightarrow (x_{nc}, y_{nc}$

$\rightarrow (x_{dc}, y_{dc})$

X modelling coordinate → X world coordinate → X normal coordinate

→ X device coordinate

main purpose is device independent.

Basic building blocks for pictures are referred to as output primitives. They include characteristics and geometric entities such as points, straight lines, curved lines, filled areas (polygons, circles etc) and shapes defined with array of color points.

Routines for generating output primitives provide the basic tools for constructing pictures.

Attributes :-

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Attributes are the properties of the output primitives. An attribute describe how a particular primitive is to be displayed. They include intensity and color specification, line styles, text styles and area of filling patterns.

* We can change the size, position or orientation of an object within a scene using geometric transformation.
* Viewing transformation are used to specify the view that is to be presented and the portion of output display area that is to be used.
* Pictures can be subdivided into component parts called objects or segments or structures.
* Input functions are used to control and process the data flow from the interactive devices

Software Standards:

* The primary goal of standardized graphics software is portability. When packages are designed with standardized graphics package (functions) software can be moved easily from one hardware system to another and used in different implementations and applications.
* Without standards, programs designed for software system often cannot be transferred to another system without extensive rewritting of the system

GKS: Graphics Kernel System:

* Graphics standards Graphical Kernal System (GKS) this is the first graphics software standard adopted by ISO (International Standards Organization) and ANSI (American National Standard Institute)
* GKS was originally designed as 2D graphics package.

* GKS+ is for 3D

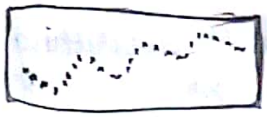
* PHIGS (Programmer's Hierarchical Interactive Graphics Standard) which is an extension of GKS.

There is no standard methodology for displaying outputs.

Standardization for device Interface method is given in Computer Graphics Interface (CGI) and Computer Graphics Metafile (CGM) system specifies standard for archiving and transporting pictures.

Workstation:

Refers to a computer system with a combination of I/P and O/P devices that is designed for a single user.

Points and Lines:  ⇒ stairstep effect.

Another defn for O/P primitives:

Graphics programming packages provide functions to describe a screen in terms of basic geometric structures referred to as O/P primitives.

Points & Straight lines ⇒ for pictures.

Points & Straight line segments are the simplest geometric components of pictures.

Additional output primitives that can be used to construct a picture includes circles and other conic sections for quadric surfaces, Spline (spline) curves and polygon colour areas and character strings.

Point plotting is accomplished by converting a single coordinate position furnished by an ~~appropriate~~ application program into appropriate operation for an output device in use. With a CRT monitor, for eg:- electron beam is turned on to ~~illuminate~~ (illuminate) the screen phosphorous at the selected location, how the electron beam is positioned depends on the display technology.

Random Scan (Vector) system stores point-plotting instructions in the display list and coordinate values in these instructions are converted to deflection voltages, the position the electron beam at the screen location to be plotted during each refresh cycle.

For a black & white raster system, a point is plotted by setting the bit value corresponding to a specified screen position within the ~~screen~~ (frame) buffer to 1. Then as the electron beam sweeps across each

horizontal scan line, it emits a bursts of electrons (plots a point) whenever a value of 1 is encountered in the frame buffer.

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Line Drawing:

calculating intermediate position along the line path.

For analog device such as pen plotter, random scan etc to draw the line

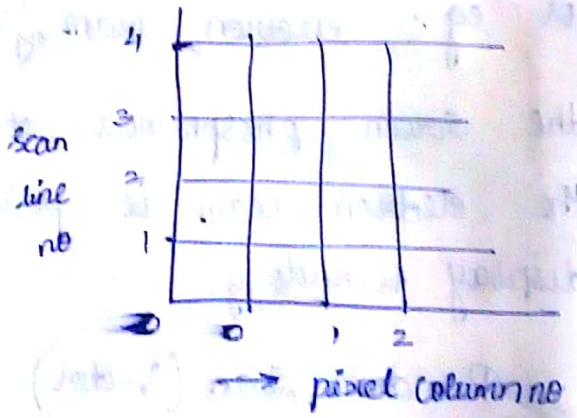
Line Drawing Algorithm:

$y = mx + b$

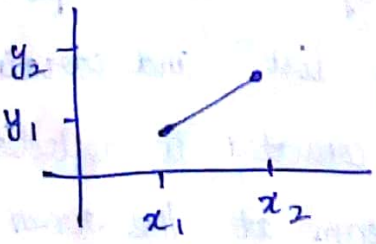
$\rightarrow b = y_1 - m x_1$

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

$\Delta y = m \Delta x$



Line path between ....



DDA Algorithm: Digital Differential analyser.

This is a scan line algorithm based on calculating Δy or Δx,

Using equation,

$$\Delta y = m \Delta x$$

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

Consider the line with positive slope. slope is less than or equal to 1, $\Delta x = 1$

$$\Delta y = m$$

$$y_{k+1} = y_k + m \quad \text{——— (1)}$$

$0 \leq m \leq 1$,

$\Delta y = 1$

$$\Delta x = \frac{1}{m}$$

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

$$x_{k+1} = x_k + \frac{1}{m} \quad \text{——— (2)}$$

Based on (1) & (2), lines are presented from left end point to right end point.

If the processing is reversed,

$\Delta x = -1$

$$\Delta y = -m$$

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

when the $m > 1$, $\Delta y = -1$

$$\Delta x = -\frac{1}{m}$$

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

```
Procedure line DDA (xa, ya, xb, yb : integer);
var
   dx, dy, steps, k : integer;
   .
   .
   .
end line DDA
```

DDA used for calculating pixel position using eqn 3.1

Rounding off error is problem in DDA.

Time consuming

Performance improved based on m & $\frac{1}{m}$

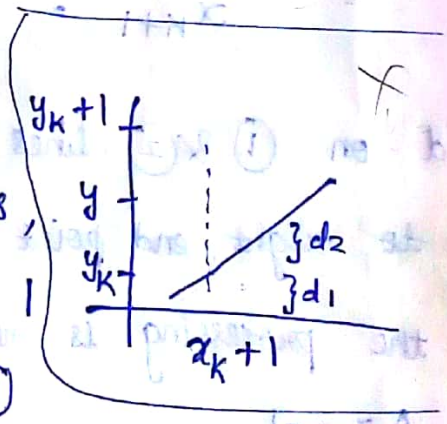
Bresenham Algorithm:

Accurate & efficient algorithm,

incremental integral calculation to display wide and curves.

sampling position x_{k+1}

d_1, d_2



considering scan conversion process, consider positive slope less than 1

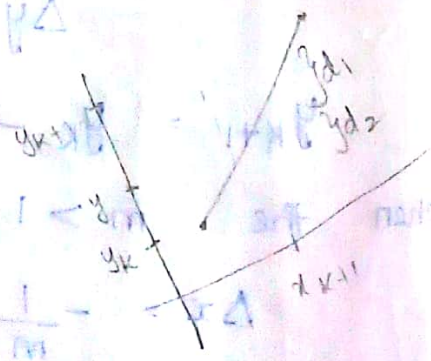
$$y = m(x_k + 1) + b \quad \text{---} \quad (1)$$

$$d_1 = y - y_k$$

$$d_1 = m(x_k + 1) + b - y_k$$

$$d_2 = (y_k + 1) - y$$

$$= y_k + 1 - m(x_k + 1) - b$$



$$d_1 - d_2 = m(x_k+1) + b - y_k - y_k - 1 + m(x_k+1) + b$$

$$= 2m(x_k+1) - 2y_k + 2b - 1 \quad \text{—— (2)}$$

$P_k \rightarrow$ decision parameter

rearranging (2), $m = \frac{\Delta y}{\Delta x}$

$$P_k = \Delta x (d_1 - d_2)$$

$$= \Delta x \left(2\frac{\Delta y}{\Delta x}(x_k+1) - 2y_k + 2b - 1 \right)$$

$$= 2\Delta y\, x_k - 2\Delta x\, y_k + 2b\Delta x - \Delta x + 2\Delta y$$

$$P_k = 2\Delta y \cdot x_k - 2\Delta x\, y_k + c \quad \text{—— (3)}$$

$$c = 2\Delta y + \Delta x(2b-1)$$

$$P_{k+1} = 2\Delta y \cdot x_{k+1} - 2\Delta x\, y_{k+1} + c$$

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

$$P_{k+1} - P_k = 2\Delta y\, x_{k+1} - 2\Delta x\, y_{k+1} + c - 2\Delta y \cdot x_k + 2\Delta x\, y_k - c$$

$P_{k+1} - P_k$

$$\Rightarrow P_{k+1} = P_k + 2\Delta y - 2\Delta x (y_{k+1} - y_k)$$

$$P_{k+1} = P_k + 2\Delta y (x_{k+1} - x_k) - 2\Delta x (y_{k+1} - y_k)$$

this value becomes 0 or 1

in (3), (x_0, y_0)

$$P_0 = 2\Delta y \cdot x_0 - 2\Delta x\, y_0 + c$$

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$$\boxed{P_0 = 2\Delta y - \Delta x}$$

then $P_{k+1} = P_k + 2\Delta y - \Delta x$

To illustrate the algorithm, line with end points (20, 10) and (30, 18). slope(m) = 0.8 where $\Delta x = 10$, $\Delta y = 8$. Find Initial decision parameter P_0.

$$P_0 = 2\Delta y - \Delta x$$

$$= 16 - 10$$

$$P_0 = 6$$

decision parameter - P_k

Initial decision parameter - P_0

K	P_K	(x_{K+1}, y_{K+1})
0	6	(21, 11)
1	2	(22, 12)
2	−2	(23, 12)
⋮		
9		(30, 18)

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

$P_{K+1} = 6 - 4 = 2$

$\therefore 2\Delta x = 2$

Conditions :

if $P_K < 0$, then $P_{K+1} = P_K + 2\Delta y$

if $P_K \geq 0$, then $P_{K+1} = P_K + 2\Delta y - 2\Delta x$

if $P_K < 0$ then (x_{K+1}, y_K)

Stop here ⇒ End point

(*)

Circle Generating Algorithm :- [13 m]

Properties of circle :

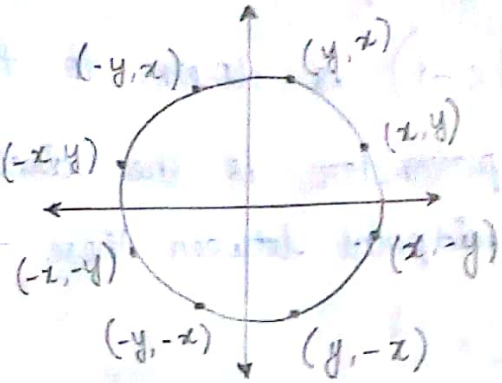
$$(x - x_c)^2 + (y - y_c)^2 = r^2$$

this is representing circle in Cartesian coordinates

$$x = x_c + r\cos\theta$$
$$y = y_c + r\sin\theta$$

Representing circle in Polar Coordinates

Mid Point Circle Algorithm: (13m)



Symmetry of circle.

Mid Point circle Algorithm:-

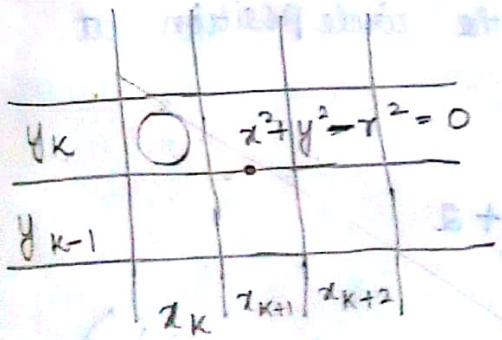
Circle equation:-

$$f_{circle}(x,y) = x^2 + y^2 - r^2 \quad \text{—— (1)}$$

Any point (x, y) on the boundary of circle with radius r, satisfies the equation

$$f_{circle}(x,y) = 0$$

$$f_{circle}(x,y) \begin{cases} < 0, & \text{if } (x,y) \text{ inside the circle boundary} \\ = 0, & \text{if } (x,y) \text{ is on the } " \ " \\ > 0, & \text{if } (x,y) \text{ is outside the } " \ " \end{cases}$$



Midpoint between candidate pixels at sampling position x_{k+1} along a circular path.

Assuming we have just plotted the pixel at

(x_k, y_k), we next to determine whether the pixel at position (x_{k+1}, y_k) (first point) or one at the position $(x_{k+1}, y_k - 1)$ (second point) is closer to the circle.

Our decision parameter is the circle function evaluated at the midpoint between these two pixels

Midpt formula:

$$\frac{x_{k+1} + x_{k+1}}{2} = \frac{2x_k + 2}{2} = \frac{2(x_k + 1)}{2} = (x_k + 1)$$

$$\frac{y_k + y_k - 1}{2} = \frac{2y_k - 1}{2} = \left(y_k - \frac{1}{2}\right)$$

sub $(x_k + 1, y_k - 1/2)$ in eqn (1)

$$P_k = (x_k + 1)^2 + (y_k - 1/2)^2 - r^2$$

if $P_k < 0$, this midpoint is inside the circle and the pixel on scan line y_k is closer to the circle boundary.

Otherwise, Mid position is outside or on the circle boundary, we select the pixel on scan line $y_k - 1$

($P_k < 0 \Rightarrow$ we're selecting y_k

$P_k \geq 0 \Rightarrow$ we're selecting $y_k - 1$)

we obtain a recursive expression for the next decision parameter by evaluating the circle position at Sampling position

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

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

$$P_{K+1} = (x_{K+1} + 1)^2 + (y_{K+1} - 1/2)^2 - r^2$$

$(a+b)^2$

Final eqn $\Rightarrow$ $P_{K+1} = P_K + 2(x_K + 1) + (y^2_{K+1} - y^2_K) - (y_{K+1} - y_K) + 1$

$$P_{K+1} = (x_{K+1})^2 + 1^2 + 2x_{K+1} + (y_{K+1})^2 + (1/2)^2 - y_{K+1}$$

add and subtract P_K $\quad -r^2$

$$P_{K+1} = P_K + (x_{K+1} + 1)^2 + (y_{K+1} - 1/2)^2 - r^2 - P_K$$

$\leftarrow$ value

$$= P_K + (x_{K+1} + 1)^2 + (y_{K+1} - 1/2)^2 - r^2 - (x_K + 1)^2$$

$$- (y_K - 1/2)^2 + r^2$$

$$= P_K + (x_{K+1})^2 + 1 + 2x_{K+1} + (y_{K+1})^2 + \frac{1}{4} - y_{K+1}$$

$$- (x_K + 1)^2 - (y_K - 1/2)^2$$

$(a-b)^2$ $\quad a^2 - 2ab + b^2$

$y_K^2 + 2y_K$

$= y_K^2 - y_K + \frac{1}{4}$

$$P_{K+1} = P_K + 2(x_K + 1) + (y^2_{K+1} - y^2_K) - (y_{K+1} - y_K) + 1$$

Increments for obtaining P_{K+1} are either $(2x_{K+1} + 1)$ if P_K is negative or $(2x_{K+1} + 1 - 2y_{K+1})$ evaluation of terms $2x_{K+1}$ & $2y_{K+1}$ can also be done incrementally $2x_{K+1} = 2x_K + 2$

$$2y_{K+1} = 2y_K - 2$$

At start Position $(0, r)$, these two terms have values 0 and $2r$ respectively. Each successive value is obtained by adding 2 to the previous value of

$2x$ and subtracting 2 from the previous value of $2y$.

Initial decision parameter is obtained by evaluating the circle function at start position

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

$$P_0 = f_{circle}\left(1, r - \frac{1}{2}\right)$$

$$\Rightarrow x^2 + y^2 - r^2$$

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

$$= 1 + x^2 + \frac{1}{4} - r - r^2$$

$$P_0 = \frac{5}{4} - r$$

$P_{k+1} = P_k + 2x_{k+1} + 1$

$= -9 + 2 + 1$

$= -6$

Initial parameter $\boxed{P_0 = 1 - r}$ ⇒ for integer values.

03-01-18

radius $r = 10$,

Midpoint circle algorithm along the circle in the I quadrant from $x = 0$ & $x = y$. Initial value of decision parameter is P_k is P_0

$$P_0 = 1 - r$$

$$= 1 - 10$$

$$P_0 = -9$$

$2x+1$ $2x$ $2y$

For the circle centered on coordinate origin, initial point is $(x_0, y_0) = (0, 10)$ and initial

increment terms for calculating decision parameters are. $2x_0 = 0$, $2y_0 = 20$. Successive decision parameter values and position along the circle path are calculated using the midpoint method as

$2x_{K+1}$ $2y_{K+1}$

2 20

K	P_K	(x_K+1, y_K+1)
0	-9	(1, 10)

Here r=10

$P_0 = 1-r$ $P_0 = -9$

K	P_K	(x_K+1, y_K+1)	$2x_K+1$ ($2x_K+2$)	$2y_K+1$
0	-9	(1, 10)	2	20
1	-6	(2, 10)	4	20
2	-1	(3, 10)	6	20
⋮	⋮			
6	5	(7, 7)	14	14

$2x_1+2$, $2(1)+2$, 4

$2x_2+2$, $2(2)+2$

I assess

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

Ellipse generating algorithm :-

An ellipse an elongated circle therefore elliptical curves can be generated by modifying circle drawing procedures. Taking into account, different dimensions of ellipse along major and minor axis.

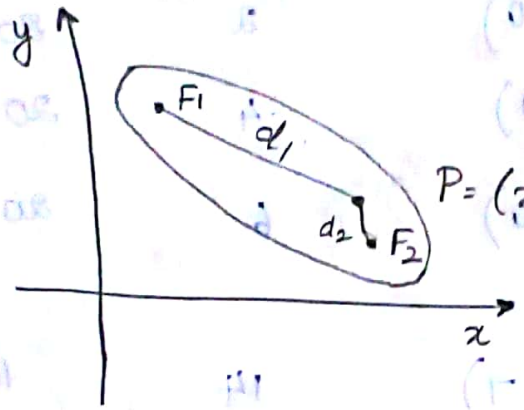
Ellipse Equation Generation equation,

$$ax^2 + by^2 + cxy + dx + ey + f = 0$$

where coeffients a, b, c, d, e, f are evaluated in terms of focal coordinates and the dimensions of major and minor axis of the Ellipse.

Major axis is the straight line, segment extending from one side of the ellipse to the other through the foci.

Minor axis spans the shorter dimension of the Ellipse, bisecting the major axis at the half-way position (Ellipse centre) between the two foci.



Ellipse Function equation with $(x_c, y_c) = (0, 0)$

$$F_{ellipse}(x, y) = r_y^2 x^2 + r_x^2 y^2 - r_x^2 r_y^2$$

which has the following properties:

$f_{ellipse}(x, y) < 0$ ⇒ inside the ellipse boundary.

$f_{ellipse}(x, y) = 0$ ⇒ is on the ellipse boundary

$f_{ellipse}(x, y) > 0$ ⇒ outside the Ellipse boundary.

Filled area Primitives:

A standard output primitive in general graphics package is solid colour or patterned

polygon area.

Other kinds of area primitives are available but polygons are easier to process since they've linear boundaries.

(2M) There are two basic approaches in area filling in raster system:

→ used in circle, polygon, ellipse

1) To fill an area is to determine the overlapped intervals for scanlines that cross the area.

2) Area filling is to start from a given interior position and paint outward from this point until we encounter the specified boundary condition.

↓ used in interactive painting system

* Scan line approach is used in general graphic packages to fill in circle, polygon, ellipse etc., and other simple curves

* Fill method starting from the interior point are useful with more complex boundaries and in interactive painting system

ScanLine Polygon Fill algorithm:

Interior pixels along a scanline passing through a polygon area.

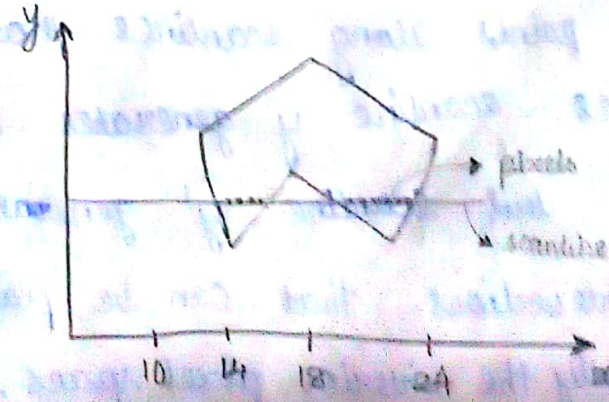
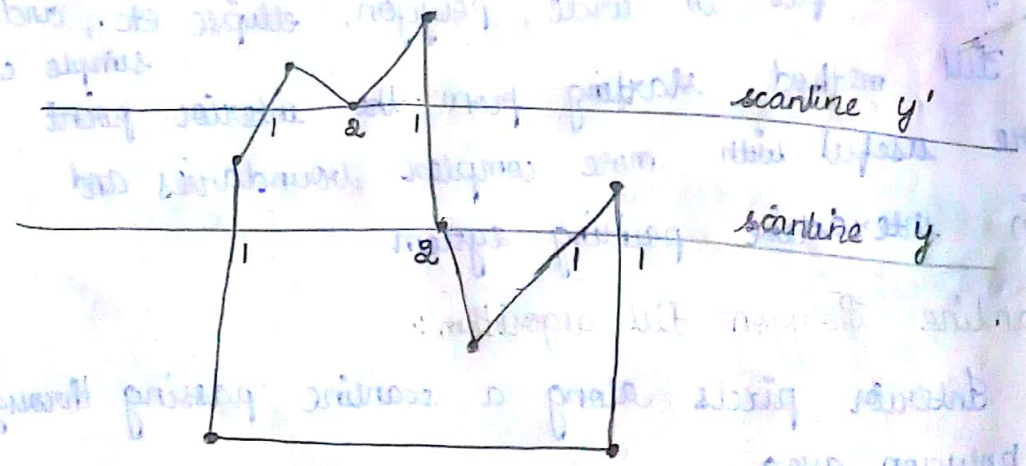


fig.1 illustrates the scanline procedure for solid filling of polygon areas. For each scan line crossing passing a polygon, the area fill algorithm locates the intersection points of the scan line with the polygon edges.

These intersection points are then sorted from left to right and corresponding frame buffer positions between each intersection pairs are set to the specified fill colour.

In fig.1 four pixel intersection position with the polygon boundaries define two stretches of interior pixels from $x = 10$ to $x = 14$ and from $x = 18$ to $x = 24$



Intersection points along scanlines that intersect polygon vertices scanline y generates an odd no of intersections but scanline y' generates an even no. of intersections that can be paired to identify correctly the interior pixel spans.

fig.8 shows two scanlines at position y and y' that intersect edge endpoints.

Scanline y intersects 5 polygon edges, scanline y' intersects an even no. of edges although it also passes through the vertex.

Intersection points along scanline y' correctly identify the interior pixel spans. but the scanline y we need to do some additional processing to determine correct interior points:

For scanline y, two intersecting edges sharing a vertex are on opposite sides of the scan line. but for scanline y', two intersecting edges are both above the scanline. thus the vertices that require additional processing are those that have connecting edges on the opposite sides of the scanline.

We can identify these vertices by tracing around the polygon boundary either clockwise or counter clockwise order and observed in relative changes in vertex y coordinates as we move from one edge to next.