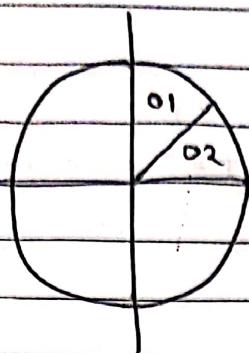


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Q1. Derive mid point ellipse drawing algorithm.



$$R_1 - m < 1$$

$$-m = 1$$

$$R_2 - m > 1$$

$$m < 1$$

$$m > 1$$

$x$  - unit int

$y$  - unit int.

$$y = ?$$

$$x = ?$$

$$(x_{k+1}, y_k) / (x_{k+1}, y_{k-1}) \quad | \quad (x_k, y_{k-1}) / (x_{k+1}, y_{k-1})$$

Equation of ellipse is  $\frac{x^2}{rx^2} + \frac{y^2}{ry^2} = 1$

$$\therefore x^2 ry^2 + y^2 rx^2 - rx^2 ry^2 = 0$$

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

$$2ry^2 \geq 2rx^2y$$

Region O1

$$m < 1$$

$$x = x_{k+1}, \quad y = y_k / y_{k-1}$$

$$(x_{k+1}, y_k) \quad (x_{k+1}, y_{k-1})$$

Apply midpoint in eq?

$$P_{k,k} = (x_{k+1})^2 ry^2 + (y_{k-1}/2)^2 rx^2 - rx^2 ry^2$$

$$\begin{aligned} P_{k,k+1} &= (x_{k+1})^2 ry^2 + (y_{k+1}-1/2)^2 rx^2 - rx^2 ry^2 \\ &= ((x_{k+1})-1)^2 ry^2 + (y_{k+1}-1/2)^2 rx^2 - rx^2 ry^2 \end{aligned}$$

$$\begin{aligned} P_{k+1} - P_{k,k} &= (x_{k+1})^2 ry^2 + rx^2y + rx(x_{k+1})ry^2 - y_{k+1}^2 rx^2 + \\ &\quad \frac{1}{4} rx^2 - y_{k+1}rx^2 - rx^2 ry^2 - (x_{k+1})^2 ry^2 \\ &\quad - y_{k+1}^2 rx^2 - 1/4 rx^2 + y_{k+1}rx^2 + rx^2 ry^2 \end{aligned}$$

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$$P_{1,k+1} = P_{1,k} + \gamma y^2 + 2(x_{k+1})\gamma y^2 + \gamma x^2 (-y_{k+1}^2 - y_k^2) - \gamma x^2 (y_{k+1} - y_k)$$

Substitute  $(0, r)$  in  $P_{1,k}$

$$\begin{aligned} P_{1,k} &= 1 \cdot \gamma y^2 + (\gamma y - 1/2)^2 r n^2 - \gamma x^2 \gamma y^2 \\ &= \gamma y^2 + \gamma y^2 r n^2 + \gamma x^2 / 4 - \gamma y^2 r n^2 - \gamma x^2 \gamma y^2 \end{aligned}$$

$$P_{1,k} = \gamma y^2 + \gamma x^2 / 4 - \gamma y \gamma x^2$$

$$P_{1,k} \leq 0$$

$$x = x_{k+1}, y = y_k$$

else

$$x = x_{k+1}, y = y_{k-1}$$

Region 2:

$$m > 1, y - \text{unit int}, x = ?$$

$$(x_k, y_{k-1}), (x_{k+1}, y_{k-1})$$

Apply midpoint in eq<sup>n</sup>.

$$P_{2,k} = (\gamma x_k + 1/2)^2 \gamma y^2 + (y_{k-1})^2 \gamma x^2 - \gamma x^2 \gamma y^2$$

$$\begin{aligned} P_{2,k+1} - P_{2,k} &= (\gamma x_{k+1} + 1/2)^2 \gamma y^2 + ((y_{k-1}) - 1)^2 \gamma x^2 - \gamma x^2 \gamma y^2 \\ &\quad - (\gamma x_k + 1/2)^2 \gamma y^2 - (y_{k-1})^2 \gamma x^2 + \gamma x^2 \gamma y^2 \end{aligned}$$

$$\begin{aligned} &= x_{k+1} \gamma y^2 + \gamma y^2 / 4 + x_{k+1} \gamma y^2 + (y_{k-1})^2 \gamma x^2 + \gamma x^2 \\ &\quad - 2(y_{k-1}) \gamma x^2 \\ &\quad - \gamma x^2 \gamma y^2 - x_k^2 \gamma y^2 - \gamma y^2 / 4 - x_k \gamma y^2 - (y_{k-1})^2 \gamma x^2 + \gamma x^2 \gamma y^2 \end{aligned}$$

$$\begin{aligned} P_{2,k+1} &= P_{2,k} + \gamma x^2 - 2 \gamma x^2 (y_{k-1}) + \gamma y^2 (x_{k+1}^2 - x_k^2) \\ &\quad + \gamma y^2 (x_{k+1} - x_k) \end{aligned}$$

$$\text{If } P_{2,k} \leq 0, x = x_k, y = y_{k-1}$$

$$\text{else } x = x_{k+1}, y = y_{k-1}$$

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Q2. Difference between random scan and raster scan displays

Random Scan	Raster Scan
① It draws a picture one line at a time.	① It draws a picture frame by frame.
② Refresh rate depends on number of lines to be displayed.	② Refresh rate is 60 fps.
③ It is used in drawing application.	③ It generates stair step appearance in straight line.
④ It does not display realistic shaded picture.	④ It is used to display realistic shaded picture.
⑤ Resolution is high.	⑤ Resolution is low.
⑥ Scan conversion speed is high.	⑥ Scan conversion speed is low.

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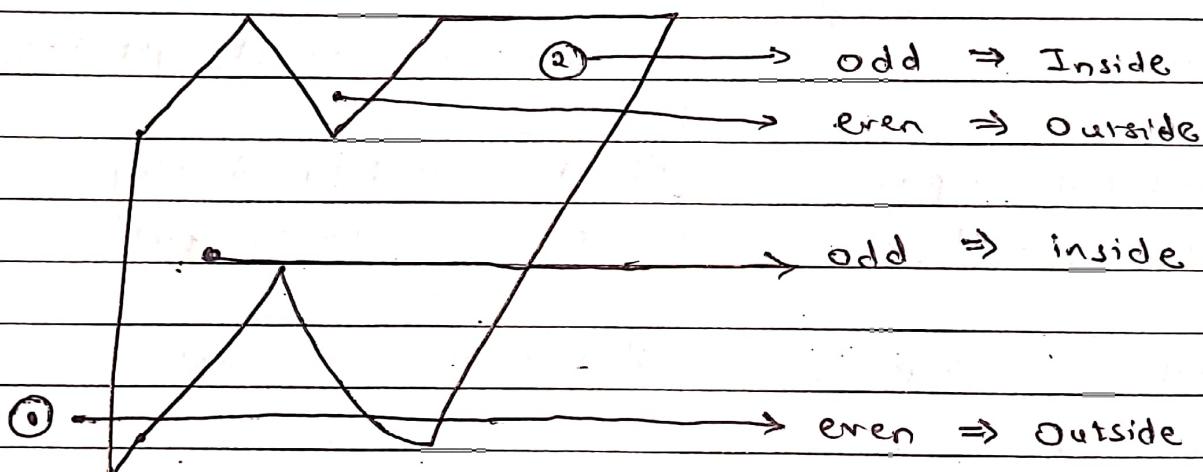
Q3. Explain inside outside test.

We can determine whether a point is inside or outside in polygon. It is possible using 2 methods

- ① Even odd rule
- ② Non-zero Winding number rule

① Even odd rule

We have to test whether a point is inside or outside.

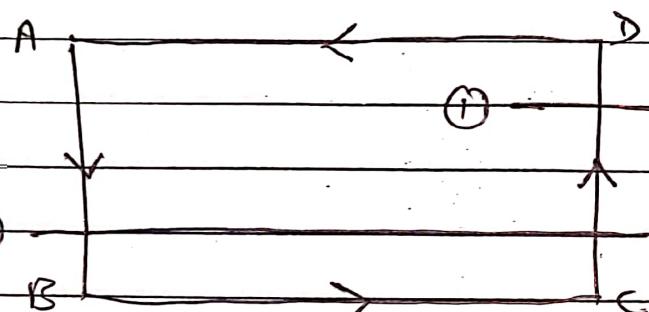


- Make a line parallel to x axis and which crossed the polygon vertices.
- Then count how many intersections are occurring with polygon boundary by the line till the point i.e line is reached.
- If there is odd number of intersections then point is inside else it is outside of polygon.
- This is even odd method.

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## ② Non zero winding rule

- In non-zero winding number system we give direction number to each boundary line which is crossed by this line and we sum these direction numbers
- Direction number indicates the direction in which polygon edges are drawn
- The side which start at above the drawn line and crosses line and then ends below the line.
- In that case, we design that side direction number as 1.
- If the edges of polygon start below the drawn line and then ends above the line, we give -1 to direction numbers.
- Then find sum of these numbers if it is non zero then point is inside. If the sum is zero then point is outside

A 

Rules:

Winding number  $w = 0$

$$R \rightarrow L = w = w + 1$$

$$L \rightarrow R = w = w - 1$$

$w + 0 \Rightarrow$  Inside

$w = 0 \Rightarrow$  Outside

Point 1

$$CD = w = 1 \Rightarrow \text{Inside}$$

Point 2.

$$\begin{aligned} CD &= R \rightarrow L = w = w + 1 = w \\ AB &= L \rightarrow R = w - 1 = 1 - 1 = 0 \end{aligned} \quad \left. \begin{array}{l} \Rightarrow \text{Outside} \\ \Rightarrow \text{Inside} \end{array} \right\}$$

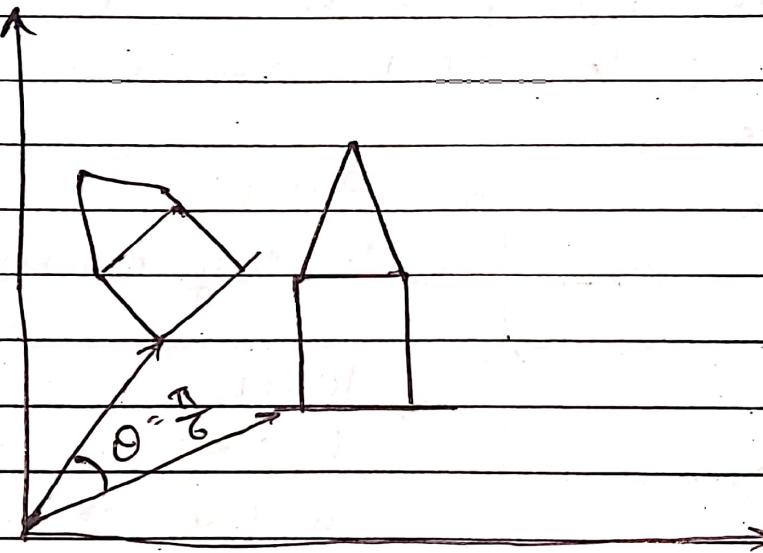
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Q4. Explain 2D rotation about arbitrary point.

- Transformation means change in image.
- We can modify the image by performing some basic transformation such as
  - Scaling
  - Rotation
  - Translation

Rotation :

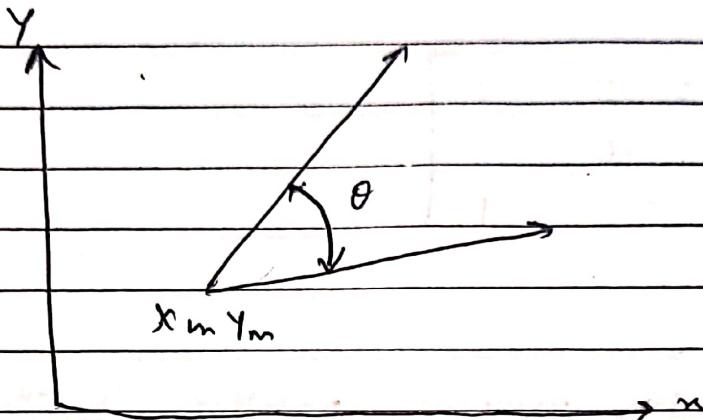
For rotation we need trigonometry logic. Suppose we have point  $P_1 = (x_1, y_1)$  and we rotate it about the origin by an angle  $\theta$  to get a new position  $P_2 = (x_2, y_2)$  as shown.



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Rotation about arbitrary point:

Suppose the reference point of rotation is other than origin, then in that case we have to follow series of transformation



Assume that we have to rotate a point  $P_1$  with respect to  $(x_m, y_m)$  then we have to perform 3 steps

## ① Translation:

First we need to translate the  $(x_m, y_m)$  to origin  
Translation matrix ( $T_1$ ) will become

$$T_1 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -x_m & -y_m & 1 \end{bmatrix}$$

Here,  $T_x = -x_m$  and  $T_y = -y_m$

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## ② Rotation :

Rotate it in clockwise or anticlockwise direction.

Let's assume anticlockwise direction by  $\theta$  angle.

So rotation matrix will be

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

## ③ Translation :

Translate back to original position. So the translation matrix ( $T_2$ ) will be

$$T_2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ x_m & y_m & 1 \end{bmatrix}$$

Now combined matrix

$$\begin{aligned} M &= \text{Translation} * \text{Rotation} * \text{Translation} \\ &= T_1 * R * T_2 \end{aligned}$$

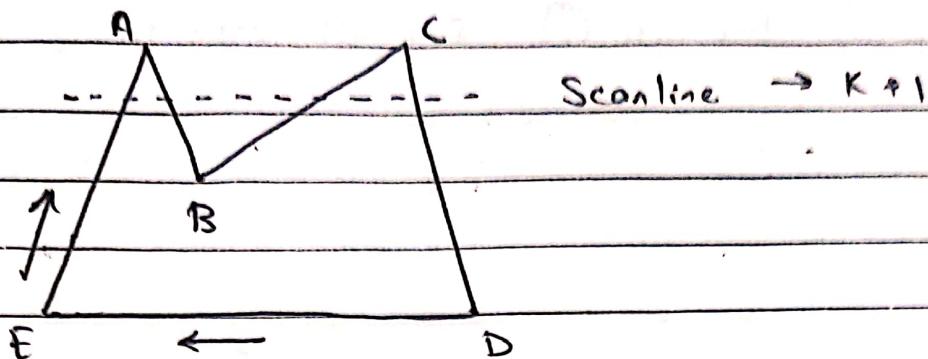
$$= \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ -x_m & -y_m & 1 \end{bmatrix} \begin{bmatrix} \cos \theta & \sin \theta & 0 \\ -\sin \theta & \cos \theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ x_m & y_m & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos \theta & \sin \theta & 0 \\ -\sin \theta & \cos \theta & 0 \\ -x_m * \cos \theta + y_m * \sin \theta + x_m & -x_m * \sin \theta - y_m * \cos \theta + y_m & 1 \end{bmatrix}$$

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Q5. Explain Scan-line polygon fill algorithm.

Step 1: Accept number of vertices

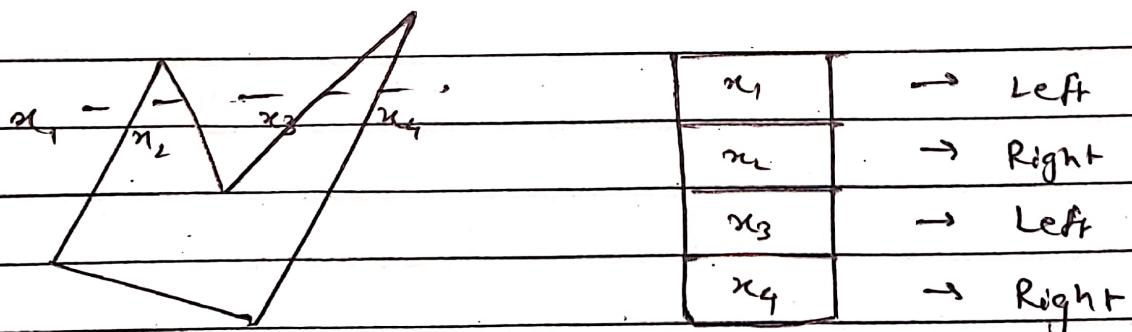


Step 2: AEL is prepared for each scan line which contains list of intersected edge.

AEL =	AB
	BC
	CD
	ED

Step 3: For each polygon in AEL intersecting points are calculated.

Step 4: Sort all intersecting points in increasing order in values.



First  $x$  value = left boundary

Second  $x$  value = Right boundary

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Step 5: Fill all pixel position between L & R boundary  
with specified color value.

Step 6: Repeat step ④ through ⑤ for all scan line.

Step 7: STOP

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Q6. Explain Cohen Sutherland line clipping algorithm

Step 1: Accept line segments  $(x_1, y_1)$  &  $(x_2, y_2)$  and window  $(x_{w\min}, y_{w\min})$  &  $(x_{w\max}, y_{w\max})$

Step 2: Find 4 bit region code

```

if  $x_1 < x_{w\min}$   $B_1 = 1$  else  $B_1 = 0$ 
if  $x_2 > x_{w\max}$   $B_2 = 1$  else  $B_2 = 0$ 
if  $y_1 < y_{w\min}$   $B_3 = 1$  else  $B_3 = 0$ 
if  $y_2 > y_{w\max}$   $B_4 = 1$  else  $B_4 = 0$ 

```

	1001	1000	1010	
	0001	0000	0010	
	0101	0100	0110	TBR <sub>2</sub>

Step 3: (a) If both end point codes are 0000 visible display and stop

(b) If logical AND of both end point codes is not 0000 invisible and discard line & STOP.

(c) If logical AND of end point code is 0000 then line is clipping candidate

Step 4: Determine intersecting point coordinates  $(x', y')$

$$x' = x_1 + \frac{1}{m} (y' - y_1) \text{ where}$$

$$y' = y_{w\min} / y_{w\max}$$

$$y' = y_1 + \frac{1}{m} (x' - x_1) \text{ where}$$

$$x' = x_{w\min} / x_{w\max}$$

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Step 6: Go to Step 2, until you get totally visible or  
invisible line segment

Step 7: STOP.

(A8)

~~Pradeep~~  
~~9/3/2020~~