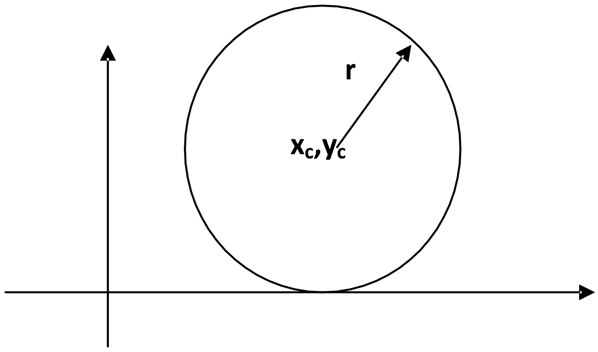
Computer Graphics

Forth Chapter

2023-2024

Circle Drawing

The circle is a special kind of curves. The circle is a closed curve with same starting and ending point. Circles are probably the most used curves in elementary graphics.



- A circle is specified by the coordinates of its center (xc,yc) and its radius (r) .
- The circle equation is : $(x-xc)^2 + (y - yc)^2 = r^2$ .... (1)
- If the center of the circle is at the origin (0,0) then the equation is :

$$x^2+y^2=r^2 \text{ ...... (2)}$$

Solving equation (1) for y :

$$y= yc \pm\sqrt{r^2-(x-xc)^2} \text{ ...... (3}$$

Note: To draw a circle increment the x values by one unit from –r to +r and use the above equation to solve for the two y values at each .step

1. Direct (implicit) algorithm

In this method the first pixel of circle is at left side as equation
$x=xc-r$
$y=yc$
to draw the circle we can increment x from –r to +r or from 0 to 2r by one unit at each step and solving for y

$$y = yc \pm \surd r^{2} - \surd (x-xc)^{2}$$

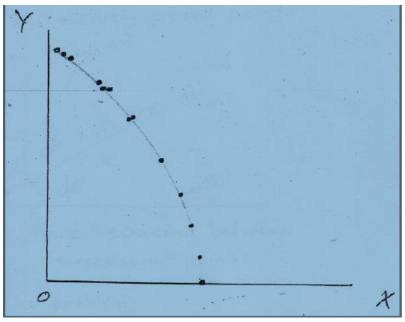
$$x=x+1$$

This method of drawing a circle is inefficient because:

1. We are not taking advantages of the symmetry of the circle.

2. The amount of processing time required to perform the squaring and square root operations repeatedly.

3. X values are equally spaced (they differ by one unit) the y values are not. The circle is denes and flat near the y-axis and has large gaps and is steep near the x-axis.



Direct Algorithm

Input : xc ,yc , r.
Output : Circle

```
{ x=xc-r;
  for i= 0 to 2*r
    {   y=yc+√(r^2 − (x − xc)^2)
        plot (x, integer (y) ,color)
        y=yc-√(r^2 − (x − xc)^2)
        plot (x, integer (y),color)
        x=x+1;
    }
}
```

H\W: Design implicit algorithm to draw circle if the first point is at right side.

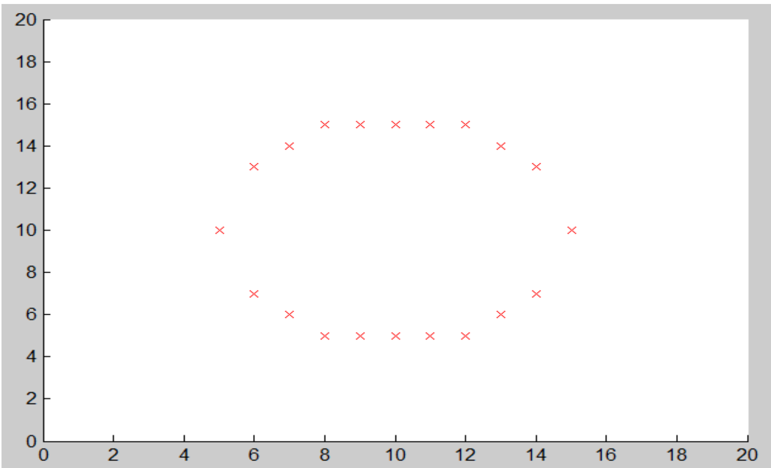
H\W: design implicit algorithm to draw circle if the first point is x=xc, y=yc - r

H\W: Find the point of a circle where xc=20, yc = 10 and r=8 ?

Example :Find the point of a circle where xc=10, yc= 10 and r=5 using direct algorithm?

```
xc=10
yc=10
x=xc-r; x=10-5=5
For i=0:2*r
        y=yc+sqrt((r^2)-(x-xc)^2)
        Plot(x,round(y),'y')
        y=yc-sqrt((r^2)-(x-xc)^2)
        Plot(x,round(y),'y')
        x=x+1
End
```

X	Y	Round(y)	Y	Round(y)	Plot(X,Y)
5	10	10	10	10	(5,10),(5,10)
6	13	13	7	7	(6,13),(6,7)
7	14	14	6	6	(7,14),(7,6)
8	14.5	15	5.4	5	(8,15),(8,5)
9	14.8	15	5.1	5	(9,15),(9,5)
10	15	15	5	5	(10,15),(10,5)
11	14.8	15	5.1	5	(11,15),(11,5)
12	14.5	15	5.4	5	(12,15),(12,5)
13	14	14	6	6	(13,14),(13,6)
14	13	13	7	7	(14,13),(14,7)
15	10	10	10	10	(15,10),(15,10)



2. parametric (polar) algorithm

One method of eliminating the problem of plotting points evenly spaced around the circle is to use polar representation of a circle:

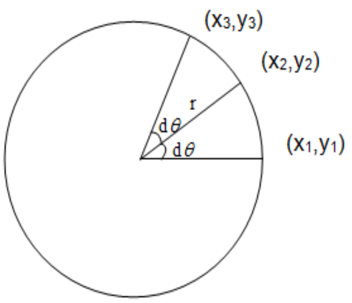
$x = x_c + r\cos\theta$,

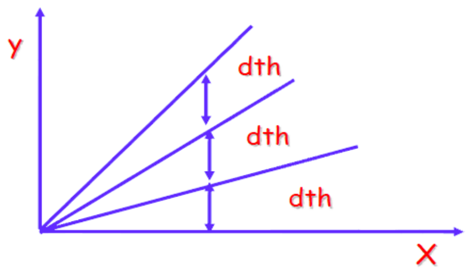
$y = y_c + r\sin\theta$.

Where: $\theta \rightarrow$ is measured in radians from 0 to 2π

arc length= $r \times \theta$, r=radius (constant)

in this method we depend on angles to draw the circle, since it propose the first angle th=0, and end angle is two_pi (360).
The change in angle (dth) must be small value dth=1/r.





Polar algorithm

```
Input : xc ,yc , r.
Output : Circle
{
  th=0; dth=1/r;
  while (th<=2*pi)
    {
      x = xc + r *cos (th)
      y = yc + r sin(th)
      plot (round(x),round(y),color)
      th = th + dth
    }
}
```

Note: the algorithm use cos & sin operation and do not take the advantage of symmetric in circle

H\W: write Matlab program to draw circle using polar algorithm?

Example :Find the point of a circle where xc=10, yc= 10 and r=5 using polar algorithm ?

```
th=0
dth=1/r=1/5
While th <=2*pi
    x=xc+r*cos(th)
    y=yc+r*sin(th)
    plot(round(x),round(y),color)
    th=th+dth
End
```

x	Round(x)	y	Round(y)	th	Plot (x,y)
15	15	10	10	0	(15,10)
14.9	15	10.9	11	0.2	(15,11)
14.6	15	11.9	12	0.4	(15,12)
14.1	14	12.8	13	0.6	(14,13)
13.4	13	13.5	14	0.8	(13,14)
12.7	13	14.2	14	1	(13,14)
11.8	12	14.6	15	1.2	(12,15)
:	:	:	:	:	:
:	:	:	:	:	:
14.9	15	9.5	10	6.4	(15,10)