2016-Fall

A picture is worth a thousand words

The English Idiom " A picture is worth a thousand words" refers to the notion that a complex idea can be conveyed with just a still image or that an image of a subject conveys its meaning or essence more effictively that a description does.

→ Reading a paragraph and memorizing it is much more complex than looking in a single still images. The Human mind is oriented more towards visualization (images) that Text. Our mind is capable of remembering a images than text. For Eg: we meet 10 people in meeting with their name in badge. If we meet again, we can distinguish those fellows are from meeting but not their name.

Besides that, Images ie. computer graphics. computer graphics is a creation of images. We can gently remember the movies that we watched but difficult with movies name to be remembered. Moreover, computer graphiss has these motivation

- Appealing picture Produce.
- Human respond better to pictorial information
- Human brain recognizes visual pattern
- "If it looks right; it is right", Jim Blinn
- communicate ideas better

The third purpose are broad Application field of computer graphics

- Art, Entertainment, Publishing
- Image Processing
- Alter image, remove noise
- Process monitoring
- Display simulation
- CAD, computer art
- Virtual worlds - flight simulator
- Scientific analysis and visualization
- Molecular biology, matlab

This is way the Biggest computer graphics customers today are

- Movies eg: Hotel Tansalyvania
- computer Games, eg: FIFA

Question no: 1a

2015- Fall

Give your opinion on why interactive graphics has been able to gain such an immense amount of popularity in diverse fields like engineering, business, medicine etc.

→ Computer Graphics is a subfield of computer science which studies methods for digitally synthesizing and manipulating visual content. computer graphics are pictures and movies created using computer. usually, refering to image data created by a computer specifically with help from specialized graphical hardware and software.

The Reason of popularity gain by interactive graphics is due to vast use and application Areas. As we know, Images is worth a 1000 words. Human mind is oriented more towards the visual form/images/graphics rather than text.

a) Engineering Field :

- Computer Aided design

CAD is the use of computer system to aid in the creation, modification, analysis, optimization of design

- Computer simulation :

computer simulation have become a useful part of mathematical modeling, computational physics, astrophysics, climatology - to reproduce behaviour of a system

- Graphics design

Graphic design is a process of visual communication and problem solving through the use of typography, space, image and color

- Scientific Analysis and visualization

It is visualization of three dimensional phenomenal where the emphasis is on realistic rendering of volumes, surface, illumination source

b) Business Field

Design :

Design is the creation of plan or convention for the construction of an object (pottery, management, Clothing, Corporate, business process, skycrapper, GUI), system or measurable human interaction.

Advertisement

Nowadays, Advertisement are very creative and designed from computer to add extra effects and visualization. Advertisement is form of marketing communication ~~with~~ of product to customers.

Infographics : infographics are graphics visual representations of information, data, knowledge intended to present information ie: statistical graphics, data visualisation, Bar chart, pie chart.

c) Medical Field :

Computational Biology

It is the science of using biological data to develop algorithm and relations among various biological system. At this time, many previews are made, from results of experiment in pictorial format.

Image processing in medical field:

X-Ray, MRI, CT scan are the application of interactive graphics. It is also known as Medical image processing. Interactive graphics is used to create picture

Rational Drug design

It is the inventive process of finding new medications based on the knowledge of biological imact. computer graphics is used to render the consequences, advantage in human readable form ie- graphical form.

Virtual operations and Surgery Simulation

We foresee fully immersive real time simulation environments ~~as~~ in which surgeons can learn, plan and rehearse complex operation using individual patient models and being supported by sophisticated input devices.

2014 Spring

Computer graphics make easier in working computer fields. why?

2014 Fall

OR

Discuss the concept of computer graphics in IT field.

2013 Fall

OR

Define computer Graphics. Discuss the major application areas of CG?

OR

Explain the use and needs of CG in IT.

→ Application field

Submission Deadline: 18 september,2016

Computer graphics Tutorial 1

1. What is computer graphics? Explain the application of computer graphics in various fields.
2. Explain the working principle of CRT with appropriate figure alongside?
3. Explain various color generation technique in CRT.
4. Explain the architecture of raster and random system.
5. Explain the difference between raster and random system.
6. Explain the frame buffer organization along with digital to analog converter.
7. Explain interlaced refresh procedure
8. Explain various kinds of tablet based on its working principle.
9. Explain the working principle of LCD panel.
10. Explain the working principle of Light Pen.
11. Derive Bresenhams line drawing algorithm for $|m| > 1$
12. Digitize the line segment with following end points using DDA and BLA algorithm and compare the result of digitization from both algorithms.
13. (20,10) to(30,18)
14. (20,10) to (18,20)
15. (10,12) to(20,18)
16. Derive DDA algorithm for abs(m)>1.
17. Digitize circle with following equations

$$x^2 + y^2 = 25$$
$$(x-2)^2 + (y-3)^2 = 25$$

Date: 2016/09/02

Computer Graphics Assignment (provided by Senior IT)

1) List the operating characteristics for the following display technologies:

a) ~~Vector Refresh~~ Scan Systems:

a CRT has the electron beam directed only to the parts of the screen where a picture is to be drawn. Random scan Monitors draw a picture one line at ~~a~~ time and for this reason are also reffered to as vector refresh system.

Refresh rate on a random-scan system depends on the number of lines to be displayed

operating characteristics:

- The pixels in the screen are related by function ex: function of line
- Slow in loading because it need some processing in its function
- when magnifying, the quality of image is increases
- The system cycles through the set of commands in the display file, drawing each component line in turn. After all line drawing commands have been processed, the system cycles back to the first command in the list.

b) Raster ~~Refresh~~ Scan System.

Electron beam is swept accross the screen, one row at a time from top to bottom. Each row is reffered to as

a scan line. As the electron beam moves across a scanline, the beam intensity turns on and off to create a pattern of illuminated spots. picture definition is stored in a memory area called the refresh buffer or frame buffer

Generally the electron beams makes the screen as imaginary number of lines and draw each one and this is called scan line (scan line) and the picture is refreshed every interval of time from the refresh buffer 'frame buffer

Its characteristics are

- The pixels in the screen are not related
- fast in loading image
- when magnifying, the quality of the image decreases

Plasma Panels

A computer display in which light output is produced from the interaction between an electric current and an ionized inert gas such as neon. The display consists of a matrix of individual cells, one per pixel. A typical monochrome or gray-scale display generates red or orange light. color generate ultravoilet radiation, which excites phosphours (red, green and blue) on the surface of the display; the excited phosphors emit light on return to the ground state.

- This is new Technology (10/1/2005)
- The screen is divided into little small cells
- have high resolution although the screen size may be small.

LCDS

Liquid crystal displays are commonly used in small systems, such as calculators and portable, laptop computers. These non-emissive devices produce a picture by passing polarized light from the surrounding or from the internal light source through a liquid crystal material that can be aligned to either block or transmit the light

2. Differentiate between Raster and vector Display Technology :

	Raster scan system	Ramdom scan System
1)	It has poor resolution because picture definition is stored as a intensity value	1) It has high resolution because it stores picture definition as a set of line commands
2	Electron beam is directed from top to bottom and row at a time on screen but electron beam is directed to whole screen	2) Electron beam is directed to only the part of screen where picture is required to drawn, one line at a time so also called vector display.

	Raster scan system	Random scan system
3)	It is less expensive than random scan system	3) It is costlier than Raster scan system
4)	Refresh rate is 60 to 80 frame per second	4) It depends on no. of lines to be displayed i.e 30-60 times/sec
5	It stores picture definition in refresh buffer also called frame buffer.	5) It stores picture definition as a set of line commands called Refresh Display file
6)	Zig zag line is produced because plotted value are discrete	6) Smooth line is produced because directly the line path is followed by the electron beam.
7)	It uses pixels along scan lines for drawing an image	7) It is designed for line drawing applications and uses various mathematical function to draw
8)	It contains shadow, advance shading, hidden surface techniques gives the realistic display of scenes. (The capability of system is to store intensity values for pixel in frame buffer.)	8) It doesnot contain shadow and hidden surface techniques so it cannot give realistic display of scenes

3 Consider three different raster systems with resolution of 640 x 480, 1280 by 1024 and 2560 by 2048. What size frame buffer (in byte) needed for each of these systems to store 12 bits per pixel. How much storage required for each system if 24 bits per pixel are to be (used/stored).

Given
Resolution of first system (R_1) = 640 x 480
Resolution of second system (R_2) = 1280 x 1024
Resolution of third system (R_3) = 2560 x 2048
pixel depth (P_1) = 12 bits per pixel
pixel depth (P_2) = 24 bits per pixel

a) Pixel depth (P_1) = 12 bits per pixel
(i) Resolution (R_1) = 640 x 480
Frame buffer size = resolution x pixel depth
= 640 x 480 x 12
= 3686400 bits
= $\frac{3686400}{8}$ byte
= 460800 byte

(ii) Resolution (R_2) = 1280 x 1024
Frame buffer size = $R_2 \times P_1$
= 1280 x 1024 x 12
= 15728640 bits
= $\frac{15728640}{8}$ bytes
= 1966080 bytes

(iii) Resolution (R_3) = 2560 x 2048

Frame buffer size = $R_3 \times P_1$

= 2560 x 2048 x 12

= 62914560 bits

= $\frac{6291460}{8}$ bytes

= 7864320 bytes

b) Pixel depth (P_1) = 24 (true color) bits per pixel

(i) Resolution (R_1) = 640 x 480

Storage required = 640 x 480 x 24

= 7372800 bits

= 900 KB

(ii) Resolution (R_2) = ~~1024~~ 1280 x 1024

Storage Required = 1310720 bits

= ~~160 KB~~ 3840 KB

(iii) Resolution (R_3) = 2560 x 2048

Storage required = 15 MB

4) Suppose an RGB system is to be designed using an (8 x 10) inch screen with a resolution of 100 pixels per inch in each direction. If we want to store 9 bits per pixel in the frame buffer. How much storage (in bytes) required for frame buffer

Sol^n:

→ Given:

Screen size = 8 inch x 10 inch

Resolution (R) = (8 x 100) x (10 x 100) pixel

= 800 x 1000

Total pixel (P) = 800000 pixels

pixel depth (Pd) = 9 bits per pixel

Now

Frame buffer size = Total pixel x pixel depth

= 800000 x 9

= 7200000 bits

= 900000 bytes

or,

→ Total pixel (P) = 800000 pixel

we know

9 bits per pixel in frame buffer

ie 9 bits = 1 pixel

1 pixel = 9 bits

800000 pixel = (800000 x 9) bit

= 7200000 bits

= 900000 bytes

5) How ~~too~~ long would it take to load 640 x 480 and 1280 x 1024. How many pixels could be accessed per second in each of these systems by a display controller that refreshes the screen at a rate of 60 frames per second? what is the access time per pixel in each system.

→

→ Given,
Resolution (R_1) = 640 by 480
Resolution (R_2) = 1280 by 1024
Refresh rate = 60 frames per second
Now,

For first system :

Pixel accessed in one second = resolution × refresh rate
= 640 × 480 × 60
= 18432000 per sec.

accessed time per pixel = $\frac{1}{\text{pixel accessed in 1 second}}$

or
accessed time per pixel = ?
Total no of pixel in one second = 1843200
1843200 pixel = 1 sec
1 pixel = $\frac{1}{1843200}$ sec = 542.5 ns

For second system:

pixel accessed in one second = R_2 × refresh rate
= 1280 × 1024 × 60
= 78643200 pixel per sec

~~in one second~~ =
Time accessed per pixel = 1.271×10^{-8} sec
= 12.71 ns

5) How long would it take to load a 640 × 480 frame buffer with 12 bits per pixel, if 10^5 bits can be transferred per second? ~~in each of these~~ How long would it take to load 24 bit per pixel frame buffer with resolution of 1280 by 1024 using this same transfer rate.

a) Resolution (R) = 640 × 480
pixel depth (P) = 12 bpp (bits per pixel)
Bits transfered rate (r) = 10^5 bps (bits per second)
Time to load frame buffer (T) = ?
Now,
Total pixel = Resolution = 640 × 480
= 307200
Frame buffer size = Total pixel * pixel depth
= 307200 * 12
= 3686400 bits

Time to load frame Buffer (T) = $\frac{\text{Frame buffer size}}{\text{Bits transfered rate}}$
= $\frac{3686400}{10^5}$
= 36.864 sec

b) Resolution = ~~640×~~ 1280 × 1024
pixel depth = 24
bit per sec = 10^5
Time to load frame = $(1280 \times 1024 \times 24) / 10^5$
= 314.5728 sec
= 5.24288 min

ASSIGNMENT CG-I

2. Explain the working principle of CRT with appropriate figure alongside.

CRTs are most common display devices on computer. A CRT is an evacuated glass tube, with a heating element on one end and phosphor-coated screen on the other end.

-A beam of electron (cathode-rays) emitted by an electron gun, passes from the focusing and deflection system that direct beam toward specified positions on the CRT (phosphor coated screen). Phosphor then emits a small spot of light at each position contacted by the electron beam. Because the light emitted by the phosphor fades very rapidly, some method is needed for maintaining the screen picture. "One way to keep the phosphor glowing by quickly directing the electron beam back over the same points. This type of display is called a refresh CRT.

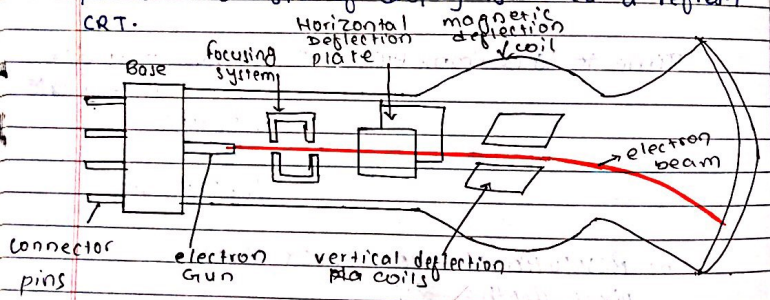


fig: CRT (Cathode Ray tubes)

- The primary components of an electron gun in a CRT are the heated metals cathode and control grid. Heat is supplied to cathod by directing a current through a coil of wire called filament, inside the cathode. This causes the electrons to be 'boiled off', the hot cathode surface. Negatively charged are then accelerated towards the phosphor coating by a high positive voltage.

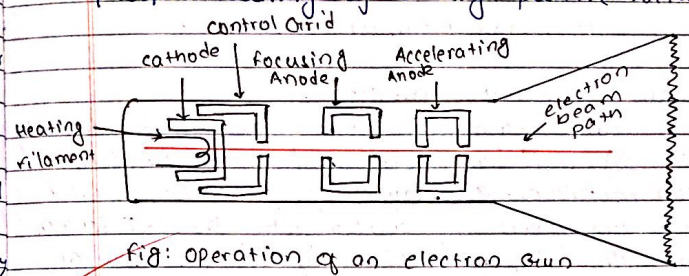


fig: operation of an electron Gun

Control grid is an electrode used in amplifying thermonic waves, is used to control the flow of electrons from cathod to cathode. The intensity of the electron beam is controlled by setting voltage levels on the control grid. A high negative voltage applied to the control grid will shut off the beam by repelling electrons and stopping them from passing through the small hole at the end of the ~~electron~~ control grid. structure. A smaller -ve voltage on the control grid simply decreases, the number of electron, passing through. We control the brightness of a display by varying on the control grid we specify the intensity level for individual screen positions with graphics s/w commands.

3 Explain various color generation technique in CRT.

A CRT monitor displays color pictures by using a combination of phosphors that emit different-colored light. By combing the emitted light from the different phosphors, a range of colors can be generated.

- Beam-Penetration method
- Shadow-mask method.

Beam Penetration method:

The beam-penetration method for displaying color pictures has been used with random-scan monitors. Two layers of phosphor, usually red and green are coated into the CRT screen, and the displayed color depends on how far electron beam penetrates into the phosphor layers. A beam of slow electron excites only the outer red layer. A beam of very fast electrons penetrates through the red layer and excites the inner green layer. An intermediate beam speeds, combinations of red and green. It is inexpensive way to produce color in random scan monitors but only four colors are possible

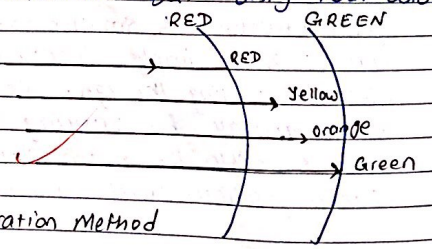


fig: Beam penetration Method

ii) Shadow mask method:

Shadow-mask methods are commonly used in raster-scan systems (including color TV) because they produce a much wider range of colors dots at each pixel position. One phosphor dot emits a red light, another emits a green light, and the third emits a blue light. This type of CRT has three electron guns, one for each color dot, and a shadow-mask grid just behind the phosphor-coated screen.

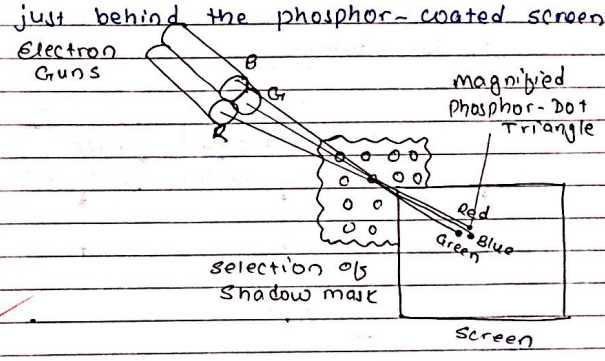


fig: Shadow-Mask Method.

4 i) Explain the architecture of raster and random system.

The architecture of raster system is shown below. A fixed area of the system memory is reserved for the frame buffer, and the video controller is given direct access to the frame buffer memory. Frame buffer location and the corresponding screen positions are referenced in cartesian cordinate. For

for many graphics monitors, the cordinate origin is defined at the lower left screen corner. Interactive raster graphics systems typically employ several processing units. In addition to the central processing unit or CPU, a special-purpose processor, called the video controller or display controller, is used to control the operation of the display device. Here the frame buffer can be anywhere in the system memory, and the video controller access the frame buffer to refresh the screen

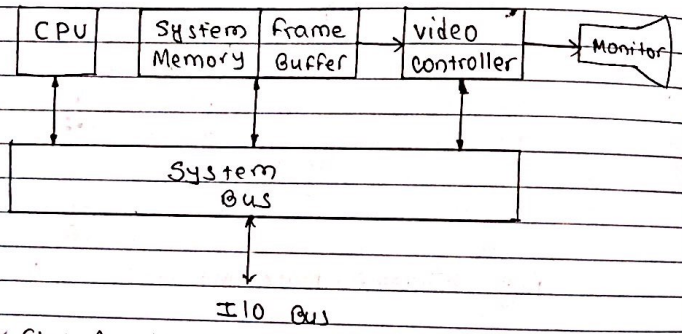


Fig: Architecture of raster graphic system

→ The architecture of random system is shown in fig (b). An application program is input and stored in the system memory along with graphics package. Graphics command in the application program are translated by the graphics package into a display file stored in the system memory. This display file is then accessed by the display ~~file stored in the system memory~~ processor to refresh the screen. The display processor cycles through each command in the display file program once during every refresh cycle. Sometimes the display processor in random-scan system is referred to as a display processing unit or a graphics controller.

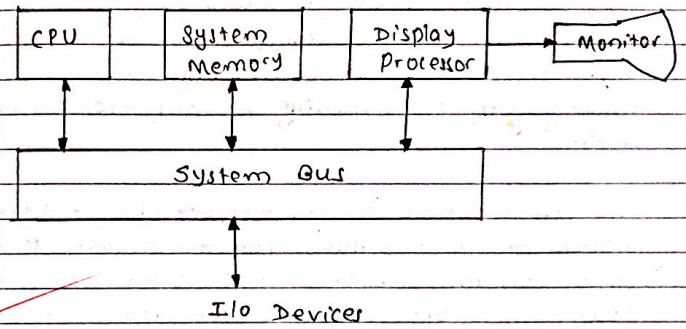


Fig: Architecture of Random graphic system

6. Explain the frame buffer organization along with digital to analog converter.

→ A frame buffer is a large, contigious piece of computer memory. ~~bit~~ At a minimum there is one memory bit for each pixel in the raster; this amount of memory is called a bit plane. The picture is built up in the frame buffer one bit at a time.

A frame buffer is a digital device and the CRT is an analog device, A conversion from a digital representation to an analog signal must take place when information is read from the frame buffer and displayed on the raster CRT graphics device. For this you can use a Digital to Analog (DAC) Converter. Each pixel in the frame buffer must be accessed and converted before it is visible on the raster CRT. A framebuffer is a portion of RAM containing a bitmap that is used to refresh a video display from a memory buffer containing a complete frame of data.

The information in the memory buffer typically consists of color values for every pixel to be shown on the display. color values are commonly stored in 1-bit binary (monochrome), 4 bit palettized, 8 bit palletized, 16 bit high color, 24 bit true color formats. An additional alpha channel is sometimes used to retain information about pixel transparency. The total amount of the memory required to drive the framebuffer depends on the resolution of the output signal, on the color depth and pallete size

The process of changing discrete digital data into a continously varying signal in relation to a standard reference. Through digital to Analog conversion techniques, the stored data can be displayed in graphical form on a mechanical plotting board. Raster graphics stores data in frame buffer and displays images as a bit map, a series of closely spaced dots (or pixel) arranged in rows and columns. Vector or object-oriented graphics stores the images as mathematical formulas: images are displayed by calculating the coordinates of the end points and then drawing

7. Explain interlaced refresh procedure.

It is a method of incrementally displaying a visual on a CRT. on some raster scan systems, each frame is displayed in two passes using an interlaced refresh procedure. in the first ~~phase~~ pass, the beam seeps accross every other scan line from top to bottom. Then after the vertical retrace, the beeam sweeps out the remaining scan line

On some raster scan systems, each frame is displayed in two passes, using an interlaced refresh procedure. ~~in the first pass.~~ Interlacing of the scan lines, in this way, allows us to see entire screen display in one half the time, it would have taken sweep accross all the line at once from top to bottom. Interlacing is primarily used with CRT with slower refresh rate on an older 30 Frame per second (30 FPS), non interlaced display,

the flicker is noticable but with interalacing. we can increase the frequency nearly to the 60 FPS (60HZ). This is an effective technique for avoiding flicker provided that adjacent lines contains similar display information.

8 Explains the working principal of LCD panel.

A Liquid crystal Display or LCD display are combination of two states of mater, solid and liquid. LCD uses liquid crystal to display image. LCD are super thin technology display screen that are generally used in Laptop, calculator, camera etc. LCD composed of several layers which include two polarized panel filters and electrodes

The principal behind the LCD's is that when an electrical current is applied to the liquid crystal molecule, the molecule tends to untwist. This causes the angle of light which is passing through the molecule of the polarized glass and also cause a change in the angle of the top polarizing filter. As a result a little light is allowed to pass the polarized glass through a particular area of the LCD. Thus that particular area will become dark compared to other. LCD works on the principal of blocking light. while constructing LCD's, a reflected mirror is arranged at that back. An electrode plate is made of indium tin oxide which is kept on top and a polarized glass with a polarizing film is also added on the bottom of the device. The complete region of the LCD hal to be enclosed by a common electrode and above it should be the liquid crystal matter.

Next comes to the second piece of glass with an electrode in the form of the rectangle on the bottom and on top, another polarizing film. It must be considered that both pieces are kept at right angles when there is no current, the light passes through the front of the LCD it will be reflected by the mirror and bounced back. As the electrode is connected to a battery it will cause liquid crystal between the common plate electrode and electrode shaped like rectangle to untwist. Thus the light is blocked from passing through. That particular rectangular area appears blank.

9. Explain various kinds of tablet based on its working principle

Generally, Tablet consist of touchpanel which allow displayed objects or screen positions to be selected with the touch of a finger. A typical application of touch panels is for the selection of processing options that are represented with graphical icons. Other systems can be adapted for touch input by fitting a transparent device with a touch-sensing mechanism over the video monitor screen. Touchinput can be recorded using optical, electrical or acoustical method

→ optical touch panels employ a line of infrared light-emitting diodes (LED) along one vertical edge and along one horizontal edge of the frame. The opposite vertical and horizontal edge contain light detectors. The detector are used to record which beams are interrupted when the panel is touched.

→ An electrical touch panel is constructed with two transparent plates separated by a small distance. one of the plates is coated with a conducting material and the other plate is coated with ~~conducting material~~ a resistive material. when the outer plate is touched, it is forced into contact with ~~outer~~ inner plate. This contact creates a voltage drop across the resistive plate that is converted to the corrdinate values of the selected screen position

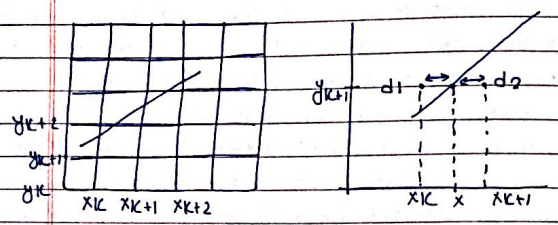
→ In acoustical touch panels, high frequency sound waves are generated in the horizontal and vertical directions across a glass plate. Touching the screen causes part of each wave to be reflected from the finger to the emitter. The screen position at the point of contact is calculated from the measurement of the time interval between the transmission of each wave and its reflection to the emitter.

Explain the working principal of light pen.

pencil-shaped devices are used to select screen positions by ~~detecting~~ detecting the light coming from points on the CRT screen. They are sensitive to the short burst of light emitted from the phosphor coating at the instant the electron beam strikes a particular point. otherwise, light sources, such as background light in the room, are usually not detected by a light pen. An activated light pen, pointed at a spot on the screen as the electron beam light up that spot, generates an electrical pulse that causes the coordinate position of the electron beam to be recorded. As with cursor position ~~locating~~ devices, recorded light pen cordinates can be used to position an object or to select a processing option.

Although light pens are still with us, they are not as popular as they once were, since they have several disadvantages compared to other input devices that have been developed. For one, when a light pen is pointed at the screen, part of the screen is obscured by the hand and pen. Also, light pens require special implementations for some application because they cannot detect positions within black areas. To be able to select positions in any screen area with a light pen we must have some non zero intensity assign to each pixel. light pens sometime gives false reading due to background lighting in a room.

Derive the Breshnhams line drawing algorithm for $|m| > 1$



let (x_k, y_k) be the pixel position determined then the next pixel to the plottened either (x_{k+1}, y_{k+1}) or (x_k, y_{k+1}).

let d_1 and d_2 be the separation of the pixel positions (x_k, y_{k+1}) and (x_{k+1}, y_{k+1}) for the actual line path.

The equation of standard line is:

$y = mx + b$

$x = (y-b)/m$ sampling position at y_{k+1}

From figure

$d_1 = x - x_k$

$d_2 = x_{k+1} - x$

let us define a decision parameter P_k and P_{k+1} is defined by:

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

$\Delta y > 0$

$P_k < 0$ if $d_1 < d_2$

$P_k \geq 0$ if $d_1 > d_2$

$\therefore P_k = \Delta y (d_1 - d_2)$

$= \Delta y (2x - x_{k+1} + x)$

$= \Delta y (2x - 2x_k - 1)$ [since $x_{k+1} = x_k + 1$]

$= \Delta y \{ 2(\frac{y_{k+1} - b}{m}) - 2x_k - 1 \}$

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

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

$\cancel{= 2\Delta x \{ (y_{k+1} - b) - 2x_k (\Delta y / \Delta x) - \frac{\Delta y}{\Delta x}}$

$\cancel{= 2\Delta x y_{k+1} - 2\Delta x b -}$

$= \Delta x \{ 2(y_{k+1} - b) - 2x_k \Delta y / \Delta x - \Delta y / \Delta x \}$

$= 1 \{ 2\Delta x (y_{k+1} - b) - 2x_k \Delta y - \Delta y \}$

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

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

$P_k = 2\Delta x y_k - 2x_k \Delta y + c$ — (ii)

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

For next step ie (x_{k+1}, y_{k+1}) — (iii)

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

From (ii) and (iii)

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

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

where $x_{k+1} - x_k$ = '0' or '1'

if $P_k \geq 0$

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

we plot $x_{k+1} = x_k + 1$, $y_{k+1} = y_k + 1$

for $P_k < 0$

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

$x_{k+1} = x_k$

For intial Parameters

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

$= 2\Delta x y_0 - 2\Delta y x_0 + 2(1-b)\Delta x - \Delta y$

$= 2\Delta x y_0 - 2\Delta y x_0 + 2\Delta x - 2b\Delta x - \Delta y$

Since $b = y_0 - m x_0$

$P_0 = 2\Delta x y_0 - 2\Delta y x_0 + 2\Delta x - \Delta y - 2(y_0 - m x_0)\Delta x_0$

$= \cancel{2\Delta x y_0} - \cancel{2\Delta y x_0} + 2\Delta x - \Delta y - \cancel{2y_0\Delta x} + \cancel{2\Delta y x_0}$

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

For $|m| > 1$

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

If $P_k \geq 0$ (x_{k+1}, y_{k+1})

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

If $P_k < 0$ (x_k, y_{k+1})

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

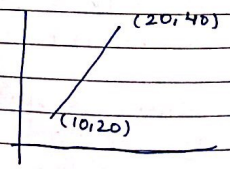
Repeat Δy times.

Derive DDA algorithm for $|m| > 1$

If $|m| > 1$

$|m| > \frac{\Delta y}{\Delta x}$

since $\Delta y > \Delta x$



Here we sample doing y-direction

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

$x_{k+1} = x_k + \Delta x$ —— ①

since, $m = \frac{\Delta y}{\Delta x}$ $\therefore \Delta y = 1$

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

From ①

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

Repeat Δy time.

Digitize the line segment using

A) DDA

B) BLA

of the following end points.

i) (20,10) to (30,18)

ii) (20,10) to (18,20)

iii) (10,12) to (20,18)

A) DDA

(i) (20,10) to (30,18)

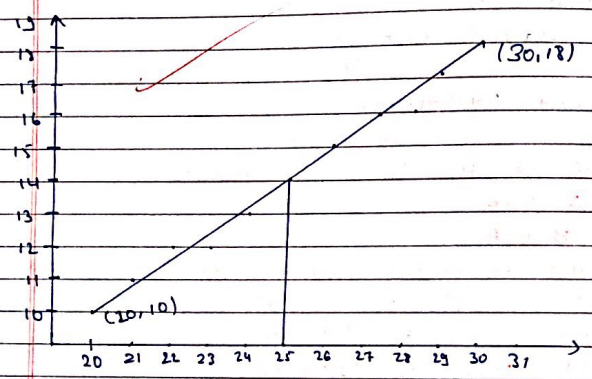
$|m| = \frac{18-10}{30-20} = \frac{8}{10} = 0.8$

$\therefore |m| < 1$

The process is repeat Δx time is 10

S.N	$x_{k+1} = x_k + 1$ (20)		$y_{k+1} = y_k + m$ (10)
1	21	10.8	≈ 11
2	22	11.6	≈ 12
3	23	12.4	≈ 12

4	24	13.2	≈ 13
5	25	14	
6	26	14.8	≈ 15
7	27	15.6	≈ 16
8	28	16.4	≈ 16
9	29	17.2	≈ 17
10	30	18	



Using BLA (20,10) to (30,18)

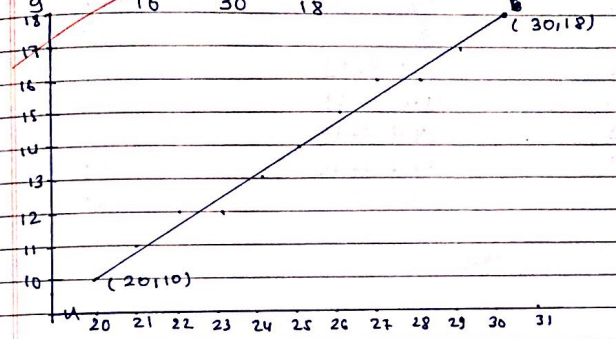
$\Delta y = 8$

$|m| < 1 = 0.8$ $\quad \Delta x = 10$

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

$P_0 = 2\Delta y - \Delta x = 6 \quad | \; 2\Delta y = 16 \quad | \; 2\Delta x = 20$

K	P_K	X_{K+1}	Y_{K+1}	P
		20	10	
0	6	21	11	6+16−20 = 2
1	2	22	12	−2
2	−2	23	12	14
3	14	24	13	14−4 = 10
4	10	25	14	10−4 = 6
5	6	26	15	6−4 = 2
6	2	27	16	−2
7	−2	28	16	14
8	14	29	17	10
9	10	30	18	6



Hence, The accurate result was from BLA.

B) (20,10) to (18, 20)

(i) Using DDA algorithm.

$\Delta x = 20 - 18 = 2$

$\Delta y = 20 - 10 = 10$

$\therefore \Delta y > \Delta x$ Repeat Δy times

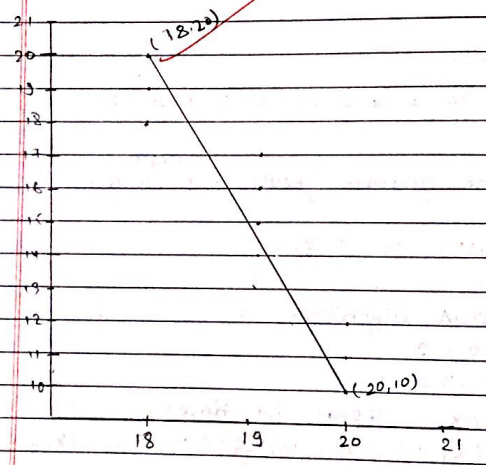
take $(x_1, y_1) = (20, 10)$ & $(x_2, y_2) = (18, 20)$

and

slope $(m) = \frac{y_2 - y_1}{x_2 - x_1} = \frac{20-10}{18-20} = -5 < 1$

$\therefore$ ~~$y_{k+1} = y_k + m$~~ $\quad x_{k+1} = x_k + 1/m = x_k - 0.2$

S.N	$x_{k+1} = x_k + 1/m$	$y_{k+1} = y_k + 1$
	20	10
1	19.8 ≈ 20	11
2	19.6 ≈ 20	12
3	19.4 ≈ 19	13
4	19.2 ≈ 19	14
5	19	15
6	18.8 ≈ 19	16
7	18.6 ≈ 19	17
8	18.4 ≈ 18	18
9	18.2 ≈ 18	19
10	18	20



Using BLA Algorithm

(20,10), (18,20)

$\Delta x = 2$ $\Delta y = 10$ $\therefore \Delta y > \Delta x$

$m = -5$ $|m| = 5 > 1$

For $|m| > 1$

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

If $P_k \geq 0$, (x_{k+1}, y_{k+1})

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

If $P_k < 0$ (x_k, y_{k+1})

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

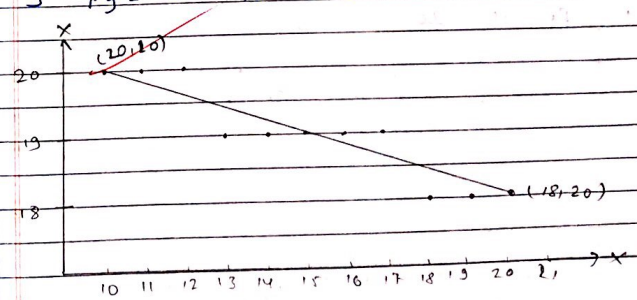
Repeat Δy times

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

$P_0 = -6$

$2\Delta x - 2\Delta y = -16$

K	P_k	x_{k+1}	y_{k+1}	P
		20	10	
0	$P_0 = -6$	20	11	$P_1 = -2$
1	$P_1 = -2$	20	12	$P_2 = 2$
2	$P_2 = 2$	19	13	$P_3 = -14$
3	$P_3 = -14$	19	14	$P_4 = -10$
4	$P_4 = -10$	19	15	$P_5 = -6$
5	$P_5 = -6$	19	16	$P_6 = -2$
6	$P_6 = -2$	19	17	$P_7 = 2$
7	$P_7 = 2$	18	18	$P_8 = -14$
8	$P_8 = -14$	18	19	$P_9 = -10$
9	$P_9 = -10$	18	20	



(c) (10, 12) and (20, 18)

(i) Using BLA:

$\therefore \Delta x = 10$ & $\Delta y = 6$

$m = 6/10 = 0.6 < 1$

For $|m| < 1$

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

-ve IF $P_k < 0$, (x_{k+1}, y_k)

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

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

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

Repeat Δx times

$P_0 = 2$

$2\Delta y = 12$

$2\Delta y - 2\Delta x = -8$

K	P_k	x_{k+1} (10)	y_{k+1} (12)	P
0	$P_0 = 2$	11	13	$P_1 = -6$
1	$P_1 = -6$	12	13	$P_2 = 6$
2	$P_2 = 6$	13	14	$P_3 = -2$
3	$P_3 = -2$	14	14	$P_4 = 10$
4	$P_4 = 10$	15	15	$P_5 = 2$
5	$P_5 = 2$	16	16	$P_6 = -6$
6	$P_6 = -6$	17	16	$P_7 = 6$
7	$P_7 = 6$	18	17	$P_8 = -2$
8	$P_8 = -2$	19	17	$P_9 = 10$
9	$P_9 = 10$	20	18	

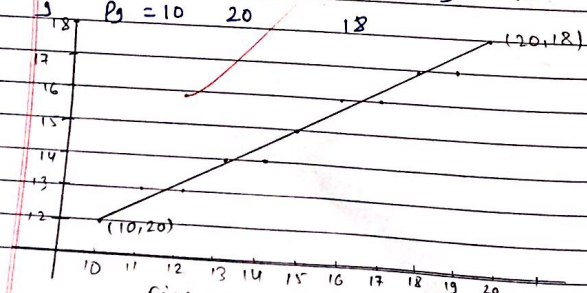


Fig: BLA.

ii) Using DDA

For $|m| < 1$

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

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

Repeat Δx times

S.N	x_{k+1} (10)	$y_{k+1} = y_k + m$ (12)
1	11	12.6 ≈ 13
2	12	13.2 ≈ 13
3	13	13.8 ≈ 14
4	14	14.4 ≈ 14
5	15	15 ≈ 15
6	16	15.6 ≈ 16
7	17	16.2 ≈ 16
8	18	16.8 = 16
9	19	17.4 ≈ 17
10	20	18 ≈ 18

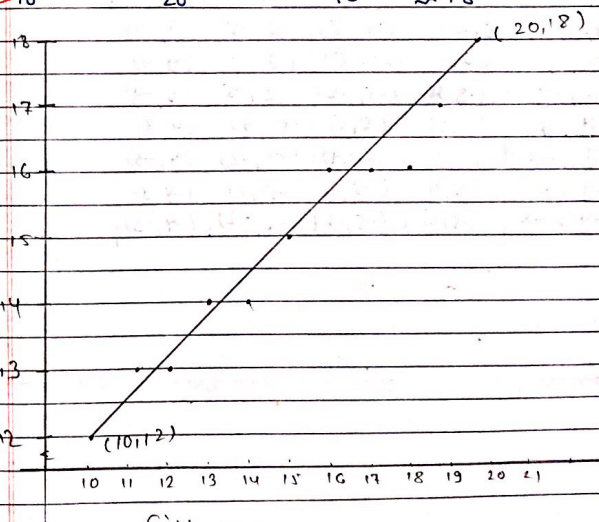


Fig: BLA

Digitize circle with following expression

1) $x^2+y^2=25$

$\therefore r=5$

starting point $(x_0,y_0) = (0,r) = (0,5)$

Initial decision parameter, $P_0 = 5/4 - r = 1-r = -4$

[until $x \geq y$] 0 5

K	P_K	x_{K+1}	y_{K+1}	$2x_{K+1}$	$2y_{K+1}$	P	(0, 5)
0	-4	1	5	2	10	$P_1=-1$	(1, 5)
1	-1	2	5	4	10	$P_2=8$	(2, 5)
2	8	3	4	6	8	$P_3=7$	(3, 4)
3	7	4	3	8	6		(

$\therefore x \geq y$

Applying 8 way symetry

x, y	0, 5	1, 5	2, 5	3, 4
x, -y	(0,-5)	(1,-5)	(2,-5	(3,-4)
-x, y	(0,5)	(-1,5)	(-2,5)	(-3,4)
-x, -y	(-0,-5)	(-1,-5)	(-2,-5)	(-3,-4)
y, x	(5,0)	(5,1)	(5,2)	(4,3)
y, -x	(5,0)	(5,-1)	(5,-2)	(4,-3)
-y, x	-5,0	(-5,1)	(-5,2)	(-4,3)
-y, -x	(-5,0)	(-5,-1)	(-5,-2)	(-4,-3)

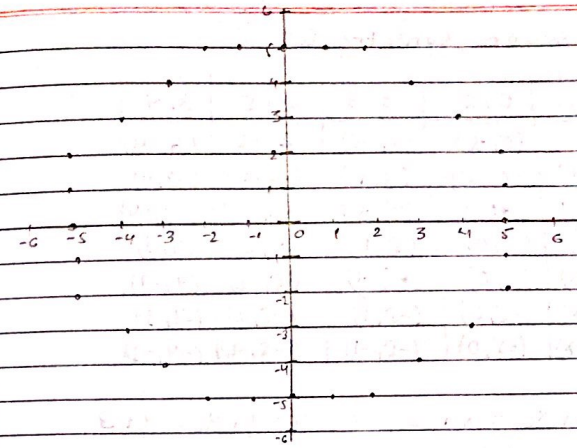


fig: Digitize the circle $x^2+y^2=25$ using Midpoint circle drawing Algorithm

ii) $(x-2)^2+(y-3)^2=25$

$(x-2)^2+(y-3)^2 = 5^2$ —— ①

comparing eqn ① with $(x-h)^2+(y-k)^2=r^2$

we get

radius $(r) = 5$

centre $(h,k) = (2,3$

$P_0 = 1-r$

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

(0, 5)

K	P_K	(x_{K+1}, y_{K+1})	$2x_{K+1}$	$2y_{K+1}$	P_K
0	-4	(1,5)	2	10	-1
1	-1	(2,5)	4	10	4
2	4	(3,4)	6	8	3
3	3	(4,3)	-	-	

The seven symetry is:

(x, y)	0, 5	1, 5	2, 5	3, 4
(x, -y)	(0, -5)	(1, -5)	(2, -5)	(3, -4)
(-x, y)	(0, 5)	(-1, 5)	(-2, 5)	(-3, 4)
(-x, -y)	(0, -5)	(-1, -5)	(-2, -5)	(-3, -4)
(y, x)	(5, 0)	(5, 1)	(5, 2)	(4, 3)
(y, -x)	(5, 0)	(5, -1)	(5, -2)	(4, -3)
(-y, x)	(-5, 0)	(-5, 1)	(-5, 2)	(-4, 3)
(-y, -x)	(-5, 0)	(-5, -1)	(-5, -2)	(-4, -3)

$x = x + x_c = x + 2$ & $y = y + y_c = y + 3$

(x, y)	2, 8	3, 8	4, 8	5, 7
(x, -y)	(2, -2)	(3, -2)	(4, -2)	(5, -1)
(-x, y)	(2, 8)	(1, 8)	(0, 8)	(-1, 7)
(-x, -y)	(2, -2)	(1, -2)	(0, -2)	(-1, -1)
(y, x)	(7, 2)	(7, 4)	(7, 5)	(6, 6)
(y, -x)	(7, 2)	(7, 2)	(7, 1)	(6, 0)
(-y, x)	(-3, 3)	(-3, 4)	(-3, 5)	(-2, 6)
(-y, -x)	(-3, -3)	(-3, 2)	(-3, 1)	(-2, 0)

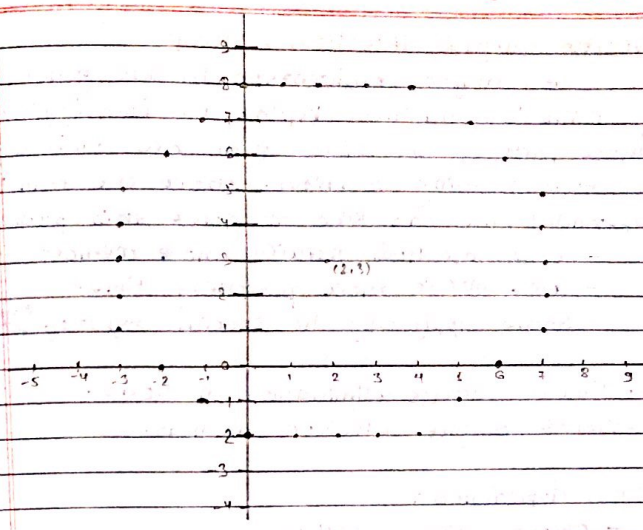
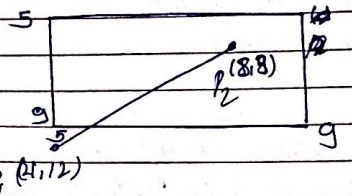


fig: Digitize the circle with radius 5 having centre (2, 3)

Consider the window size from 5 to 9
following line (4,12), (8,8)



Line $P_1(4,12)$ and $P_2(8,8)$

$x_{wmin} = 5 = y_{wmin}$

$x_{wmax} = 9 = y_{wmax}$;

$\Delta x = x_2 - x_1 = 4$

$\Delta y = y_2 - y_1 = -4$

$p_1 = -4$ $\quad q_1 = 4-5 = -1$

$p_2 = 4$ $\quad q_2 = 9-4 = 5$

$p_3 = 4$ $\quad q_3 = 12-5 = 7$

$p_4 = -4$ $\quad q_4 = 9-12 = -3$

Intial value $t_1 = 0$, $t_2 = 1$

$p_1 p_4 < 0$

$t_1 = \max(0, q_1/p_1, q_4/p_4)$

$= \max(0, 1/4, 3/4)$

$t_1 = 3/4$

$p_2 p_3 > 0$

$t_2 = \min(1, q_2/p_2, q_3/p_3)$

$t_2 = \min(1, 5/4, 7/4)$

$t_2 = 1$ [Bended line inside the window

$t_1 = 3/4$ $\quad t_2 = 1$ · t_1 value is changed

$x = x_1 + t_1 \Delta x = 4 + 3/4 \cdot 4 = 7$

$y = y_1 + t_1 \Delta y = 12 + 3/4 (-4) = 9$

$x = 7$, $y = 9$

clipped line (7,9) to (8,8)

2016 fall

Q6 (a) Resolution for first Raster system (R_1) = 640x480

Refresh Rate (r) = 60 frame per second

no. of pixel accessed per second (n) = ?

access time per pixel (t) = ?

Now

total no. of pixel in system = 307200

- no. of pixel in a system with 60 FPS

rate = $307200 \times r$

$= 307200 \times 60$

$= 18432000$ pixels

- in 1 second, pixels are 18432000
- again 18432000 pixel accessed in 1 second
- 1 pixel accessed in $\frac{1}{18432000}$ second

$= 5.42 \times 10^{-8}$

$= 54.25 \times 10^{-9}$ s

$= 54.25$ ns

(b) Resolution for second Raster system (R_2) = 1280x1024

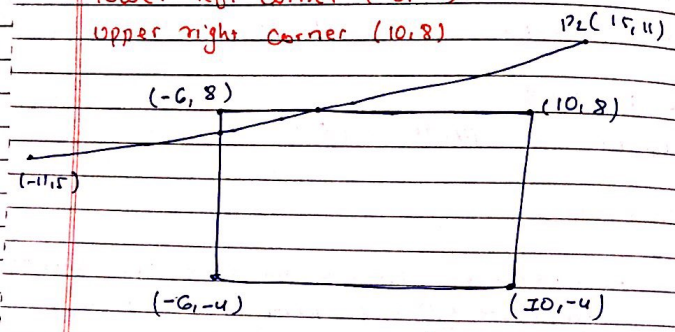
refresh rate = 60 FPS

Now

total no. of pixel = $60 \times 1280 \times 1024 = 78643200$ pixel

access time per pixel = 1.27×10^{-8} = 12.7 ns

(2b) Lian Barsky line clipping algorithm to clip a line (-11,5) to (15,11) having window lower left corner (-6,-4) upper right corner (10,8)



Line $P_1(\overset{x_1}{-11}, \overset{y_1}{5})$ and $P_2(\overset{x_2}{15}, \overset{y_2}{11})$

$x_{wmin} = -6$ $\quad x_{wmax} = 10$

$y_{wmin} = -4$ $\quad y_{wmax} = 8$

$\Delta x = x_2 - x_1 = 26$

$\Delta y = y_2 - y_1 = 6$

$p_1 = -\Delta x = -26$ $\quad q_1 = x_1 - x_{wmin} = -5$

$p_2 = \Delta x = 26$ $\quad q_2 = x_{wmax} - x_1 = 21$

$p_3 = -\Delta y = -6$ $\quad q_3 = y_1 - y_{wmin} = -11$

$p_4 = \Delta y = 6$ $\quad q_4 = y_{wmax} - y_1 = 3$

Intial value $t_1 = 0$, $t_2 = 1$

$p_1 p_2 > 0$

$t_1 = \max(0, q_1/p_1, q_3/p_3) = \max(0, 5/26, 11/6)$

$= \cancel{\frac{\pi}{6} = 0.8333}$ $\quad \frac{5}{26}$

$p_2 p_2 > 0$

$t_2 = \min(1, q_2/p_2, q_4/p_4)$

$= \min(1, 0.8076, 0.5)$

$= 1/2$

For $t_1 = 5/26$

$x = x_1 + t_1 \Delta x = -11 + \frac{5}{26} \cdot 26 = -6$

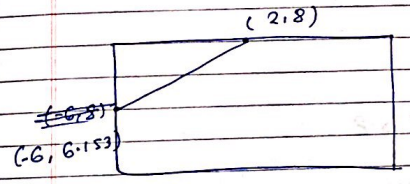
$y = y_1 + t_1 \Delta y = 5 + 11/6 \cdot 6 = 6.1538$

For $t_2 = 1/2$

$x = x_1 + t_1 \Delta x = -11 + 0.5 * 26 = 2$

$y = y_1 + t_1 \Delta y = 5 + 0.5 * 6 = 8$

(-6, 6.1538) to (2,8)



(3b) Soln:

Net Transformation matrix composed of

T_1 = rotation 45 degrees in clockwise

$= -R(45)$

$$T_{2\times 2} \begin{bmatrix} \sin\theta & \cos\theta & \sin\theta & 0 \\ & -\sin\theta & 0 & 0 \\ & 0 & 0 & 1 \end{bmatrix}$$

$(3\times 1)\times(3\times 3)$

T_2 = Scaled by factor of 3

$S(3,3)$

$$\begin{bmatrix} 3 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Net Transform matrix is = $T_2\ T_1$

$$T = \begin{bmatrix} 3 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ -1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

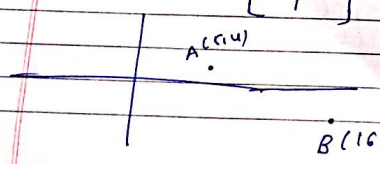
$$= \begin{bmatrix} 2.1213 & 2.1213 & 0 \\ -2.1213 & 2.1213 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

for point $P(5,3)$:

$$\begin{bmatrix} 5 \\ 3 \\ 1 \end{bmatrix} \quad T \times P$$

$$\begin{bmatrix} 2.1213 & 2.1213 & 0 \\ -2.1213 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 5 \\ 3 \\ 1 \end{bmatrix}$$

$$\cancel{\begin{bmatrix} 16.97 \\ 10.6 \\ 1 \end{bmatrix}} \qquad \begin{bmatrix} 16.97 \\ -4.242 \\ 1 \end{bmatrix}$$



Filled Area primitives :

There are two basic ~~kind~~ approaches to area filling on raster systems. One way to fill an area is to determine the overlap intervals for ~~eac~~ scanline that cross the area

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

The scan line approach is typically used in general graphics packages to fill polygon, circle. Fill methods starting from interior point are useful with more complex boundaries and in interactive painting system

$$x_{k+1} = x_k + \frac{\Delta x}{\Delta y}$$

- Scan-Line polygon fill Algorithm
- Boundary fill algorithm.
- Flood fill algorithm

Q1) Discuss why homogenous coordinates are used in computer Graphics for transformation computations? Also explain homogeneous transformation matrix for various 2D basic transformation.

Homogeneous coordinates:

A coordinate system that algebrically treats all points in the projective plane equally.

Example, the standard homogenous coordinates $[P_1, P_2, P_3]$ of a point p in the projective plan are of the form $[x, y, 1]$ if P is a point in Euclidean plane $z=1$ whose cartesian coordinates are $(x, y, 1]$

Note that the triple $(0,0,0)$ is omitted and doesnot represent any point. The origin is represented by $(0,0,1)$

The simplify and unify the mathematics used in computer graphics:

- They allows you to represent transformation with matrices
- They allows you to represent the division by depth in perspective projection

homogeneous coordinates allows to represent infinity: $(x, y, z, 0) = \frac{xyz}{0}$ in 3D. the point at infinity in direction x, y, z.

$$x = \frac{x_h}{h}, \quad y = \frac{y_h}{h}$$

Thus a general homogenous coordinate representation can also be represented as $(h \cdot x, h \cdot y, h)$

we choose $h=1$. Each two dimentional position is then represent (x, y) with homogenous cordinates $(x, y, 1)$

(i) Translation

$x' = x + t_x$

$y' = y + t_y$

In x, y

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

In homogenous

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

(ii) Scaling

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

(iii) Rotation

-ve clockwise

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

+ve Anticlockwise

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

(4/b) Describe different types of parallel projection. Derive the transformation matrix for parallel projection

oblique and orthographics projection.

We write equation for a line passing through the point (x_1, y_1, z_1) and the direction of projection with the use of parametric form.

$x = x_1 + x_p u$ — (i)

$y = y_1 + y_p u$ — (ii)

$z = z_1 + z_p u$ — (iii)

If $z = 0$ the value of u from (iii) becomes

$u = \frac{-z_1}{z_p}$

substituting value of u in (ii) & (i)

$x_2 = x_1 - z_1 (x_p / z_p)$

$y_2 = y_1 - z_1 (y_p / z_p)$

The projection formula may be written in matrix in homogeneous form as:

$$[x_2 \; y_2 \; z_2 \; 1] = [x_1 \; y_1 \; z_1 \; 1] \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ -x_p/y_p & -y_p/x_p & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

1 X 4

Difference between Image space Method (ISM) and object space Method (OSM).

Object space Method (OSM)

- deals with object definition directly
- Compare objects and parts of objects ~~with~~ to each other within the scene definition to determine which surfaces, as a whole, should label as visible
- It is continous method.
- Compare each object with all the other objects to determine the visibility of the object part.
- For n objects, complexity $O(n^2)$
- Display is more accurate and more expensive to ISM
- methods are more complex.
- suitable for small no. of Object

Image space method (ISM)

- Deals with the projected images of the object and not directly with objects
- Accuracy of calculation is bounded by the display resolution
- It is a discrete method
- A change of display resolution requires re-calculation.
- widely used
- simple to implement
- problem when too many ~~software~~ surfaces are there

2016

Q10) Explain the expression used for calculating the intensity of light incident on a surface due to specular reflection? How is intensity interpolated in case of Goroud shading?

When we look at an illuminated shiny surface such as polished metal, an apple or person's forhead, we see a highlight or a bright spot, at certain viewing direction. This phenomenon is called specular reflection.

The specular reflection angle is equals to the angle of the incident light. Shiny surface have narrow and dull surfaces have a wider reflection range. An empirical model is calculating specular reflection is by phong specular reflection model or simply phong model, sets the intensity reflection proportional to $\cos^{n_s}\phi$.

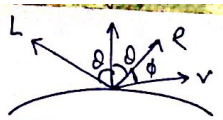
where

→ ϕ range from 0° to 90°, so that $\cos\phi$ varies from 0 to 1.

→ n_s determined by the type of material that we want to display.

→ Shiny surface have high n_s ie 100 and dull surface have low n_s ie 1 (ie chalk) For perfect surface n_s will ∞

Intensity of S.R depends on
- types of material
- angle of incidence
- polarization
- color of the incident light.



we can approx^ty model monochromatic specular intensity variations using specular-reflection coefficient, $W(\theta)$, For each surface. In general, $W(\theta)$ tends to increases as the angle of incidence increases.

$W(\theta) \propto \theta$

At $\theta = 90°$, $W(\theta) = 1$

The variation of specular intensity with angle of incidence is described by Fresnel's law of Reflection. Using the spectral-reflection function $W(\theta)$, we can write expression for calculating the insity of light incident on a surface due to specular reflection (Phong specular reflection model as):

$$I_{spec} = W(\theta) \cdot I_l \cos^{n_s}\phi \quad \text{—— (1)}$$

where

I_l = intensity of light source

ϕ = viewing angle relation to SR direction

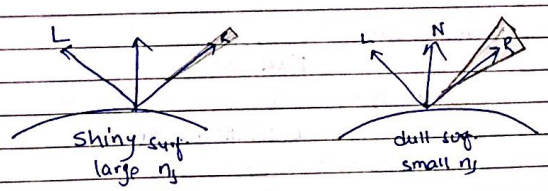


Fig: modeling SR

Second part : Done already in Goroud Shading

Different types of graphical package are:

1. GKS (Graphics Kernel System)
2. PHIGS (programmer Hierarchical interaction graphics Standard)
3. GL (Graphics Library)
4. OpenGL

2013 Spring:

On an average it takes 200 ns to access a pixel value from the buffer and glow a phosphor dot on the screen for a raster system. If resolution is 1024 x 1024, will this access rate create a flickering effect on the screen? illustrate.

→

Total no. of pixel = 1024x1024 = 1048576 pixels

In 200 ns, a phosphor dot glows
for 1 pixel, it takes 200 ns
for 1048576 pixel it takes 209715200 ns
= 0.2097 sec

pixel per sec = Resolution x refresh rate

$\therefore$ Access time = $\frac{1}{\text{pixel per sec}}$

$200\,ns = \frac{1}{\text{Resolution} \times RR}$

$200 \times 10^{-9} = \frac{1}{1024 \times 1024 \times RR}$

$RR = \frac{1}{1024 \times 1024 \times 200 \times 10^{-9}} \approx 5$

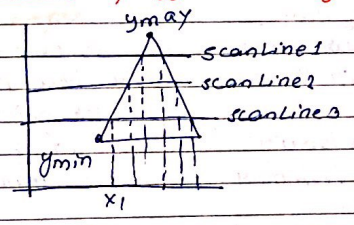
Yes flicker occurred.

Filled Area Primitives:

A standard output primitive in general graphics packages is a solid-color or patterned polygon area. Other kind of area primitives are sometimes available, but polygon are easier to process since they have linear boundaries.

- There are two basic approaches to area filling on raster systems. one way to fill an area is to determine the overlap intervals for scan lines that cross the area.
- Another method of area filling is to start from a given interior position and paint outside from that point until we encounter the specified boundary condition.

Scan Line polygon fill algorithm:



The algorithm works by intersecting scanline with polygon edges and fills the polygon between pairs of intersection. The algorithm is:

step1: Find out ymin and ymax from given polygon

ymin

Step-2 : Scanline intersect with each edge of the polygon from ymin to ymax. Name each intersection point of the polygon. As per the figure shown above, they are named as P_0, P_1, P_2 and P_3

Step-3 : Sort the intersection point in the increasing order of x coordinate ie (P_0, P_1), (P_1, P_2) and (P_2, P_3)

Step-4 : Fill all those pair of coordinates that are inside polygons and ignore the alternate pair

Some scan line intersection at polygon vertices require special handling.

Flood fill Algorithm

(Copy ~~m~~ 8)

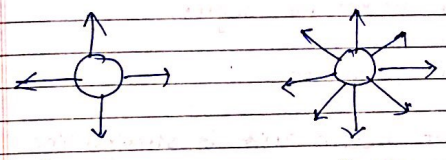
Sometime, we come accross an object where we want to fill the area and its boundary with different colors. we can paint such object with a specified interior color instead of searching for particular boundary color as in boundary filling algorithm

Instead of relying on the boundary of object, it relies on the fill color. In other words, it replaces the interior color of the object with the fill color. when no more pixels of the original interior color exist, the algorithm is completed. This approach is called flood fill algo.

Boundary fill algorithm :

The boundary fill algorithm works as its name. This algorithm picks a point inside an object and starts to fill untill it hits the boundary of the object. The color of the boundary and the color that we fill should be different for this algorithm to work

In this algorithm, we assume that color of the boundary is same for the entire object. The boundary fill algorithm can be implemented by 4-connected pixels or 8-connection pixel



4-way 8-way

```
void boundary_fill (int x, int y, int bcolor, int fcolor)
    int currentpixel = getpixel(x,y);
    if (currentpixel != bcolor && currentpixel != fcolor) {
        putpixel( x, y, fcolor);

        b_f( x-1, y, bcolor, fcolor);
        b_f( x+1, y, bcolor, fcolor);
        b_f( x, y-1, bcolor, fcolor);
        b_f( x, y+1, bcolor, fcolor);
    }
}
```

Bezier curves :

These curves can be generated under the control of other points. Approximate tangent by using control points are used to generate curve. The bezier curve can be represented as:

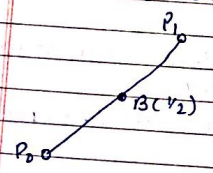
$$\sum_{k=0}^{n} P_i \, B_i^n(t)$$

where P_i is the set of points and $B_i^n(t)$ represents the :

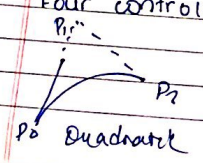
$$B_i^n(t) = c(n,i)\, u^i (1-u)^{n-i}$$

Where n is polynomial degree,
i is index
u is parameter

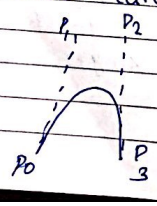
The simplest Bezier curve is straight line from P_0 to P_1



A quadratic Bezier curve is determined by three control points. A cubic Bezier curve is determined by four control points



Quadratic



→ cubic Bezier curve

Properties of Bezier curves

- They generally follow the shape of the control polygon, which consist of the segment joining the control point.
- They always pass through the first and last control points.
- The degree of polynomial defines the curve segment is one less than the number of polygon point
  ie- 4 control points, degree of polynomial is 3 ie cubic polynomial
- Bezier curves lies within the convex hull (convex polygon boundary) of the control points.
- They are all positive and their sum is always 1

$$\sum_{k=0}^{n} BEZ_{k,n}(u) = 1$$

- A Bezier curve generally follows the shape of the defining polygon

Mach bands

Mach bands is an optical illusion named after the physicist ~~ea~~ Ernst mach. It exaggerates the constrast between the edge of the slightly differing shades of gray, as soon as they contact one another.

The mach bands effect is due to the spatial high-boost filtering by the human visual system.
The effect is independent of the orientation of the boundary.

fig: Mach bands illusion

Application :
help scientist study the way the eye & brain process visual information.

Mach bands are an optical illusion where a band of gradients will appear in places to be lighter or darker than they actually are.
Mach bands, ~~as well~~ provide a valuable way to investigate how the eye and brains process visual information.

When looking at mach bands, one sees a central band of a light to dark gradient surrounded on one side by the darkest color and on the opposite side by the lightest color. In reality, there is no color darker or ligher than the surrounding fields, its a illusion

Projection hierarchy

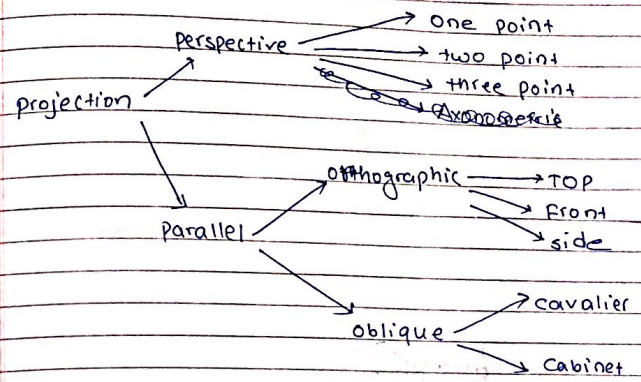


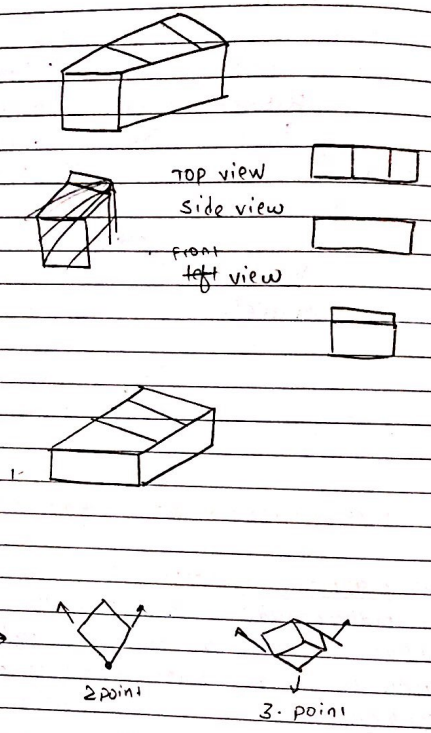
fig: projection hierarchy

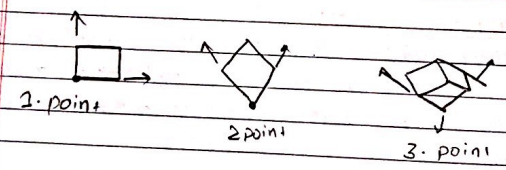
Orthographic projection :

In orthographic projection, the direction of projection is normal to the projection of the planes. There are three types of orthographic projection

- Front projection
- TOP projection
- side projection
- axonometric projection

Front side, and rear orthographic projection of an object are called elevation. The most commonly used axonometric projection is Isometric projection.





Orthographic projection is a means of representing a three dimensional object in two dimension.

The axis or plane of the object is also parallel with the projection plane

What is projections ?

projection in computer graphics means the transformation of a three dimensional (3D) area into a two dimensional (2D) area.

- Parallel projection
- perspective projection

fig: projection hierarchy.

OpenGL :

OpenGL is a software interface that allow the programmer to create 2D and 3D graphics image. OpenGL is both a

- Standard API and

the implementation of that API. You can call the function that comprise OpenGL from a program you write and expect to see the same result no matter where your program is running.

OpenGL is independent of the hardware, operating and windowing systems in use. The fact that it is windowing-system independent, makes it portable. OpenGL program must interface with the windowing system of the platform where the graphics are to be displayed. Therefore a number of windowing toolkits have been developed for use ~~op~~ with OpenGL.

OpenGL functions in a client/server environment. That is, application program producing the graphics may run on a machine other than one on which graphics are displayed. The server part of OpenGL, which runs on the workstation where the graphics are displayed can access whatever physical graphics device or frame buffer is available on that machine.

Features in OpenGL :

- 3D Transformations
  - Rotations, scaling, translation, perspective
- Color models
  - R, G, B, alpha
- Lighting
  - Gouraud shading, Phong shading
- Rendering
  - Texture mapping

  → The ability to apply an image to a graphics surface. This technique is used to rapidly generate ~~rapi~~ images without having to specify an excessive amount of details.

~~# Why~~
- Z-buffering
- Double buffering
- Smooth shading

Why OpenGL ?

- Device independence
- Platform independence
  - SGI, Linux, windows
- Open source
- Hardware independent software interface
- Support of client-server protocol
- Other API

  DirectX (windows), Java3D (Sun) etc.

(3a) Digitize a circle centered at (100, 200) having radius 8.

→ The midpoint algorithm states that:

$P_0 = 1 - r$

and intial cordinate $(x_0, y_0) = (0, r)$

if $P_k < 0$, (x_{k+1}, y_k)

(x) $P_{k+1} = P_k + 2x_{k+1} + 1$

if $P_k > 0$, (x_{k+1}, y_{k+1})

(y) $P_{k+1} = P_k + 2x_{k+1} - 2y_{k+1} + 1$

Repeat until $x \geq y$

→ Given:

radius = 8

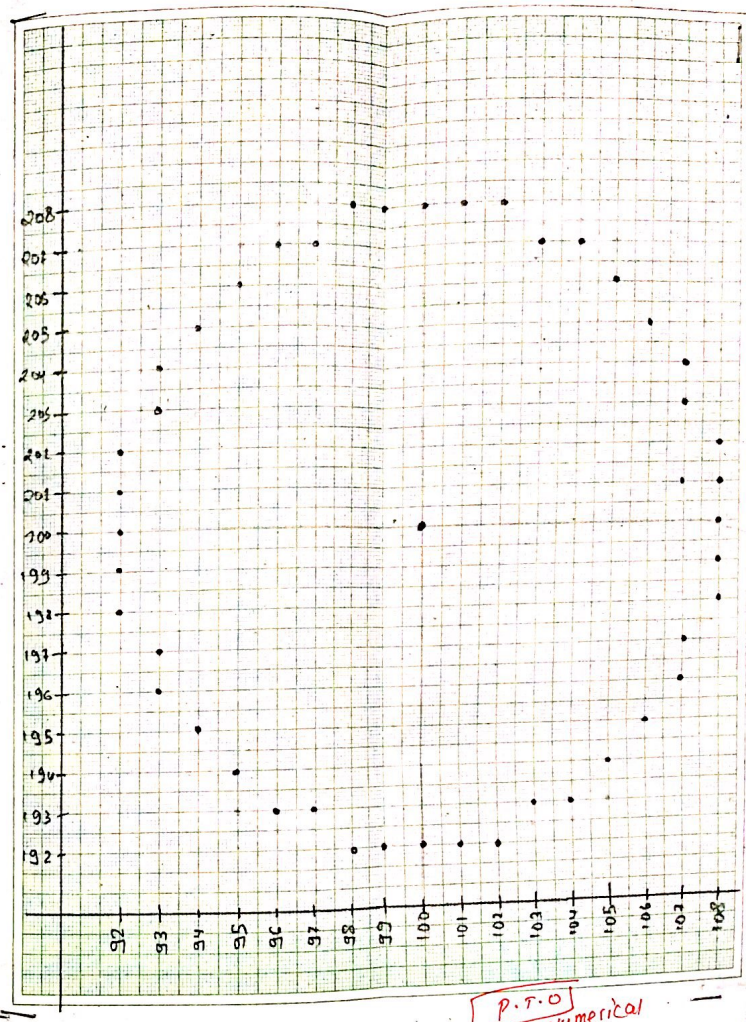
center $(h, k) = (100, 200)$

starting coordinates $(x_0, y_0) = (0, 8)$

intial parameter $(P_0) = 1 - r = 1 - 8 = -7$

S.N	P_k	x_{k+1} (0)	y_{k+1} (8)	P_{k+1}
0	-7	1	8	-4 < 0
1	-4	2	8	1 > 0
2	1	3	7	-6 < 0
3	-6	4	7	3
4	3	5	6	2
5	2	4	5	

$x \geq y$



P.T.O Numerical

8-way symetry

	0,		2, 8	3, 7	4, 7	5, 6
x, y	0, 8	1, 8	2, -8	3, -7	4, -7	5, -6
x, -y	0, -8	1, -8	-2, 8	-3, 7	-4, 7	-5, 6
-x, y	0, 8	-1, 8	-2, -8	-3, -7	-4, -7	-5, -6
-x, -y	0, -8	-1, -8	8, 2	7, 3	7, 4	6, 5
y, x	8, 0	8, 1	8, -2	7, -3	7, -4	6, -5
y, -x	8, 0	8, -1	-8, 2	-7, 3	-7, 4	-6, 5
-y, x	-8, 0	-8, 1	-8, -2	-7, -3	-7, -4	-6, -5
-y, -x	-8, 0	-8, -1				

$x_c = x + h = x + 100$

$y_c = y + k = y + 200$

x, y	100, 208	101, 208	102, 208	103, 207	104, 207	105, 206
(x, -y)	100, 192	101, 192	102, 192	103, 193	104, 193	105, 194
-x, y	100, 208	99, 208	98, 208	97, 207	96, 207	95, 206
-x, -y	100, 192	99, 192	98, 192	97, 193	96, 193	95, 194
y, x	108, 200	108, 201	108, 202	107, 203	107, 204	106, 205
y, -x	108, 200	108, 199	108, 198	107, 197	107, 196	106, 195
-y, x	92, 200	92, 201	92, 202	93, 203	93, 204	94, 205
-y, -x	92, 200	92, 199	92, 198	93, 197	93, 196	94, 195

[3|b] Final coordinates of a triangle with vertices A(2,3), B(3,3), C(3,2) rotating it a by 45 degrees in anticlockwise direction then shifting it by down by 3 units and enlarging it by twices of its original size

→ T_1 = 45 degree anticlockwise rotation
= $R(45)$

T_2 = shifting it by down by 3 units
= $T(0,-3)$

T_3 = enlarging it by twice
$S(2,2)$

Then
Transformation matrix (T) = $T_3\ T_2\ T_1$

$$T = \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -3 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & -6 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

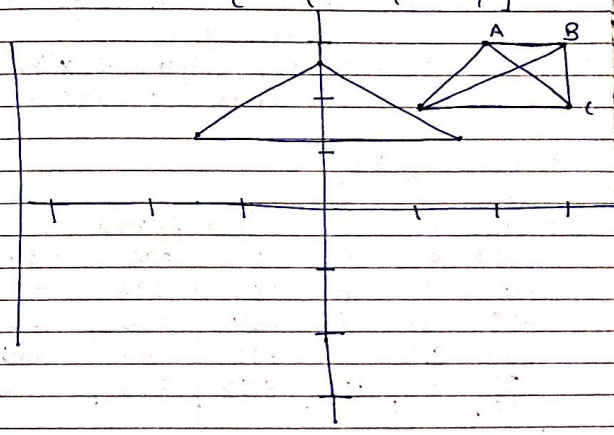
$$\begin{bmatrix} 1.4142 & -1.4142 & 0 \\ 1.4142 & 1.4142 & -6 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \sqrt{2} & -\sqrt{2} & 0 \\ \sqrt{2} & \sqrt{2} & -6 \\ 0 & 0 & 1 \end{bmatrix}$$

For triangle,

Final coordinates = $\begin{bmatrix} \sqrt{2} & -\sqrt{2} & 0 \\ \sqrt{2} & \sqrt{2} & -6 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 3 & 3 \\ 3 & 3 & 2 \\ 1 & 1 & 1 \end{bmatrix}$

$$\begin{bmatrix} -\sqrt{2} & 0 & \sqrt{2} \\ 1.071 & 2.4852 & 1.071 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} -1.4142 & 0 & 1.4142 \\ 1.071 & 2.4852 & 1.071 \\ 1 & 1 & 1 \end{bmatrix}$$



Q (31a) Ellipses

Region 1 in first quadrant

major axis = 8 $r_x = 8$

minor axis = 7 $r_y = 7$

centre (0,0)

Midpoint Ellipse algorithm:

$(x_0, y_0) = (0, r_y) = (0, 7)$

$P_{10} = r^2 y - r^2 \times r y + \frac{1}{4} r^2$

If $P_{1K} < 0$, x_{K+1}, y_K

$P_{1K+1} = P_{1K} + 2r^2 y x_{K+1} + r^2 y$ (x)

else, x_{K+1}, y_{K-1}

$P_{1K+1} = P_{1K} + 2r^2 y x_{K+1} - 2r^2 x y_{K+1} + r^2 y$

Repeat until $2r^2 y x_{K+1} \geq 2r^2 x y_{K+1}$ (y)

→ $P_{10} = -383$

S.N	P_{1K} (A)	x_{K+1} (B)	y_{K+1} (C)	$2r^2 y x_{K+1}$	$2r^2 x y_{K+1}$	P_{1K+1}
	-383	1	7	0	896	-334
	-334	2	7	196	896	-89
	-89	3	7	294	896	254
	254	4	6	392	768	~~605~~ -73
	~~605~~ -73	5	6	490	768	466
	466	6	5	588	640	463
	463	7	4	686	512	686

$\geq$ (True)

Region 1 complete

2014 Spring

31b Digitize one octant of circle center at 10,20 and radius is 10

→ Midpoint circle algorithm say:

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

$P_{00} = 1 - r$

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}

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

Repeat until $x \geq y$

Given:

radius = 10

intial point $(x_K, y_K) = (0, 10)$

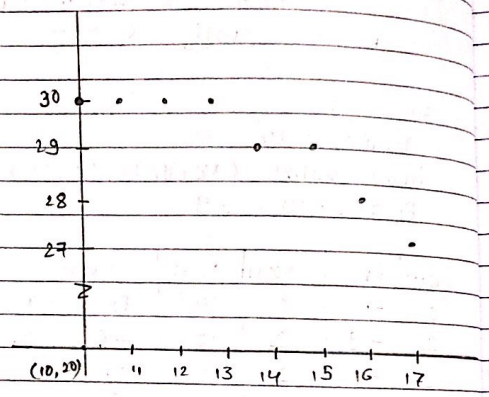
$P_0 = 1 - 10 = -9$

S.N	P_K	x_{K+1}	y_{K+1}	P_{K+1}
0	—	0	10	$P_0 = -9$
1	-9	1	10	-6
2	-6	2	10	-1
3	-1	3	10	6
4	6	4	9	-3
5	-3	5	9	8
6	8	6	8	21
7	21	7	7	

$x_{K+1} \geq y_{K+1}$

• circle octant points are:

(0,10) → (10, 30)
(1, 10) → (11, 30)
(2, 10) → (12, 30)
(3, 10) → (13, 30)
(4, 9) → (14, 29)
(5, 9) → (15, 29)
(6, 8) → (16, 28)
(7, 7) → (17, 27)



(4a) Perform a 45 degree rotation of a line A(8,3) and B(14,10)
(a) origin (b) (4,2)

→ (a) $T_1 = R(45)$ → anticlockwise

$$\therefore T = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

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

AB + CD + EF

$$\therefore \text{Transform coordinate} = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 8 & 14 \\ 3 & 10 \\ 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 3.5355 & 2.8284 \\ 7.7781 & 16.97 \\ 1 & 1 \end{bmatrix}$$

(b) $T_1 = T(-4, -2)$
$T_2 = R(45)$

$$T = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -4 \\ 0 & 1 & -2 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.7071 & -0.707 & +4.1142 \\ 0.7071 & 0.7071 & -4.242 \\ 0 & 0 & \end{bmatrix}$$

$$\text{coordinate} \begin{bmatrix} 0.7071 & -0.7071 & +4.142 \\ 0.7071 & 0.7071 & -4.242 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 8 & 14 \\ 3 & 10 \\ 1 & 1 \end{bmatrix} = \begin{bmatrix} 2.1213 & 1.4142 \\ 3.5361 & 2.728 \\ 1 & 1 \end{bmatrix}$$

[3 4(b) Reflect a rectangle A(2,2), B(5,2), C(2,4), D(5,4) about a line $x=y$

$x=y$

$\therefore x'=y$

$y'=x$

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

$$= \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 5 & 2 \\ 2 & 2 & 4 \\ 1 & 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 & 2 & 4 \\ 2 & 5 & 2 \\ 1 & 1 & 1 \end{bmatrix}$$

OR

$y=x$

Slope $(m) = 1$

Comparing with $y = mx + b$

$m=1,\ b=0$

$$T = \begin{bmatrix} \frac{1-m^2}{1+m^2} & \frac{2m}{1+m^2} & \frac{-2bm}{1+m^2} \\ \frac{2m}{1+m^2} & \frac{m^2-1}{1+m^2} & \frac{b-bm^2}{1+m^2} \\ 0 & 0 & 1 \end{bmatrix}$$

$$T = \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

coordinate: $\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 5 & 2 \\ 2 & 2 & 4 \\ 1 & 1 & 1 \end{bmatrix} = \begin{bmatrix} 2 & 2 & 4 \\ 2 & 5 & 2 \\ 1 & 1 & 1 \end{bmatrix}$

$=$

(4a) 2014 fall

Perform a 45 degree rotation of a line A(5,3) and B(10,15

$\rightarrow$

$$T = R(\theta) = R(45) = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\text{Transformed} = \begin{bmatrix} 1/\sqrt{2} & -1/\sqrt{2} & 0 \\ 1/\sqrt{2} & 1/\sqrt{2} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 5 & 10 \\ 3 & 15 \\ 1 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 1.4142 & -3.535 \\ 5.6568 & 17.677 \\ 1 & 1 \end{bmatrix}$$

#

Q 4a OR :

calculate viewing transformation matrix with given information of given triangle A(5,5), B(15,5), C(10,10) given window coordinate (7,4),(13,4) (13,8),(7,8) and view port (17,7) (18,7) (18,8),(17,8)

→ $T_1 = T(-x_{wmin}, -y_{wmin})$

$T_2 = S(S_x, S_y)$

$T_3 = T(x_{vmin}, y_{vmin})$

where

$$S_x = \frac{x_{vmax} - x_{vmin}}{x_{wmax} - x_{wmin}} = \frac{18-17}{13-7} = \frac{1}{6}$$

$$S_y = \frac{y_{vmax} - y_{vmin}}{y_{wmax} - y_{wmin}} = \frac{1}{4}$$

$\therefore T = T_3 T_2 T_1$

Given :

For window

$x_{wmin} = 7$ $\quad x_{wmax} = 13$

$y_{wmin} = 4$ $\quad y_{wmax} = 8$

For view port :

$x_{vmin} = 17$ $\quad x_{vmax} = 18$

$y_{vmin} = 7$ $\quad y_{vmax} = 8$

$\therefore T_1 = T(-7, -4)$

$T_2 = S(1/6, 1/4)$

$T_3 = T(17, 7)$

$\therefore T = T_3 T_2 T_1$

$$= \begin{bmatrix} 1 & 0 & 17 \\ 0 & 1 & 7 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1/6 & 0 & 0 \\ 0 & 1/4 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & -7 \\ 0 & 1 & -4 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 1 & 0 & 17 \\ 0 & 1 & 7 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0.1667 & 0 & -1.1667 \\ 0 & 0.25 & -1 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 0.1667 & 0 & 15.833 \\ 0 & 0.25 & 6 \\ 0 & 0 & 1 \end{bmatrix}$$

For triangle :

$$\text{matrix} = \begin{bmatrix} 0.1667 & 0 & 15.833 \\ 0 & 0.25 & 6 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 5 & 15 & 10 \\ 5 & 5 & 10 \\ 1 & 1 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 16.666 & 18.333 & 17.5 \\ 7.25 & 7.25 & 8.5 \\ 1 & 1 & 1 \end{bmatrix}$$

2013 Spring

(4/b) scale a triangle $A(0,0)$, $(1,1)$, $C(3,2)$ by twice its original size

(i) about origin

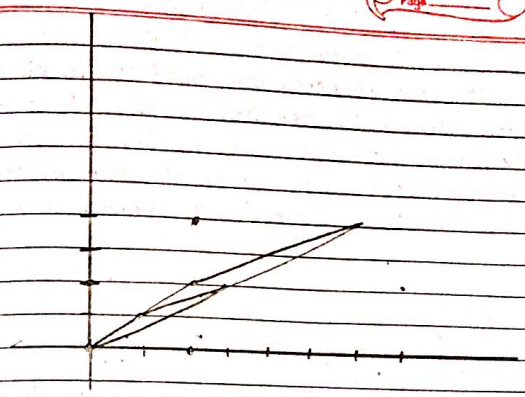
(ii) about $P(-1,-2)$

(i) About origin

$T = S(S_x, S_y) = S(2,2)$

transformed coordinate $= \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 & 3 \\ 0 & 1 & 2 \\ 1 & 1 & 1 \end{bmatrix}$

$= \begin{bmatrix} 0 & 2 & 6 \\ 0 & 2 & 4 \\ 1 & 1 & 1 \end{bmatrix}$



(ii) About $P(x_p, y_p) = P(-1,-2)$

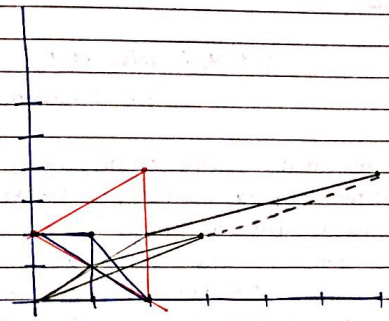
$T_1 = T(-x_p, -y_p) = T(1,2)$

$T_2 = S(S_x, S_y) = S(2,2)$

$T_3 = T(x_p, y_p) = T(-1,-2)$

$T = T_2 \cdot T_1$

$= \begin{bmatrix} 1 & 0 & -1 \\ 0 & 1 & -2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \phi & 0 & 1 \\ 0 & \phi & 2 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 2 \\ 0 & 0 & 1 \end{bmatrix}$



Note:

Polygon Clipping

To clip polygon, we need to modify the line clipping in previous section. A polygon boundary processed with the line clipper may be displayed as a series of unconnected line clipping segments as shown in fig a.

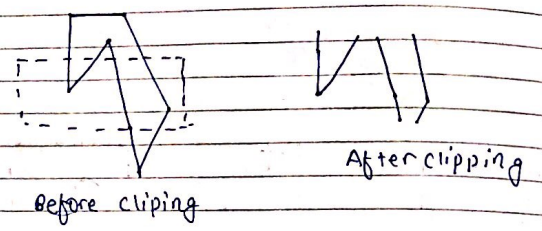
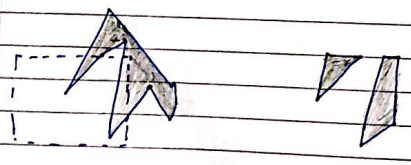


fig (a): Display a polygon using Line clipping

What we really want to display is a bounded area after clipping as in fig b. For polygon clipping, we require an algorithm which produces one or more closed areas that are then scan converted for the appropriate area fill. The output of a polygon clipper should be a sequence of vertices that defines the clipped polygon boundaries.



Sutherland Hodgeman polygon clipping

We can correctly clip a polygon by processing the boundary as a whole against each window edge.

Begining with the intial set of polygon vertices we could first clip the polygon against the left rectangle boundary to produce a new sequence of vertices; then right, then bottom and top.

Describe 4 condition as:

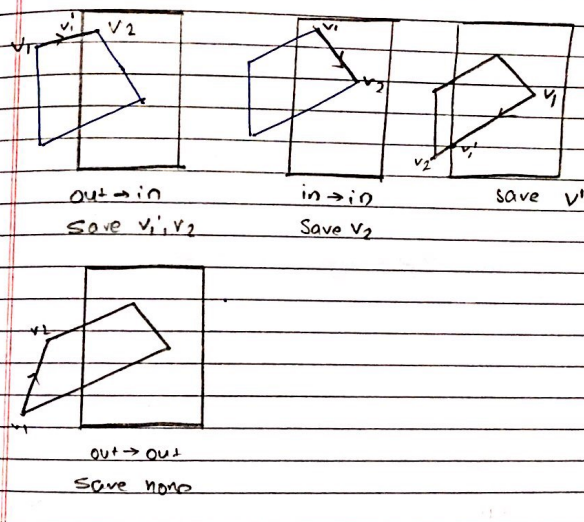
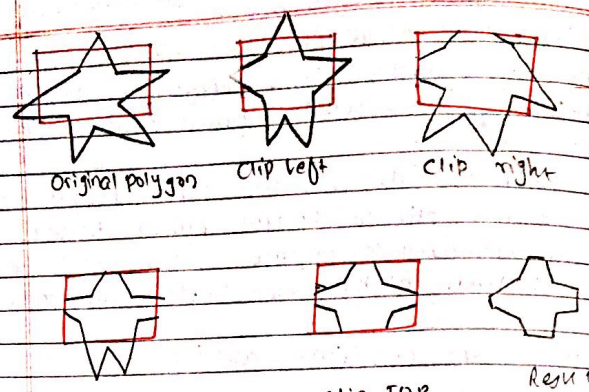


fig: successive processing of pairs of polygon

once all vertices have been processed for one clip window boundary, the output list of vertices is clipped against the next window boundary



A raster system can produce a total number of 1024 different level of intensities from a single pixel compared of red, Green and Blue phosphor dots. If the total resolution of the screen is 1280X1024, what will be the required size of frame buffer for the display purpose

— Number of Intensity (I) = 1024

We know,

$$\text{Intensity} = 2^{\text{no. of bits}}$$

∴ let pixel depth = n = no. of bits

$$1024 = 2^n$$

$$n = 10$$

∴ pixel depth = 10

resolution of screen (R) = 1024 x 1280

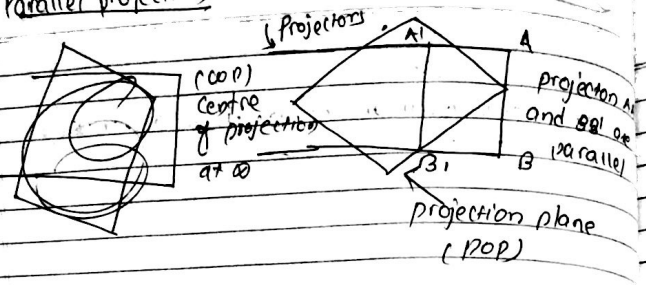
So, size of frame buffer (S) = n x R

= 10 x 1280 x 1024

= 1,31,07,200 bits

=

Parallel projection



If the distance between COP and POP is infinite then projection is called parallel projection. ie the rays from COP are parallelled. So it maintains the relative proportion of the objects in the project we extend parallel lines each vertex plane of the screen.

in 3D,

$$x = x_1 + (x_2 - x_1)u$$
$$y = y_1 + (y_2 - y_1)u$$
$$z = z_1 + (z_2 - z_1)u$$

let direction of projection is given by vector $[x_p, y_p, z_p]$ and the image is to be projected on the xy plane. If we have a point on the object at (x_1, y_1, z_1) and projected point be (x_2, y_2) then eqn of line is:

$$x_2 = x_1 + x_p u$$
$$y_2 = y_1 + y_p u$$
$$z_2 = z_1 + z_p u$$

But on xy. Plane, $0 = z_1 + z_p u$

$$\therefore u = \frac{-z_1}{z_p}$$

substituting these values of u in x and y, we get

$$x = x_1 + x_p\left(\frac{-z_1}{z_p}\right)$$
$$y = y_1 + y_p\left(\frac{-z_1}{z_p}\right)$$

then

$$x = x_1 + z_1\left(\frac{-x_p}{z_p}\right)$$
$$y = y_1 + z_1\left(\frac{-y_p}{z_p}\right)$$

The projection formula may be written in homogeneous form as:

$$\begin{bmatrix} x_2 \\ y_2 \\ z_2 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 & 0 & -x_p/z_p & 0 \\ 0 & 1 & -y_p/z_p & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ z_1 \\ 1 \end{bmatrix}$$

perspective projection:

If the distance between POP and COP is finite and converges to a single point (vanishing point) then the projection is called perspective projection

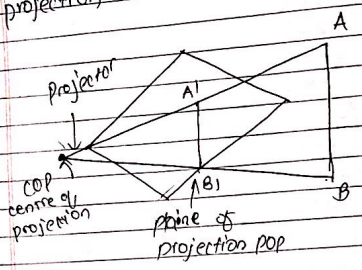


fig: perspective project

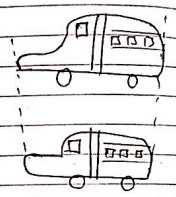
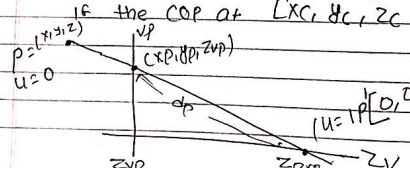


fig: Same vehicle

It transforms point of 3D object along projection lines that meet at vanishing point. The size of object doesnot remain same and varies with the distance of object from COP. but it is more realistic than parallel.

If the COP at $[x_c, y_c, z_c]$



$x' = x - xu$

$y' = y - yu$

$z' = z - (z - z_{prp})u$

we know, on view plane $z' = z_{vp}$

$\therefore z_{vp} = z - (z - z_{pr})u$

$-(z - z_{pr})u = z_{vp} - z$

$u = \dfrac{z_{vp} - z}{z_{prp} - z}$ $\quad \therefore 1 - u = \dfrac{z_{prp} - \cancel{z} - z_{vp} + \cancel{z}}{z_{prp} - z}$

Substituting the value of u into the eqn of x' and y'.

$x_p = x - xu = x(1-u)$

$= x \times \dfrac{(z_{prp} - z_{vp})}{z_{prp} - z} = x\left(\dfrac{d_p}{z_{prp} - z}\right)$

$y_p = y(1-u) = y\left(\dfrac{z_{prp} - z_{vp}}{z_{prp} - z}\right) = y\left(\dfrac{d_p}{z_{prp} - z}\right)$

where $d_p = z_{prp} - z_{vp}$,

$$\begin{bmatrix} x_h \\ y_h \\ z_h \\ h \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & -z_{vp}/d_p & z_{vp}(z_{prp}/d_p) \\ 0 & 0 & -1/d_p & z_{prp}/d_p \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

$z' = z - (z - z_{prp})u$

$z' = z - zu + z_{prp}u$

$= z(1-u) + z_{prp}u$

$= z\left(\dfrac{d_p}{z_{prp} - z}\right) +$

$h = \dfrac{z_{prp} - z}{d_p}$

$x_p = x_h/h \quad y_p = y_h/h$

Oblique / Orthographic projection :

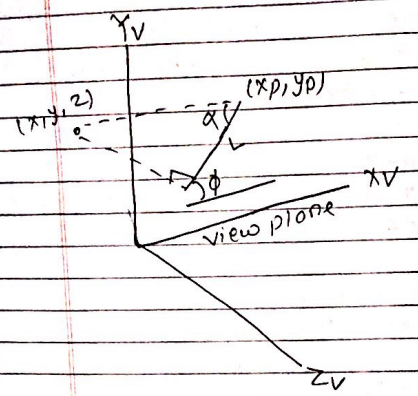


fig: oblique projection of coordinate position (x, y, z) to position (x_p, y_p) on the view plane

$$x_p = x + L\cos\phi$$
$$y_p = y + L\sin\phi$$

Length L depends on the angle α and the z coordinate of the point to be projected

$$\tan\alpha = z/L$$

thus,

$$L = \frac{z}{\tan\alpha}$$

$L = zL_1$ where L_1 is inverse of $\tan\alpha$ which is also the value of L when $z=1$

$$x_p = x + z(L_1\cos\phi)$$
$$y_p = y + z(L_1\sin\phi)$$

The transformation matrix for producing any parallel projection onto the $x_v y_v$ plane can be written as:

$$M_{parallel} = \begin{bmatrix} 1 & 0 & L_1\cos\phi & 0 \\ 0 & 1 & L_1\sin\phi & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Note: Orthographic projection is obtained when $L_1 = 0$ (which occurs at a projection $x_p = x$, $y_p = y$

cavilier Projection when $\tan\alpha = 1$
$\phi = 30^\circ$ or 45°

OpenGL:

OpenGL is a software interface to graphics hardware. The interface consist of 250 distinct command.

Designed as hardware independent interface to be implemented on different hardware platform.

To achieve these, no windowing tasks or obtaining user inputs are included in open GL.

Primitive:

```
getpixel(x,y);
putpixel(x,y, RED);
```

GL related libraries:

(i) GLU (openGL utility library)

Contains several routines that use lower level openGL commands to perform tasks as setting up matrices for specific viewing orientations and projections etc.

(ii) OpenGL Utility Toolkit (GLUT):

A window system independent toolkit to hide the complexities of differing system APIs. OpenGL contains only rendering commands and no commands for opening windows or reading events from keyboard or mouse.

Windows management

- OpenGL is completely platform independent.
- Need a windowing system for things like
  - Interaction
  - handling event
  - opening - closing window.

Options

- GLX (*nix)
- WGL (window)
- GLUT (window system independa

Event driven interaction

- Indicates what action need to be taken window is resized
- Allow you to link a keyboard key or mouse button with a routing when event occur what to do?
- Events usually placed in a que awaiting action
- callbacks let you associate a functi

Create a triangle

```
glBegin(GL_POLYGON)
    glColor3f(1.0f, 0.0f, 0.0f); // pure red
    glVertex3f(0.0f, 0.0f, 0.0f);
    glVertex3f(50.0, 0.0, 0.0f);
    glVertex3f(25.0, 50.0, 0.0);
    glEnd();
    glFlush();
}
```

What is openGL?
- Configurable state machine
  - input is 2D or 3D data

- widely used and supported
- very well documented
- choice for Linux developer
- Geometric and ~~2D~~ pixel processing
- high end feature
- Licence free

OpenGL is used for:
- real time application
- fast preview for visualization
- interactive virtual env.
- video games
- Easy to prog

GKS (Graphics Kernel system)
GKS is an ANSI and ISO stdard.
it standarized two-dimenional graphics functionality at a relatively low level

objective of GKS is the production and manipulation of pictures in a computer or graphical device independent way.

purpose are
- provide portability of graphics application program
- aid in the understanding of graphics method
- To provide guidelines for manufacturers in describing useful graphics capabilities

It consist of three basic parts
* informal exposition
  - how text is positioned
  - how polygon is filled
* formalization of expository material
  - input/output parameter
  - language independent
  - description of error condition
* Language binding
  implementation of these abstract function in a specific computer language as C, C++.

The main primitive of GKS are
- polyline :- seq of line
- polymakers - marks a seq of points with same symbol
- fill area
- text
- cell array

Graphical languages :

(i) Software std (Need for machine Independent GL)
- The primary goal of standarized policy is portability.

when packages are designed

(i) GKS → Graphics kernel system was developed for 2D and later for 3D

(ii) programmer hierarchical Interactive Graphics standard (PHIGS)
→ an extension of GKS with increased capabilities
- objects modeling
- color specifications
- surface rendering
- picture manipulation

→ independent of any PL.

But it doesnot provide a std methodology for a graphical interface to output devices not for storing.
separate std develope

(iii) simple Raster Graphics package (SRGP)
→ GL is device independent using raster capabilities and primitive like line, rect, circle, ellipse & text string.

But SPHIGS (simple PHIGS) → for both raster & vector.

project management :

A project can be defined loosely as an item of work which requires
- Planning, organizing, dedication of resources and funds in order to produce a concept, a product like (game, software etc) or a plant.

project mgmt :
- identifying risk
- maximizing cost savings
- minimizing time delays
- improving economic return

To achieve these :
- effective mgmt of people
- tough but fair project deadlines
- Efficient business technique
- Outstanding leadership skill

Function
1. major factor like :
   - cost mgmt
   - time,
   - Human resource
   - Comm.
2. Over company life cycle
3. Engin. req.
4. proj dev.
5. Budgeting & mgmt
6. proj execution.

Graphics file formats :

A graphics file format (file reader) is responsible for - opening a file,
- determining its validity
- interpretating the information contained within it.

two reader design
(i) filter! one character at a time
(ii) Scanner - randomly read any where

(i) BMP :

A bitmap file (BMP) contains an exact pixel mapping of an image which can then be reconstructed by rendering application on the display surface of an o/p device. (beginning of file

BMP consist of
Header → file identifier
→ file version
→ Bitmap bmp
color pallate
other data

(ii) TIFF (tag image file format)

TIFF specification was intent intend for storing black and white images created by scanner. it contains (beginning
- Image file header (IFH)
- Image file Directory (IFD)
- Bit map data.

Diffuse Reflection :

+ Ambient light is an approx of global diffuse, light effects.
→ Diffuse reflection are constant over each surface.

Kd or diffuse reflection coefficient vary from 0 to 1. Kd is nearly 1 for highly reflective (shiny) surfaces and Kd is 0 for light absorbs/blacks

Diffuse reflection intensity at any point on the surface is

$$I_{amb\,Diff} = K_d \cdot I_d$$

where $I_{amb\,Diff}$ = ambient light due to diffusion
I_d = light due to diffusion
K_d = diffuse reflection coefficient.

viewing direction (called 'ideal') also called Lambertian reflection

$$I_{L\,Diff} = K_d \cdot I_L \cos\theta$$

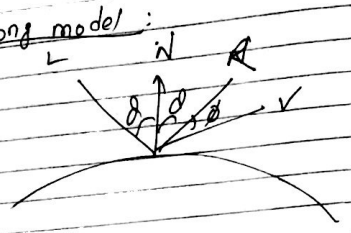
If N is unit Normal vector to a surface and L is unit direction vector

$$I_{L\,Diff} = K_d \cdot (N \cdot L)\, I_L$$

In addition

$$I_{Diff} = K_a \cdot I_d + K_d \cdot I_L (N \cdot L)$$

Phong model :



for shiny surface, polished metal, is called specular reflection

shiny have narrow ϕ and dull have wider ϕ
∴ perfect mirror is a perfect shine object.
so it has $\phi = 0$.

An empirical model by phong was dolerer for calculating phong specular reflection.

$\cos^{n_s} = \phi \rightarrow 0^\circ$ to 90°

for rough surface, chalk has $n_s = 1$

$I_{spec} = W(\theta) \cdot I_L \cos^{n_s}\theta$

$I_{spec} = W(\theta) \cdot I_L (V \cdot R)$