COMPUTER GRAPHICS

THIRD CLASS

University of Diyala/ College of education for pure science / Computer science department

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2. DRAWING ELEMANTARY FIGURES (PART 2-3)

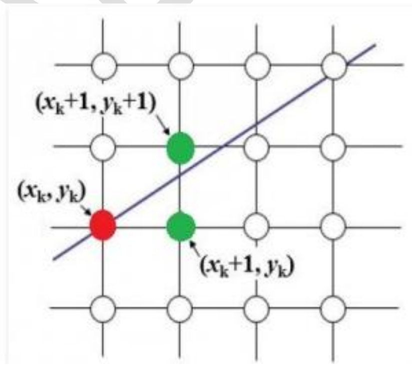
3. Bresenhams line drawing algorithm (simple form)

In this algorithm each iteration changes one of the coordinate values by ±1 depending on the slop of the line. The other coordinate may or may not change depending on the value of an error term maintained by the algorithm. This error term records the distance measure perpendicular to the axis of greatest movement, between the exact path of the line and the actual dots generated.

The idea of Bresenham's algorithm is to avoid floating point, and then using **round** function in every step as we have seen in DDA algorithm. In Bresenham's algorithm (**m<1**):

1. We always increase x by 1, and we choose about next y, whether we need to go to y+1 or remain on y. In other words, from any position (X_k, Y_k) we need to choose between (X_k + 1, Y_k) and (X_k + 1, Y_k + 1).

2. We would like to pick the y value (among Y_k + 1 and Y_k) corresponding to a point that is closer to the original line.



We need to a decision parameter to decide whether to pick Y_k + 1 or Y_k as next point. The idea is to keep track of slope error from previous increment to y. If the slope error becomes greater than 0.5, we know that the line has moved upwards one pixel, and that we must increment our y coordinate and readjust the error to represent the distance from the top of the new pixel – which is done by subtracting one from error. Bresenham algorithm for the first octant : { 0 ≤ ΔY ≤ ΔX }

```
Start
  X=X1
 Y=Y1

       DX=X2-X1
       DY=Y2-Y1

       E= (DY / DX) – 0.5

       For i=0 to DX
       Begin
              Plot (X,Y)
              While (E ≥ 0 )
                     Y=Y+1
                     E=E-1
              End While
```

X=X+1
E=E + (DY / DX)
End
Finish

Example: Example: Consider the line from (0,0) to (6,3). Rasterize this line using Bresenham's algorithm. Complete the following table.

Dx= 6, Dy=3, m = 3/6 = 0.5
E=m – 0.5 = 0.5 – 0.5 =0

I	X	Y	Plot	Error
0	0 1	0 1	(0,0)	0 -0.5
1	1 2	1 1	(1,1)	-0.5 0
2	2 3	1 2	(2,1)	0 -0.5
3	3 4	2 2	(3,2)	-0.5 0
4	4 5	2 3	(4,2)	0 -0.5
5	5 6	3 3	(5,3)	-0.5 0
6	6 7	3 4	(6,3)	0 -0.5

4. Integer Bresenham's algorithm

The above algorithm still includes floating point arithmetic and division to calculate the slop of the line and to evaluate the error term. The speed of the algorithm can be increased by using integer arithmetic and eliminating the division.

Consider the value below value m:

m = (y2 - y1)/(x2 - x1)

We multiply both sides by (x2 - x1)

We also change **slope_error** to slope_error * (x2 - x1). To avoid comparison with 0.5, we further change it to slope_error * (x2 - x1) * 2.

Also, it is generally preferred to compare with 0 than 1.

So:

$$E = \{ (DY / DX) - 0.5 \} * 2\,\Delta X \longrightarrow E = 2\,\Delta Y - \Delta X$$

$$E = \{ E - 1 \} * 2\,\Delta X \longrightarrow E = E - 2\,\Delta X$$

$$E = \{ E + (DY / DX) \} * 2\,\Delta X \longrightarrow E = E + 2\,\Delta Y$$

This allows the algorithm to be efficiently implemented in hardware.

Bresenham's integer algorithm for the first octant { $0 \le \Delta Y \le \Delta X$ } i.e. slop between zero and one is shown below:

```
Start
        X=X1
        Y=Y1
        dX=X2-X1
        dY=Y2-Y1
        E= 2 ΔY - ΔX
        For i=0  to dX
                Begin
                        Plot  (X , Y)
                        While (E ≥  0 )
                        Begin
                                Y=Y+1
                                E= E - 2 ΔX
                        End While
                        X=X+1
                        E = E+ 2 ΔY
        Next i
Finish
```

5. General Bresenham's algorithm for all quadrants

A full implementation of Bresenham algorithm requires modification for lying in the other octants. These can easily be developed by considering quadrant in which the line lies and its slope. When the absolute magnitude of the slop of the line is > 1 , Y is incremented by one end Bresenham error is used to determine when to increment X. Whether X or Y incremented by +(-) 1 depends on the quadrant.

General Bresenham's algorithm for all quadrants is shown below

```
Begin

X=X1
Y=Y1
dX=Abs (X2-X1)
dY=Abs(Y2-Y1)
S1=Sign (X2-X1)
S2=Sign (Y2-Y1)
If dY > dX Then
        Begin
                T=dX : dX=dY : dY=T : Interchange=1
        End
        Else
                Interchange =0
End If
        E= 2 dy - dx
        For i=0 to dX
                Plot (X,Y)
                While ( E ≥ 0)
                        Begin
                                If Interchange=1       Then X=X + S1
                                        Else Y= Y + S2
                                End If
                                E= E - 2 dx
                End While
                If Interchange=1        Then Y=Y + S2
                   Else                 X=X + S1
                End If
                E = E+ 2 dy
        Next i

Finish
```

Example 4 : Draw the line from (0,0) to (-8,-4) using general Bresenham’s algorithm.

X=0 ; Y=0 ; dX=8 ; dY=4 ; S1=-1 ; S2=-1

Because dX>dY, then Interchange=0 ; E=0

I	Plot	E	X	Y
		0	0	0
0	(0,0)			
		-16	0	-1
		-8	-1	-1
1	(-1,-1)			
		0	-2	-1
2	(-2,-1)			
		-16	-2	-2
		-8	-3	-2
3	(-3,-2)			
		0	-4	-2
4	(-4,-2)			
		-16	-4	-3
		-8	-5	-3
5	(-5,-3)			
		0	-6	-3
6	(-6,-3)			
		-16	-6	-4
		8	-7	-4
7	(-7,-4)			
8		0	-8	-4