CSE-4203
Computer Graphics

Topic List :

1. Line Generation-
   a) DDA
   b) Brasenhum + Proof
2. Circle Generation-
   a) Midpoint Circle Algorithm + Proof
   b) Bresenhum Circle Algorithm
3. Ellipse Generation-
   a) Midpoint Ellipse Algorithm

Line Generation : DDA

$y = mx \qquad m = \frac{dy}{dx} = \frac{\Delta y}{\Delta x}$

* Steps = max $(|\Delta x|$ or $|\Delta y|)$

* $x_{increment} = \frac{\Delta x}{Steps}$; $y_{increment} = \frac{\Delta y}{Steps}$.

* new x $(x') = x + x_{inc}$; new y $(y') = y + y_{inc}$.

Question: Given (5,4) & (12,7) two co-ordinates of a line. Compute all the points to generate the line.

Solution: $\Delta x = x_2 - x_1 = 12 - 5 = 7$

$\Delta y = y_2 - y_1 = 7 - 4 = 3$

$\therefore$ Steps = max $(|\Delta x|$ or $|\Delta y|)$

$= \max\{(|7|)$ or $(|3|)\}$

$= 7$ [as $|\Delta x| = 7 > |\Delta y| = 3$]

$\therefore x_{inc} = \frac{\Delta x}{Steps} = \frac{7}{7} = 1$

$\therefore y_{inc} = \frac{\Delta y}{Steps} = \frac{3}{7} = 0.43$.

Calculation table :

x_i	$x_{i+1} = x_{inc} + x_i$	y_i	$y_{i+1} = y_i + y_{inc}$	y'_{i+1}
5	6	4	$4+0.4 = 4.4$	4
6	7	4.4	$4.4+0.4=4.8$	5
7	8	4.8	$4.8+0.4=5.2$	5
8	9	5.2	$5.2+0.4=5.6$	6
9	10	5.6	$5.6+0.4=6.0$	6
10	11	6.0	$6.0+0.4=6.4$	6
11	12	6.4	$6.4+0.4=6.8$	7
12	–	6.8	–	

$\therefore$ The points are, (5,4), (6,4), (7,5), (8,5), (9,6), (10,6), (11,6), (12,7) : (Ans)

Question: Given (4,5) & (7,12) two co-ordinates of a line. Compute all the points to generate the line.

Solution: $\Delta x = x_2 - x_1 = (7-4) = 3$; $\Delta y = y_2 - y_1 = (12-5) = 7$

$\therefore$ steps $= \cancel{m}\ 7$ [as; $|\Delta x| = 3 < |\Delta y| = 7$]

$x_{inc} = \frac{\Delta x}{Steps} = \frac{3}{7} = 0.43$; $y_{inc} = \frac{\Delta y}{Steps} = \frac{7}{7} = 1.$

Calculation table:

x_i	$x_{i+1} = x_{inc} + x_i$	y_i	$y_{i+1} = y_{inc} + y_i$	x_{i+1}
4	4+0.43 = 4.43	5	6	4
4.43	4.43+0.43 = 4.8	6	7	5
4.8	4.8+0.43 = 5.2	7	8	5
5.2	5.2+0.4 = 5.6	8	9	6
5.6	5.6+0.4 = 6.0	9	10	6
6.0	6.0+0.4 = 6.4	10	11	6
6.4	6.4+0.4 = 6.8	11	12	7
6.8	6.8+0.4 = 7.12	12	—	—

$\therefore$ The points are (4,5), (4,6), (5,7), (5,8), (6,9), (6,10), (6,11), (7,12)

(Ans)

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Line Algorithm

Bresenhum Line Algorithm:

1. Input two points (x_0, y_0) & (x_1, y_1) where $y_1 \geq y_0$, $x_1 > x_0$ & $m < y$

2. Plot (x_0, y_0)

3. Calculate, Δx, Δy, $2\Delta y$, $2\Delta y - 2\Delta x$ &

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

4. If $P_k < 0$ then next point is (x_{k+1}, y_k) &

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

else if, $P_k \geq 0$ then plot (x_{k+1}, y_{k+1}) &

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

5. Repeat step 4 for $(\Delta x - 1)$ times.

Question: Calculate all points in a line using bresenham line algorithm, where initial points is (20,10) & final point is (30,18)

Solution: initial point $(x_0, y_0) = (20,10)$

final point $(x_1, y_1) = (30,18)$

$\therefore \Delta x = (x_1 - x_0) = (30-20) = 10$

$\Delta y = \cancel{18-1} (y_1 - y_0) = (18-10) = 8$

$2\Delta x = 2 \times 10 = 20$

$2\Delta y = 2 \times 8 = 16$

$2\Delta y - 2\Delta x = 16 - 20 = -4$

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

$= 16 - 10$

$= 6$

No.	P_k	x_k	y_k	P_{k+1}	x_{k+1}	y_{k+1}
0	6	20	10	$6+(-4)=2$	21	11
1	2	21	11	$2+(-4)=-2$	22	12
2	-2	22	12	$-2+16=14$	23	12
3	14	23	12	$14+16=20$	24	13
4	10	24	13	$10+(-4)=6$	25	14
5	6	25	14	$6+(-4)=2$	26	15
6	2	26	15	$2+(-4)=-2$	27	16
7	-2	27	16	$-2+(16)=14$	28	16
8	14	28	16	$14+(-4)=10$	29	17
9	10	29	17	$10+(-4)=6$	30	18
10	6	30	18	-	-	-

So, all the points are - (20,10), (21,11), (22,12), (23,12), (24,13), (25,14), (26,15), (27,16), (28,16), (29,17), (30,18).

(Ans)

Circle Algorithm

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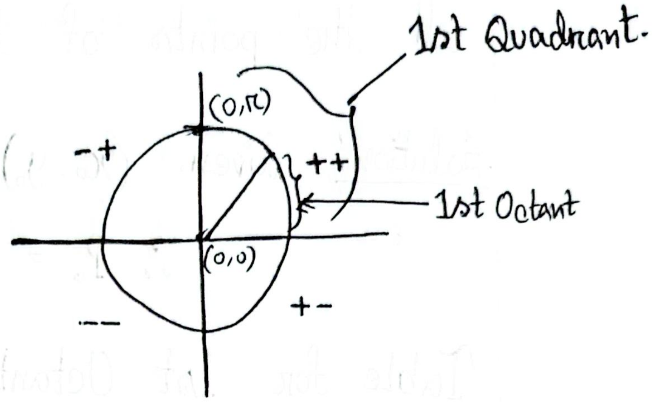
Midpoint Circle Algorithm:



1. Int $x = 0$, $y = r$;

2. $P = 1 - r$;

3. While $(x \leq y)$ {

   set pixel (x, y)

   (a) If $(P < 0)$ {

   $P = P + 2x + 3$;

   $x{+}{+}$; }

   (b) else {

   $P = P + 2(x - y) + 5$;

   $y{-}{-}$;

   $x{+}{+}$; }

Question: Suppose, center (0,0) & radius 8. Compute all the points of the circle using midpoint circle algorithm

Solution: Given, $(x_0, y_0) = (0,8)$, $r=8$

$\therefore P_0 = 1-R = 1-8 = -7$

Table for 1st Octant,

No.	(x_k, y_k)	P_k	(x_{k+1}, y_{k+1})	P_{k+1}
0	(0,8)	-7	(1, 8)	$P_1 = -7+2\cdot0+3 = -4$
1	(1,8)	-4	(2, 8)	$P_2 = -4+2\cdot1+3 = 1$
2	(2, 8)	1	(3, 7)	$P_3 = 1+2(2-8)+5 = -6$
3	(3, 7)	6	(4, 7)	$P_4 = 6+2(3-7)+5 = 3$
4	(4, 7)	3	(5, 6)	$P_5 = 3+2(4-7)+5 = 2$
5	(5,6)	2	(6, 5)	$P_6 = 2+2(5-6)+5 = 5$

So all the points of 1st octant are, (0,8), (1,8), (2,8), (3,7), (4,7), (5,6).

(Ans)

Table for 1st Quadrant :

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

Table for all points :

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

Question: Suppose, center (-2,4) & Radius 5, compute all the points of the circle using Midpoint Circle Algorithm

Solution:

Given, $(x_0, y_0) = (0, 5)$ $r = 5$

$\therefore P = 1 - 5 = -4$

Calculation Table for 1st octant:

No.	(x_k, y_k)	P_k	(x_{k+1}, y_{k+1})	P_{k+1}
0	(0, 5)	-4	(1, 5)	$P_1 = -4 + 2 \cdot 0 + 3 = -1$
1	(1,5)	-1	(2, 5)	$P_2 = -1 + 2 \cdot 1 + 3 = 4$
2	(2,5)	4	(3,4)	$P_3 = 4 + 2(2-5) + 5 = 3$
3	(3,4)	3	(4, 3)	$P_4 = 3 + 2(3-4) + 5 = 6$

$\therefore$ All the point of 1st octant are,

(x_k, y_k)	$(x_p = x_c + x_k,\ y_p = y_c + y_k)$
(0, 5)	(-2,9)
(1, 5)	(-1,9)
(2, 5)	(0,9)
(3,4)	(1,8)

Table for 1st Quadrant:

(x_p, y_p)	(y_p, x_p)
$(-2, 9)$	$(9, -2)$
$(-1, 9)$	$(9, -1)$
$(0, 9)$	$(9, 0)$
$(1, 8)$	$(8, 1)$

So, all the points of 1st Quadrant are, $(-2,9)$, $(-1,9)$, $(0,9)$, $(1,8)$, $(9,-2)$, $(9,-1)$, $(9,0)$, $(8,1)$

Table for all points:

$(+,+)$	$(-,+)$	$(-,-)$	$(+,-)$
$(-2,9)$	$(2,9)$	$(2,-9)$	$(-2,-9)$
$(-1,9)$	$(1,9)$	$(1,-9)$	$(-1,-9)$
$(0,9)$	$(0,9)$	$(0,-9)$	$(0,-9)$
$(1,8)$	$(-1,8)$	$(-1,-8)$	$(1,-8)$
$(9,-2)$	$(-9,-2)$	$(-9,2)$	$(9,2)$
$(9,-1)$	$(-9,-1)$	$(-9,1)$	$(9,1)$
$(9,0)$	$(-9,0)$	$(-9,0)$	$(9,0)$
$(8,1)$	$(-8,1)$	$(-8,-1)$	$(8,-1)$

So all the points of the circle are, $(-2,9)$, $(2,9)$, $(2,-9)$, $(-2,-9)$, $(-1,9)$, $(1,9)$, $(1,-9)$, $(-1,-9)$, $(0,9)$, $(0,-9)$, $(1,8)$, $(-1,8)$, $(-1,-8)$, $(1,-8)$, $(9,-2)$, $(-9,-2)$, $(-9,2)$, $(9,2)$, $(9,-1)$, $(-9,-1)$, $(-9,1)$, $(9,1)$, $(9,0)$, $(-9,0)$, $(8,1)$, $(-8,1)$, $(-8,-1)$, $(8,-1)$

(Ans)

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Bresenham circle Algorithm:

\# Given, Center point of circle = (x_c, y_c)

Radius of circle $= r$

1. Assign the starting point co-ordinate (x_0, y_0) as,

$$x_0 = 0 \; ; \; y_0 = r$$

2. Calculate decision parameter $P_0 = 3 - 2r$

3. Current point (x_k, y_k) & next point (x_{k+1}, y_{k+1})

4. If $(P_k < 0)$ {

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

$P_{k+1} = P_k + 4x_{k+1} + 6$; }

else {

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

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

$P_{k+1} = P_k + 4(x_{k+1} - y_{k+1}) + 10$; }

5. If the given center point is not (0,0), then,

$x\,plot = x_c + x_k$;

$y\,plot = y_c + y_k$;

6. Repeat step 4 & 5 untill $(x\,plot \geq y\,plot)$

Question: Suppose, center (3,5) & Radius 8. Compute all the points of the circle using Bresenhum circle algorithm.

Solution: Let, $x_0 = 0$; $y_0 = r = 8$ $x_c = 3$; $y_c = 5$

$P_0 = 3 - 2r = 3 - 2 \cdot 8 = -13$

Calculation Table:

No.	(x_k, y_k)	P_k	(x_{k+1}, y_{k+1})	P_{k+1}	(x_p, y_p)
0	(0, 8)	-13	(1, 8)	$P_1 = -13 + 4 \cdot 1 + 6 = -3$	(3, 13)
1	(1, 8)	-3	(2, 8)	$P_2 = -3 + 4 \cdot 2 + 6 = 11$	(4, 13)
2	(2, 8)	11	(3, 7)	$P_3 =$ 5	(5, 13)
3	(3, 7)	5	(4, 6)	$P_4 = 5 + 4(4-6) + 10 = 7$	(6, 12)
4	(4, 6)	7	(5, 5)	$P_5 = 7 + 4(5-5) + 10 = 17$	(7, 11)
5	(5, 5)	17	(6, 4)	$P_6 = 17 + 4(6-4) + 10 = 35$	(8, 10)
6	(6, 4)	35	(7, 3)	$P_7 = 35 + 4(7-3) + 10 = 61$	(9, 9)

∴ all the point of 1st Quadrant are:

(x_p, y_p)	(y_p, x_p)
(3, 13)	(13, 3)
(4, 13)	(13, 4)
(5, 13)	(13, 5)
(6, 12)	(12, 6)
(7, 11)	(11, 7)
(8, 10)	(10, 8)

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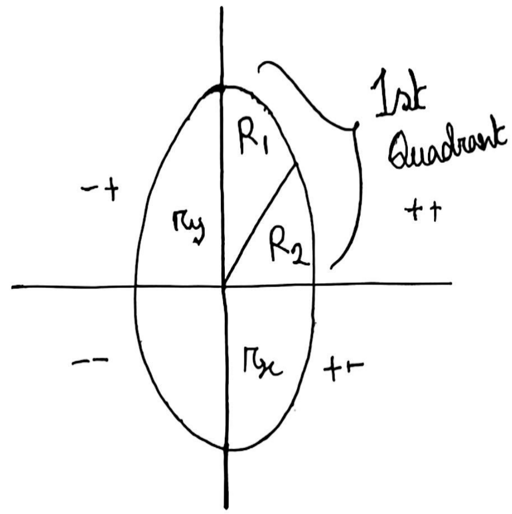
Midpoint Ellipse Algorithm:



1. Read radius r_x, r_y.

2. Initialize starting point of region 1 as, $x=0$; $y=r_y$

3. Calculate $P1 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$

4. Calculate $dx = 2r_y^2 x$; $dy = 2r_x^2 y$

5. For Region 1, Repeat while $(dx < dy)$ {

   (a) Plot (x, y)

   (b) if $(P1 < 0)$ {

   $x = x + 1$;

   update dx;

   $P1 = P1 + 2r_y^2 x + r_y^2$;

   $= P1 + dx + r_y^2$; }

   else {

   $x = x + 1$;

   $y = y - 1$;

   update dx;

   update dy;

   $P1 = P1 + 2r_y^2 x - 2r_x^2 y + r_y^2$;

   $= P1 + dx - dy + r_y^2$; }

6. When ($dx \geqslant dy$) plot Region 2 as {

(a) Find $P2 = r_y^2 (x+\frac{1}{2})^2 + r_x^2 (y-1)^2 - r_x^2 r_y^2$

(b) Repeat till ($y>0$) {

(i) plot (x, y) ;

(ii) if ($P2 > 0$) {

$y = y-1$;

update dy ;

$P2 = P2 - dy + r_x^2$; }

else {

$x = x+1$;

$y = y-1$;

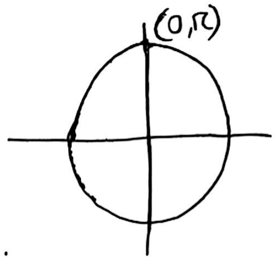
update dx ;

update dy ;

$P2 = P2 + dx - dy + r_x^2$; }

}

Proof - Midpoint Circle Algorithm:



x increaseing as unit interval,

the y decreasing along the values of x.

next point, (x_k+1, y_k) or (x_k+1, y_k-1)

mid point, (x_m, y_m)

$$x_m = \frac{x_k+1+x_k+1}{2} = \frac{2x_k+2}{2} = x_k+1.$$

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

equation of the circle,

$$\boxed{x^2+y^2=r^2}$$

$$\Rightarrow x^2+y^2-r^2=0$$

$$\therefore P=f(x,y) = x^2+y^2-r^2 \qquad \left[\begin{array}{l} f(x,y)<0, \ y_k=y_k \\ f(x,y)>0, \ y_k=y_k-1 \end{array}\right]$$

$$P_k = x_m^2 + y_m^2 - r^2$$

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

$$P_k = (x_k+1)^2 + \left(y_k - \frac{1}{2}\right)^2 - r^2 \qquad \text{(i)}$$

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

from (ii) - (i),

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

$$= \left\{(x_k+1)+1\right\}^2 - (x_k+1)^2 + \left\{\left(y_{k+1}-\frac{1}{2}\right)^2 - \left(y_k-\frac{1}{2}\right)^2\right\} \quad [x_{k+1} = x_k+1]$$

$$= \cancel{(x_k+1)^2} + 2\cdot(x_k+1)\cdot 1 + 1^2 - \cancel{(x_k+1)^2} + \left\{y_{k+1}^2 - \cancel{2}\cdot y_{k+1}\cdot\frac{1}{\cancel{2}} + \frac{1}{4}\right\}$$
$$- \left\{y_k^2 - \cancel{2} y_k \cdot \frac{1}{\cancel{2}} + \frac{1}{4}\right\}$$

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

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

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

if, $P_k < 0$, $y_{k+1} = y_k$ else, $y_{k+1} = y_k - 1$

$\therefore$ if, $P_k < 0$,

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

$$= 2x_k + 2 + 1$$

$$= 2x_k + 3.$$

$$\therefore P_{k+1} = P_k + 2x_k + 3.$$

else ,

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

$$= 2x_k + 2 + (\cancel{y_k^2} - 2y_k \cdot 1 + 1^2 - \cancel{y_k^2}) - (-1) + 1$$

$$= 2x_k + 2 - 2y_k + 1^2 + 1 + 1$$

$$= 2x_k - 2y_k + 5$$

$$= 2(x_k - y_k) + 5$$

$$\therefore P_{k+1} = P_k + 2(x_k - y_k) + 5$$

$$\therefore P_{k+1} = \begin{cases} P_k + 2x_k + 3, & \text{if } P_k < 0 \\ P_k + 2(x_k - y_k) + 5, & \text{if } P_k \geq 0 \end{cases}$$

Starting $(0, r) \rightarrow x_k = 0, \; y_k = r$

$$\therefore P_k = (x_k+1)^2 + (y_k - \tfrac{1}{2})^2 - r^2$$

$\boxed{\text{So, } P_0 = 1 - r}$

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

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

$$= 1 - r + \frac{1}{4}$$

$$= \frac{4-1}{4} - r$$

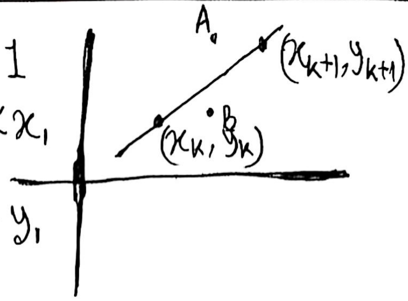
$$= \frac{5}{4} - r = 1.25 - r \approx 1 - r$$ (Approximate to avoid fractional).

Bresenham line Algorithm Proof:

$m < 1$

$x_0 < x_1$

$y_0 \leq y_1$



here, $y = m(x_k+1) + b$ .... (i)

$d_1 < d_2 \rightarrow B$, $d_2 < d_1 \rightarrow A$

Decision Parameter,

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

$$d_1 = y - y_k$$

$$= m(x_k+1) + b - y_k \text{ ---- (ii)}$$

Similarly,

$$d_2 = y_k + 1 - y$$

$$= y_k + 1 - m(x_k+1) - b \text{ .... (iii)}$$

$$\therefore d_1 - d_2 = \{m(x_k+1) + b - y_k\} - \{y_k + 1 - m(x_k+1) - b\}$$

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

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

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

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

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

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

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

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

$$= 2\Delta y x_k - 2\Delta x y_k + 2\Delta y + \Delta x (2b-1) \text{ ..... (v)}$$

$$= 2\Delta y x_k - 2\Delta x y_k + c \text{ ..... (vi)}$$

$$\therefore P_{k+1} = 2\Delta y \, x_{k+1} - 2\Delta x y_{k+1} + c \text{ ..... (vii)}$$

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

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

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

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

$$= 2\Delta y - 2\Delta x (y_{k+1} - y_k) \text{ ..... (viii)}$$

Where, $y_{k+1} - y_k = 0$ or 1

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

from (V),

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

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

$$= 2\Delta y x_k + 2\Delta y - 2\Delta x y_k + \Delta x\{2(y-mx)-1\}$$

$$= 2\Delta y x_k + 2\Delta y - 2\Delta x y_k + 2\Delta x y - \Delta x \cdot 2mx - \Delta x.$$

initially, $x_k = x$, $y_k = y$

$$\therefore P_0 = 2\Delta y x + 2\Delta y - 2\Delta x y + 2\Delta x y - \Delta x \cdot 2mx - \Delta x$$

$$= 2\Delta y x + 2\Delta y - \Delta x \cdot 2 \cdot \frac{\Delta y}{\Delta x} x - \Delta x \qquad \left[\because m = \frac{\Delta y}{\Delta x}\right]$$

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

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

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2D Transformation : → Types :

* Shape
* Position
* Zoom in/out

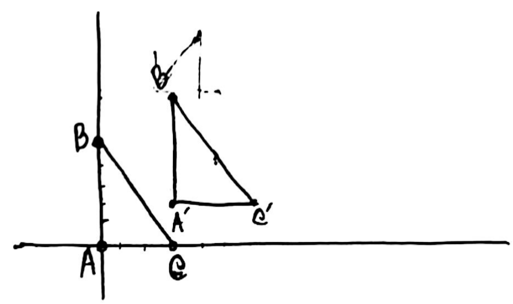
a) Translation
b) Scaling
c) Shearing
d) Rotation.
e) Reflection

A) Translation :

old point (P_x, P_y)

New point $P'_x = P_x + \boxed{t_x}$ → translation Parameter.

$P'_y = P_y + t_y$



Suppose there is an object with A(0,0), B(0,5), C(0,3). The ~~of~~ object is moved 3 unit along x axis and 2 unit along y axis. Compute the new co-ordinates

$A'_x = 0 + 3 = 3$; $A'_y = 0 + 2 = 2$ $A'(3,2)$

$B'_x = 0 + 3 = 3$; $B'_y = 5 + 2 = 7$ $\therefore B'(3,7)$

$C'_x = 3 + 3 = 6$; $C'_y = 0 + 2 = 2$ $\therefore C'(6,2)$

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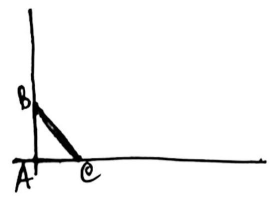
For scaling factor, $S_x = 0.5$, $S_y = 0.5$

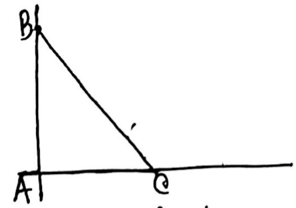
old point A (0,0), New point A $(0.5 \times 0, 0.5 \times 0) \rightarrow (0,0)$

B (0,5) $\longrightarrow$ $(0 \times 0.5, 5 \times 0.5) = (0, 2.5)$

C (3,0) $\longrightarrow$ $(3 \times 0.5, 0 \times 0.5) = (1.5, 0)$



Scaling factor < 1



Scaling factor > 1

when, Scaling factor (x) = Scaling factor (y)

↳ uniform scaling.

when, Scaling factor (x) $\neq$ Scaling factor (y)

↳ nonuniform scaling.

Assignment-03

Difference between DDA & Bresenham Line Algorithm

DDA	Bresenham Line Algorithm
1. Uses slope formula ($m = \frac{\Delta y}{\Delta x}$) & calculates next point using floating-point addition	1. Uses decision parameter to choose the nearest pixel using only integer arithmetic.
2. The speed is slower	2. The speed is faster.
3. Result is less accurate due to rounding of floating numbers.	3. Result is more accurate because of it avoids floating-point rounding errors.
4. Easier to understand & implement.	4. Slightly more complex but more efficient.
5. Less efficient for hard-ware implementation.	5. More efficient & widely used in real graphics system.
6. Rounding errors may accumulate.	6. No rounding errors because it uses decision variable.

Difference between midpoint circle & bresenhum circle Algorithm:

Mid point Circle Algorithm	Bresenhum circle Algorithm
1. Uses midpoint between two pixel to decide which pixel is closer to the circle.	1. Uses a decision parameter to choose the best pixel.
2. The speed is fast.	2. The speed is very fast. slightly more optimized.
3. Easier to understand conceptually.	3. Slightly more optimized but conceptually.
4. Checks whether midpoint is inside or outside the circle.	4. Uses incremental error calculation.
5. The implementation is commonly taugh in practical.	5. The implementation is more optimized in practical system.