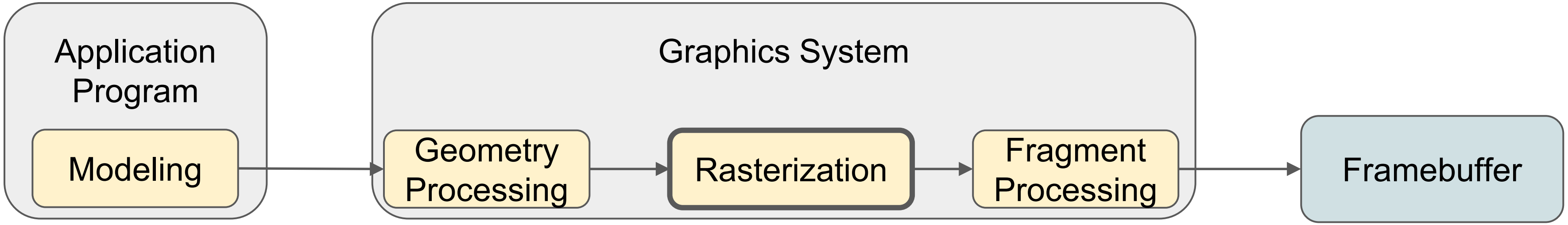
Rasterization and Fragment Processing

CS 425: Computer Graphics 1

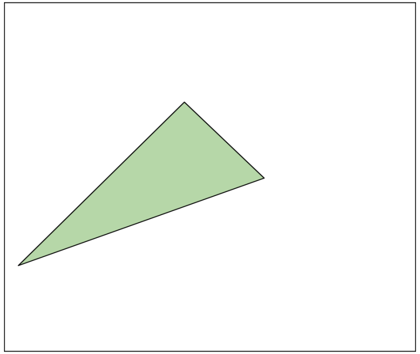
UIC Computer Science

Rasterization

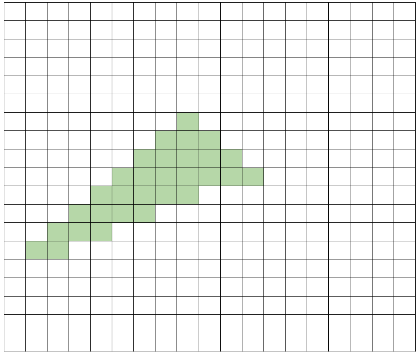


Rasterization

- Process of converting the vertices that are output from the clipping stage to fragments.
- Fragments are potential pixels.



Clipped object in vertex representation



Fragments of the rasterized object

Rasterization: Lines

DDA algorithm: Idea

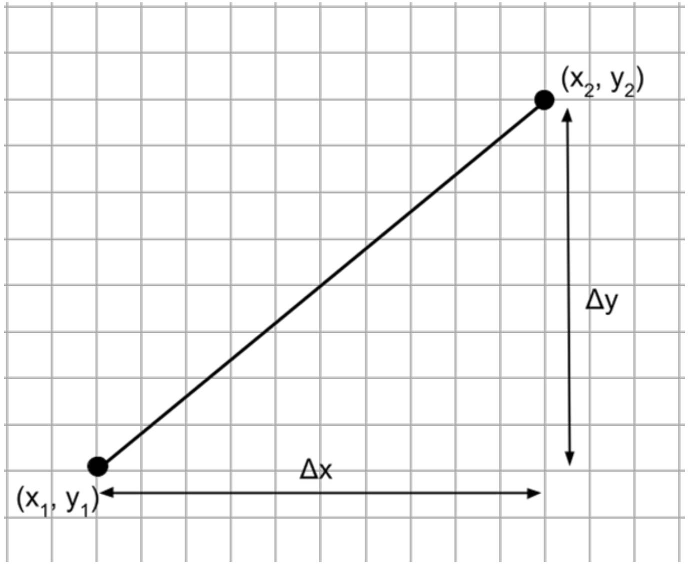
$y = mx + h$

$y_{i+1} = m\,(x_i + \Delta x) + h$

$y_{i+1} = mx_i + h + m\Delta x = y_i + m\Delta x$

If we set $\Delta x = 1$, then

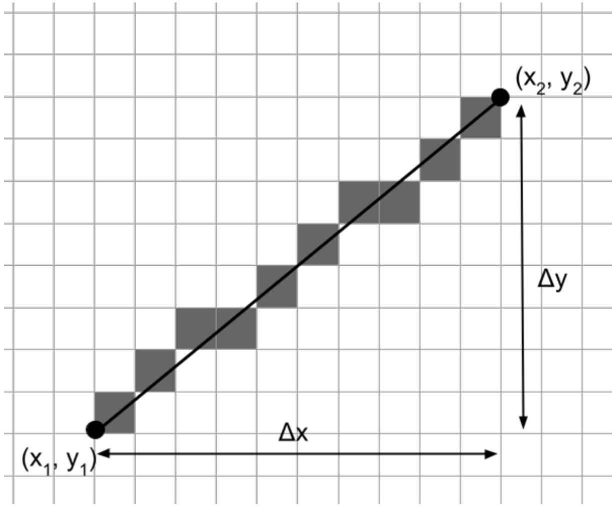
$\mathbf{y_{i+1} = y_i + m}$



Rasterization: Lines

DDA algorithm

```
for (ix = x1; ix <= x2; ++ix) {
        y += m;
        writePixel(x, round(y), line_color);
}
```



Rasterization: Lines

DDA algorithm

- Assumes 0 <= m <= 1
- For each x, find best y.
- For slopes greater than 1 we can swap the roles of x and y.
- Approximating m by rounding it over many iterations can induce error and result in the rasterized line being off the actual line.
- Has floating point calculations and rounding function which are computationally expensive.

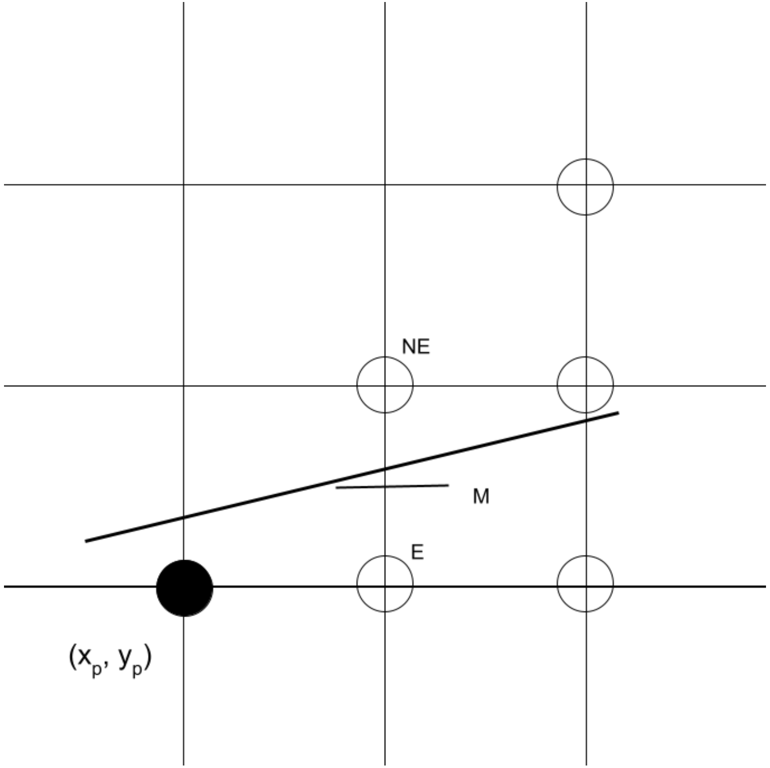
Rasterization: Lines

Bresenham's Algorithm:

We assume a line with a slope m such that: $0 \le m \le 1$

$y = mx + h$

$y = (dy / dx)\, x + h$



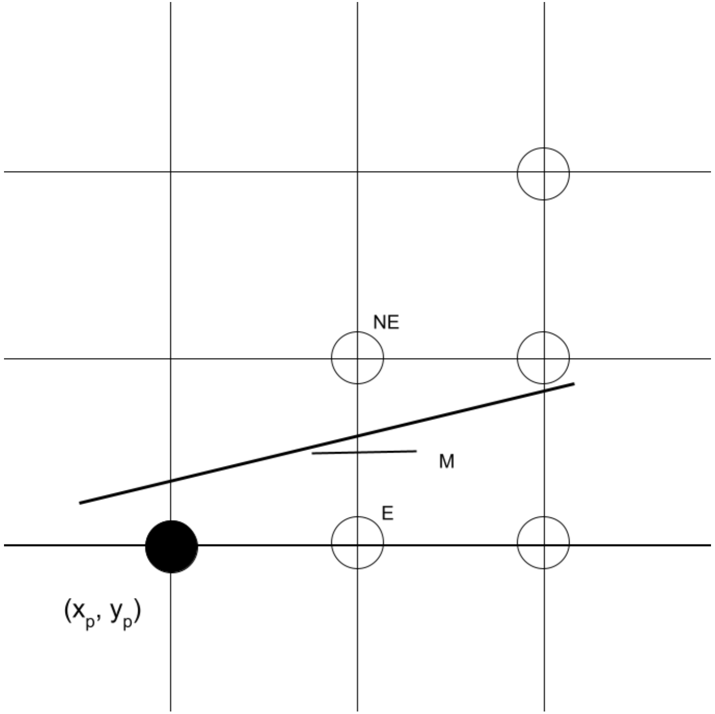
Rasterization: Bresenham's Algorithm

In the implicit form,
$F(x, y) = x.dy - y.dx + h.dx = 0$

Or, $F(x, y) = A.x + B.y + C = 0$

$A = dy$, $B = -dx$, $C = h.dx$

$F(x, y) = 0$ on the line, < 0 above the line, and > 0 below the line



Rasterization: Bresenham's Algorithm

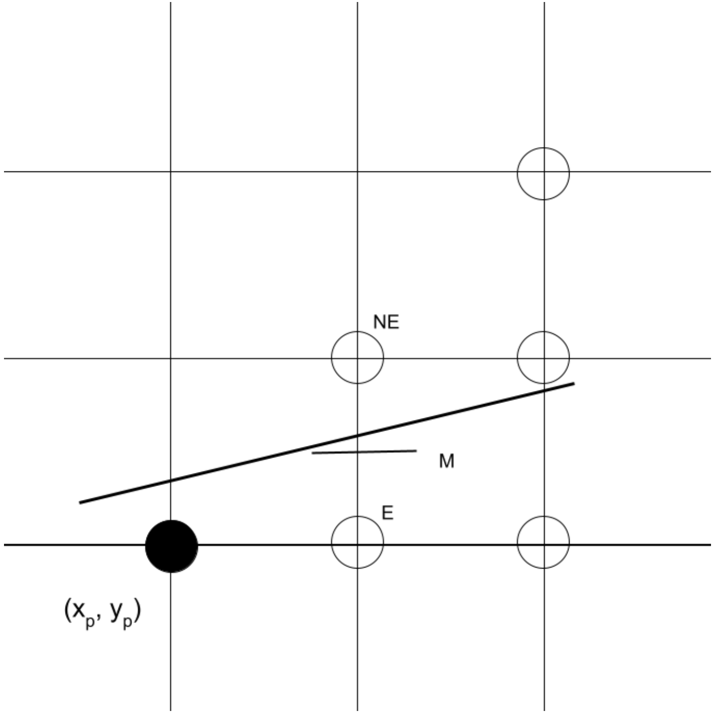
At the current iteration, the pixel at (x_p, y_p) is chosen. Now how to choose the next pixel?

The choice is between pixels E and NE.

Compute F(M), F(M) is the decision value 'd'

$$d = A\,(x_p + 1) + B\,(y_p + \tfrac{1}{2}) + C$$

If $d > 0$, choose NE, otherwise choose E



Rasterization: Bresenham's Algorithm

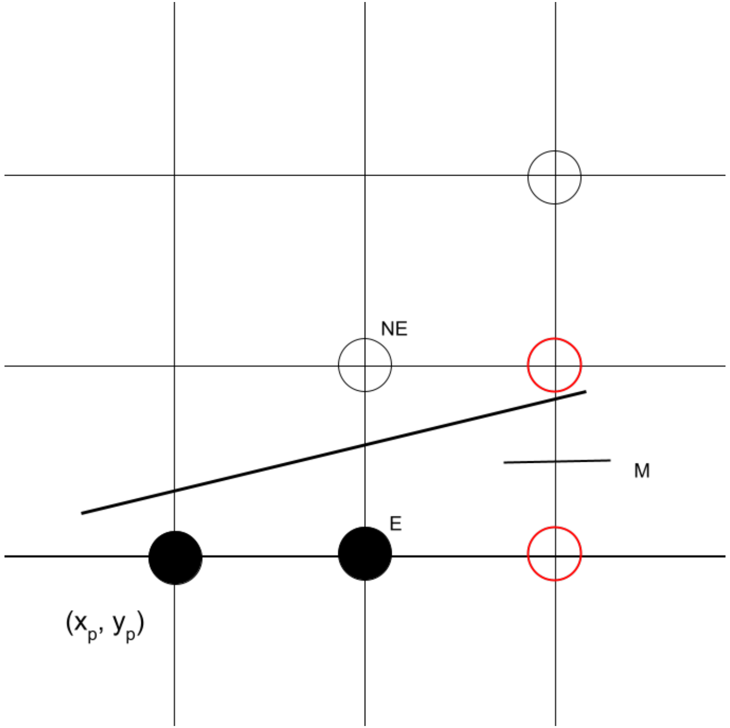
For next iteration, what is the value of d?

If we chose E,

$d_{new} = A (x_p + 2) + B (y_p + ½) + C$

$d_{new} = d_{old} + A$

$\Delta d = A = dy$



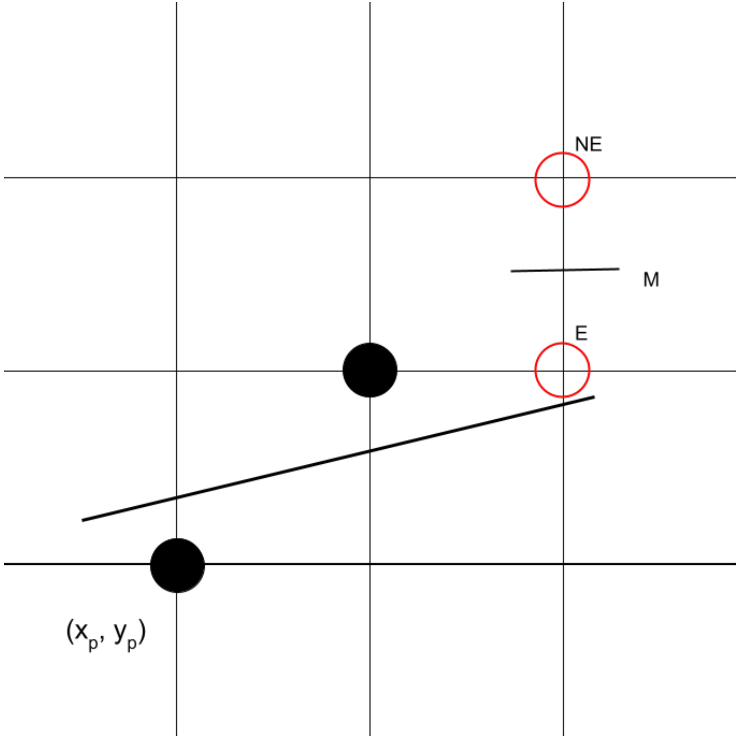
Rasterization: Bresenham's Algorithm

If we chose NE,

$d_{new} = A\,(x_p + 2) + B\,(y_p + 3/2) + C$

$d_{new} = d_{old} + A + B$

$\Delta d = A + B = dy - dx$



Rasterization: Bresenham's Algorithm

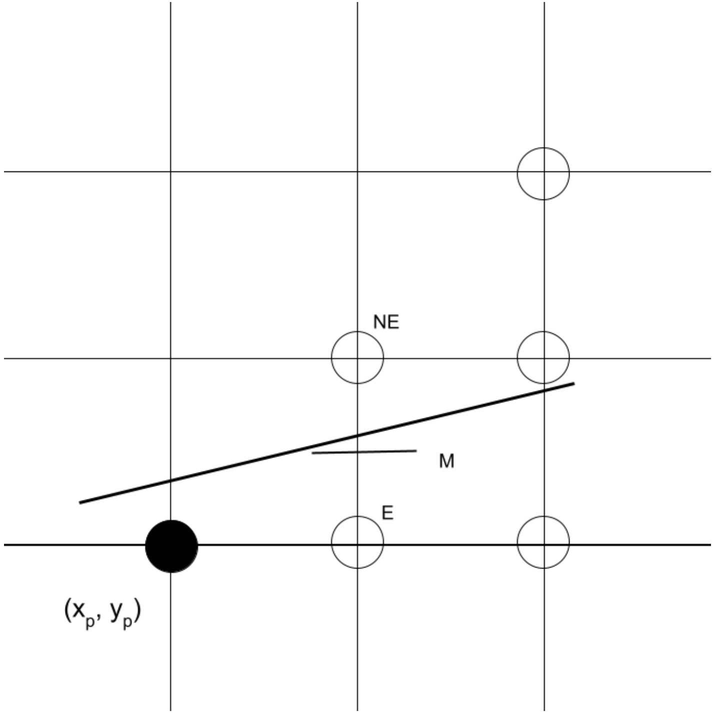
Initial d?

$d = A(x_0 + 1) + B(y_0 + ½) + C$

$d = A.x_0 + B.y_0 + C + A + ½ B = A + ½ B$

$d = dy - dx / 2$

To eliminate fractions, we multiply by 2.



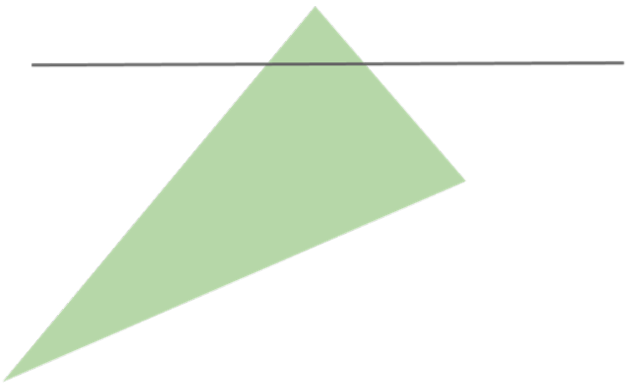
Rasterization: Filling

Primitive assembly information is utilized for filling.

Inside-out testing is done to determine what pixels are part of the polygon.

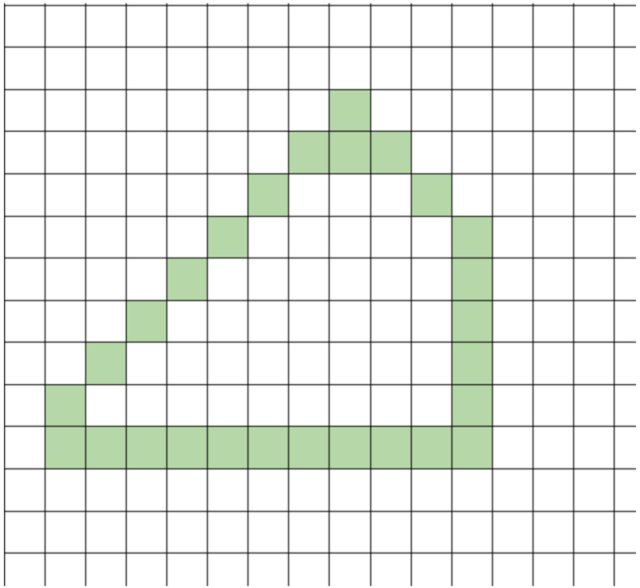
Two tests are commonly used:

- Crossing or odd-even test.
- Winding test

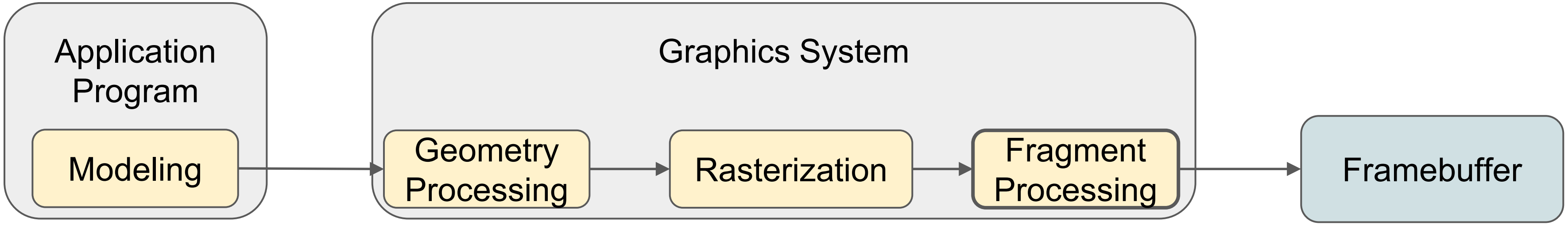


Rasterization: Flood fill

```
function floodFill(x, y) {
	if (readPixel(x, y) == WHITE) {
		writePixel(x, y, BLACK);
		floodFill(x-1, y);
		floodFill(x+1, y);
		floodFill(x, y-1);
		floodFill(x, y+1);
	}
}
```



Hidden Surface Removal

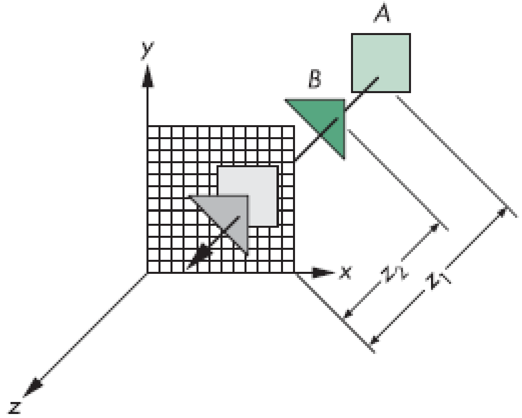


Hidden Surface Removal: The z-Buffer algorithm

A separate buffer to hold the depth information.

Initialized to maximum depth value from center of projection. Color buffer to the background color.

Iteratively rasterize polygons and simultaneously fill the z-buffer.



Hidden Surface Removal: The z-Buffer algorithm

Compare depth of incoming fragment with value in z-buffer.

$Depth_{new} > Depth_{z\text{-}buffer}$ we have already rasterized a fragment that is closer to the viewer.

Otherwise the incoming fragment is placed in the color buffer and the z-buffer is updated.