CD Module 1

Graphics - Drawing pic on comp screen

Graphics

Interactive
- 2 way comm. users & comp
- input device → commands → modify.
- Adv:-
  - Higher Quality
  - Precise results
  - Productivity ↑
  - ↑ ability to understand data & perceive trends.

Non Interactive
- pic on monitor
- user has no control
- Titles shown in TV.

Applications of Comp Graphics

Education & Training
- Flight Simulator.
- Biology

Comp. Generated Maps.
Architects
Presentation.
Computer Art / commercial arts
Entertainment
Visualization
Educational Software.
Printing Technology.

PIXEL

- smallest element - Each pixel → 1 value.
- 8 bit gray scale → 0 - 255
- intensity of Light photons.
- Pixel = picture element = PEL
  no of rows x no. of cols.
- image 2D signal or matrix
- intensity = gray level.
  - 0 → absence of light / black
- Aspect ratio = $\frac{\text{width of img}}{\text{height of img}}$
- Resolution = total no. of pixels on screen without overlap.

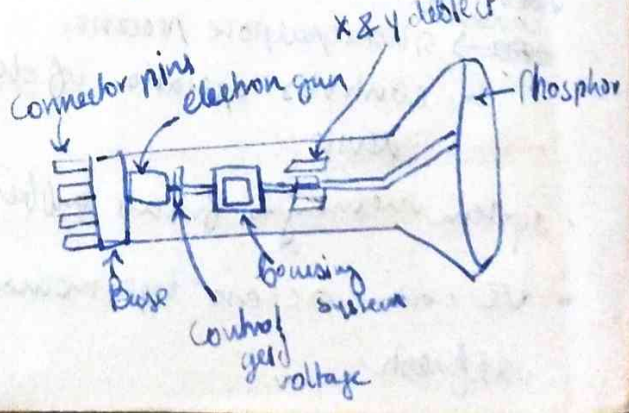
Display Devices

VDU (video display unit)

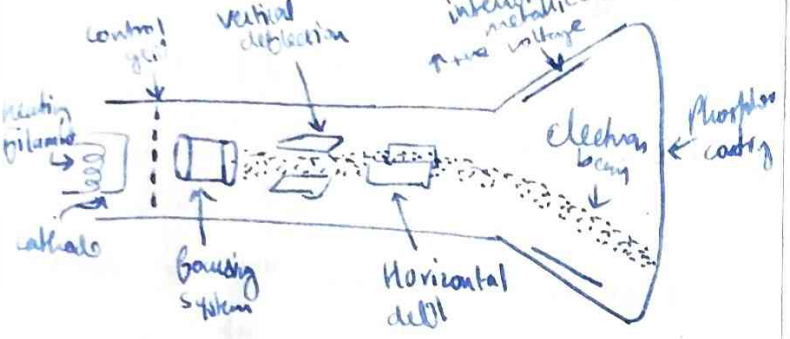
Display devices:-
- Cathode Ray Tube (CRT)
- Color CRT monitor
- Liquid Crystal Display (LCD)
- Light emitting Diode (LED)
- Direct view storage Tubes (DVST)
- Plasma Display.
- 3D display.

CRT

- electronic tube to display electrical data
- 4 major components:
  - Electron gun
  - Focusing & accelerating anode.
  - Horizontal & vertical deflection plates.
  - Evacuated glass envelope.

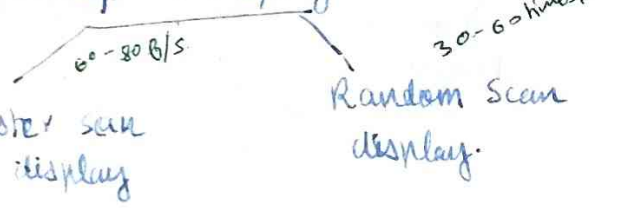


· Refresh CRT → Repeatedly direct electron beams over same points to maintain the screen picture.

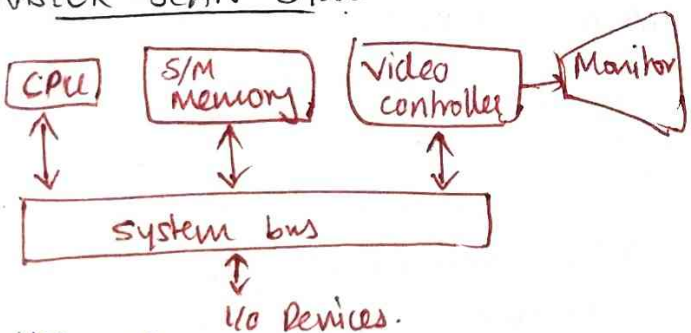


· Persistence = the time it takes the emitted light from screen to decay to one-tenth of its original intensity.
→ low pers → animation
→ high pers → static pictures.

* Two ways to display on screen



RASTER SCAN SYSTEMS

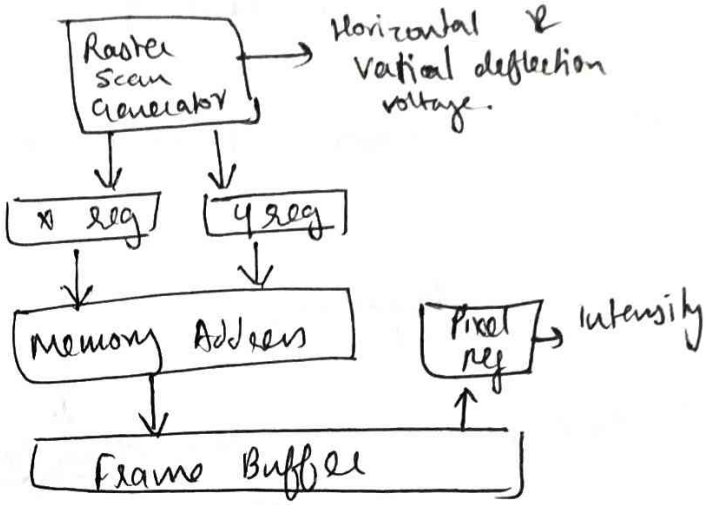


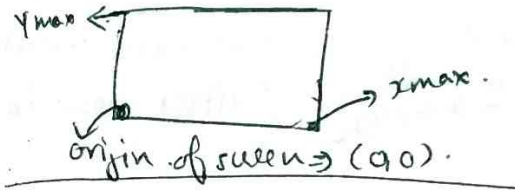
video controller.
→ special purpose processor
- controls operation of display device.

· system memory → frame buffer.

· VC can access sys. memory to refresh.

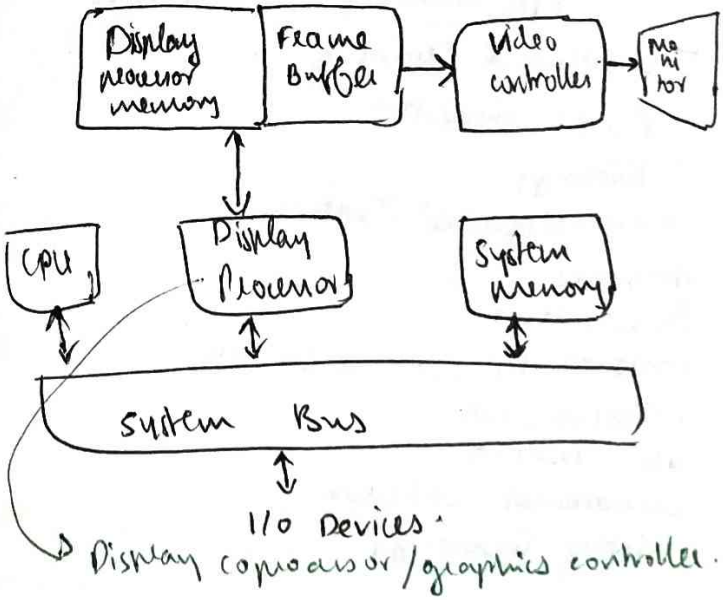
VIDEO CONTROLLER



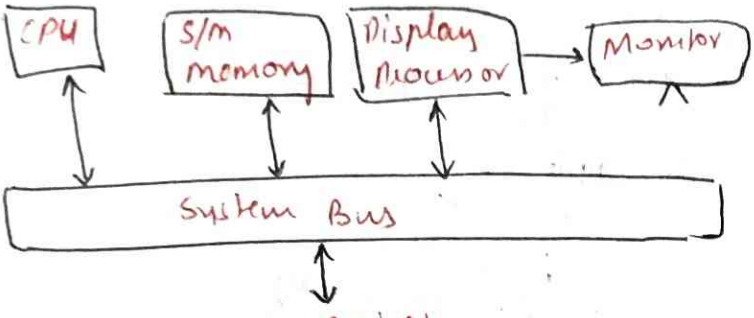


$x = 0$, $y = y_{max}$.
x → increased ... → scan line ends
y decremented; $x = 0$.

to speed up pixel processing, retrieves multiple pixel values from refresh buffer on each pass.
⇒ stored in pixel reg.



RANDOM SCAN SYSTEMS



- application program - input stored in memory with graphics package.
- graphics commands in application program are translated into a display file (by graphics package)
- Display processor → display file accessed to refresh the screen.

COLOR CRT MONITORS

- combination of phosphors - emits diff colored lights.
  → beam penetration method
  → shadow mask method.

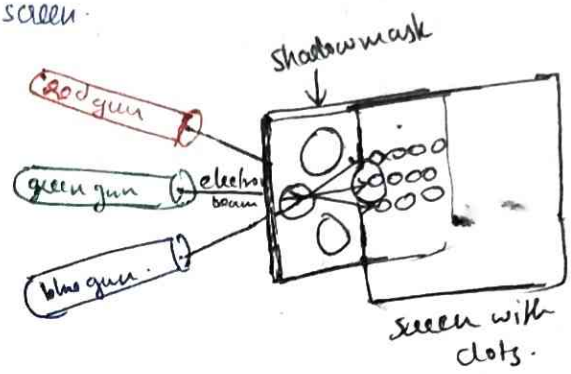
1) Beam Penetration Method

→ used with random scan monitors.
→ 2 layers of phosphor (red & green) coated on CRT screen.
displayed color depends on how far the electron beam penetrates into the phosphor layers.
→ slow electrons → only outer red layer.
→ fast electrons → excites red and inner green layer.
→ intermediate → combinations → orange & yellow.
→ color depends on accelerating voltage.
* inexpensive * only 4 colors * quality ↓

2) Shadow-Mask Method

→ with raster [color TV]; produces wider range of colors.

- Three phosphor color dots @ each pixel position
- Three electron guns (one for each color dot)
- A shadow mask grid behind the phosphor coated screen.



* three beams → dot triangle activated. (small color spot)
* each electron beam can activate only its corresponding color dot when it passes thru the shadow mask.
* color variations → vary intensity values of electron beams.
* eyes merge the three colors into 1.
  - white - all three.
  - yellow - green & red.
  - magenta - blue & red.
  - cyan - blue & green.

DVST (Direct View Storage Tube)

→ stores pic info inside the CRT inside of refreshing the screen.
→ pic info = charge distribution just behind the phosphor coated screen.
→ 2 electron guns
  ↳ Primary gun = store pic. pattern
  ↳ Flood gun = maintain picture display.

Advantages :-
→ complex pic can be displayed @ very high resolution without flicker.

Disadvantages :-
→ no color
→ erasing & redrawing process can take several seconds for a complex picture.

Points & Lines

- Line drawing is accomplished by calculating intermediate positions along the line path btw 2 specified endpoint positions.

$y = mx + b$ → $y_{interval}$ —— (1)

(m = slope)

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\Delta y}{\Delta x}$ —— (2), (3)

$b = y_1 - mx_1$ —— (4)

Digital Differential Analyzer (DDA)

- DDA is a scan conversion line algorithm.
  Δy or Δx calculated.
- sample the line at one coordinate @ unit intervals & determine corresponding integer values nearest the line path for the other coordinate.

* positive slope (left to right)

$m <= 1$; we sample @ x intervals ∴ $\Delta x = 1$

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

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

y values are rounded to nearest integer values.

* ~~positive slope~~ (right to left)

$\Delta x = -1$

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

* positive slope with $m > 1$

reverse the roles of x & y; $\Delta y = 1$

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

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

* (right to left)

$\Delta y = -1$

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

<Algo>

abs(dx) > abs(dy) ?

⇒ step = abs(dx)

else step = abs(dy)

$x_{inc} = \frac{dx}{step}$; $y_{inc} = \frac{dy}{step}$ $\quad x = x_1$, $y = y_1$

for(1 upto step).

x = x + xinc.

y = y + yinc.

plot the nearest integer value.

Advantages

- faster than using line eqn. $y = mx + b$.
- eliminates multiplication
- easy ⇒ only 2 additions.

Disadvantages

- floating point additions rounding off → causes error.
- Rounding off & floating point operations takes time.
- not suited for hardware implementation.

BRESENHAM'S LINE ALGO

<Derivation>

<Algo>

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

k=0; IF $p_k < 0$ ⇒ plot (x_{k+1}, y_k)

$p_{k+1} = p_k + 2\Delta y$

else, plot (x_{k+1}, y_{k+1})

$p_{k+1} = p_k + 2\Delta y - 2\Delta x$.

} Δx times

* +ve slope > 1,

interchange roles of x and y directions.

y fixed, x calculate.

Advantages:

- easy to implement
- fast & incremental
- fast but less faster than DDA
- more accurate points
- uses fixed points only.

Disadvantages:

- The accuracy↑, still resulted line is not smooth.
- basic line drawing purposes only

Circle Generating Algorithms

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

$y = y_c \mp \sqrt{r^2 - (x-x_c)^2}$ } ✗

2) polar coordinates → r & θ

$x = x_c + r\cos\theta$

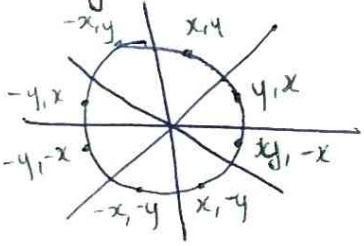
$y = y_c + r\sin\theta$ } ✗ computing time↑

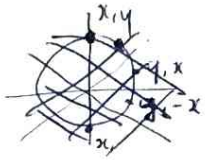
Algo

Midpoint circle algo — Bresenham's Algo.

Midpoint

- symmetry of circles. (45°)





$f_{circle}(x,y) = x^2+y^2-r^2$: $\begin{cases} <0, \text{inside boundary} \\ =0, \text{on boundary} \\ >0, \text{outside boundary} \end{cases}$

<Derivation>

<Algorithm>

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

$p_0 = \frac{5}{4} - r \quad [1 - r]$

$k=0$; if $p_k < 0$, (x_{k+1}, y_k)

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

else, $(x_{k+1}, y_k - 1)$

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

$2x_{k+2}$; $2y_{k+1}$; $2y_{k-2}$

while $x > y$.

All other octants.

Add center.

k	p_k	(x, y)	$2x_{k+1}$	$2y_{k+1}$
.	..	→	+1	

Q_1	Q_2	Q_3	Q_4
x, y	-x, y	-x, -y	x, -y
y, x	-y, x	-x, -y	y, -x

Advantages: → on raster display.

- powerful & efficient
- $x^2+y^2=r^2$. eqn based
- programmer – easy to implement.

Disadv

- accuracy ↓ . circle not smooth . time consuming.

Bresenhams Circle Drawing Algo

<Algo>.

$(0, r)$ ✓

$p_0 = 3 - 2r$

$p_k < 0 \rightarrow x_{k+1}, y_k$.

$\rightarrow p_{k+1} = p_k + 4x_k + 6$.

else → $x_{k+1}, y_k - 1$

$\rightarrow p_{k+1} = p_k + 4(x_k - y_k) + 10$.

✗ ✗