Rasterization and Fragment Processing

CS 425: Computer Graphics 1

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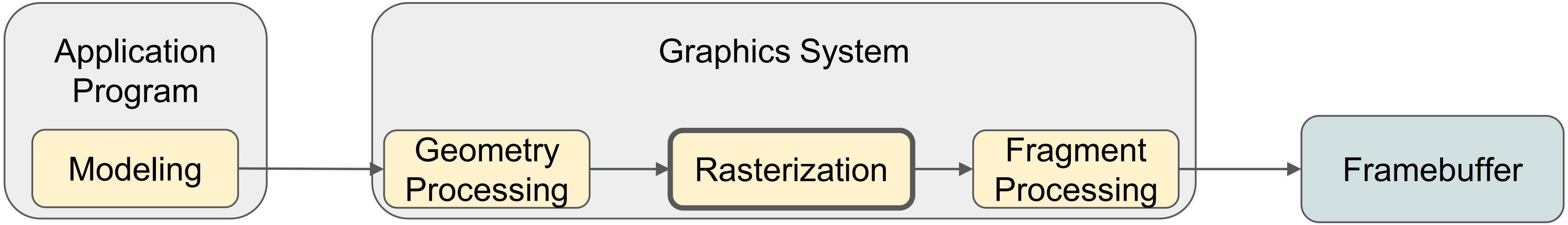
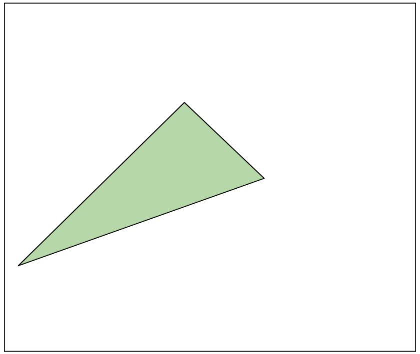
Rasterization

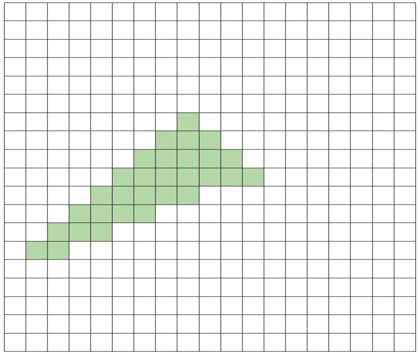


Rasterization

- 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

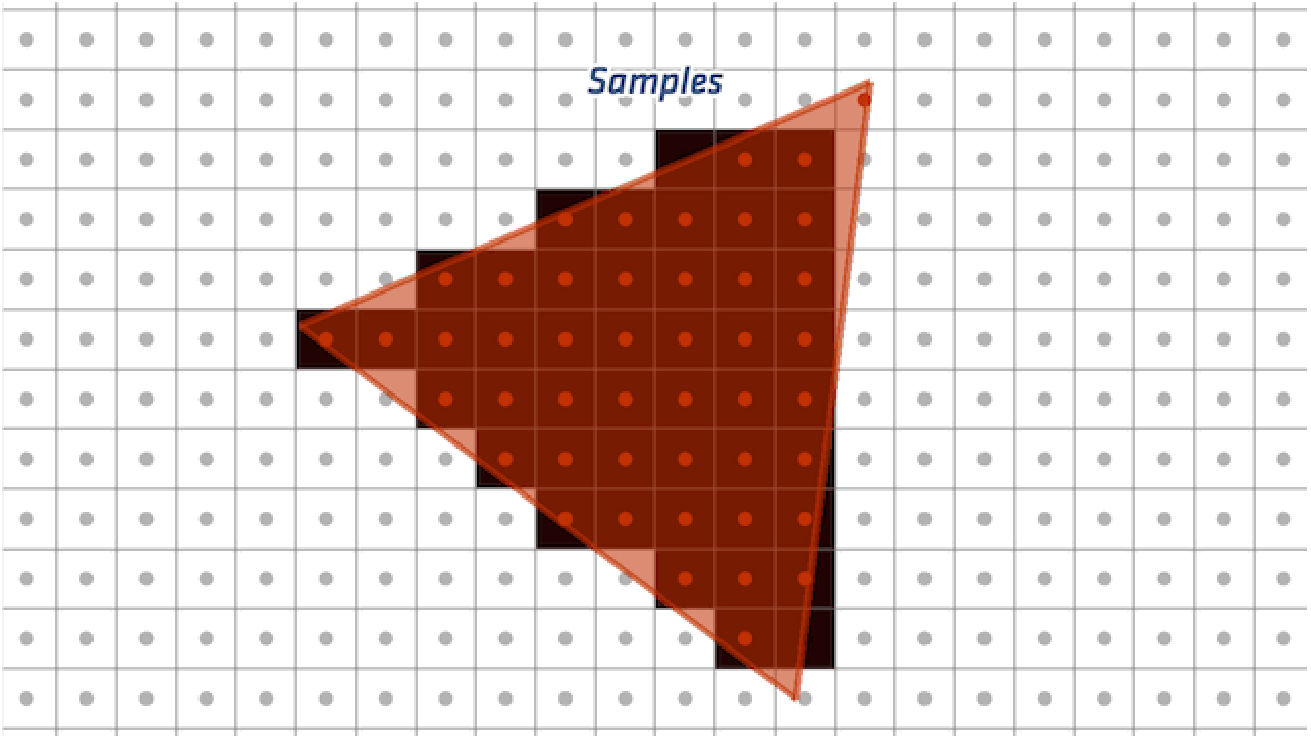


Image Copyright: Andrea Tagliasacchi

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Rasterization: Lines

DDA algorithm: Idea

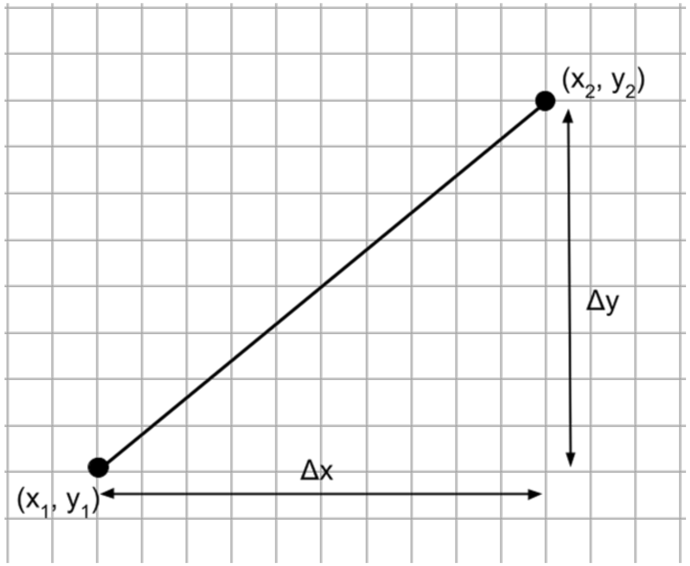
$y = mx + h$

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

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

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

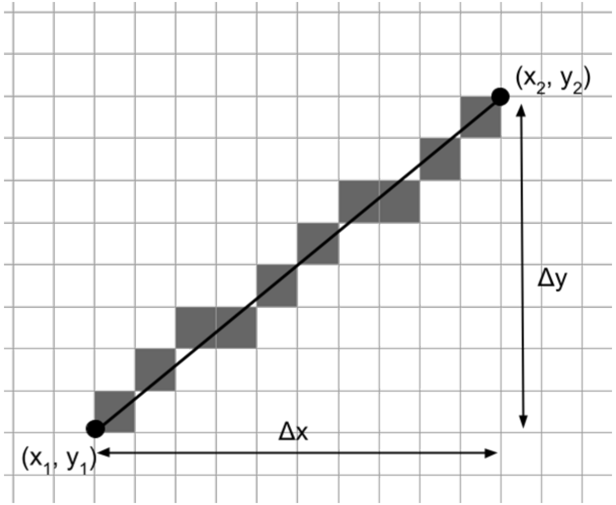
$\mathbf{y_{i+1} = y_i + m}$



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.

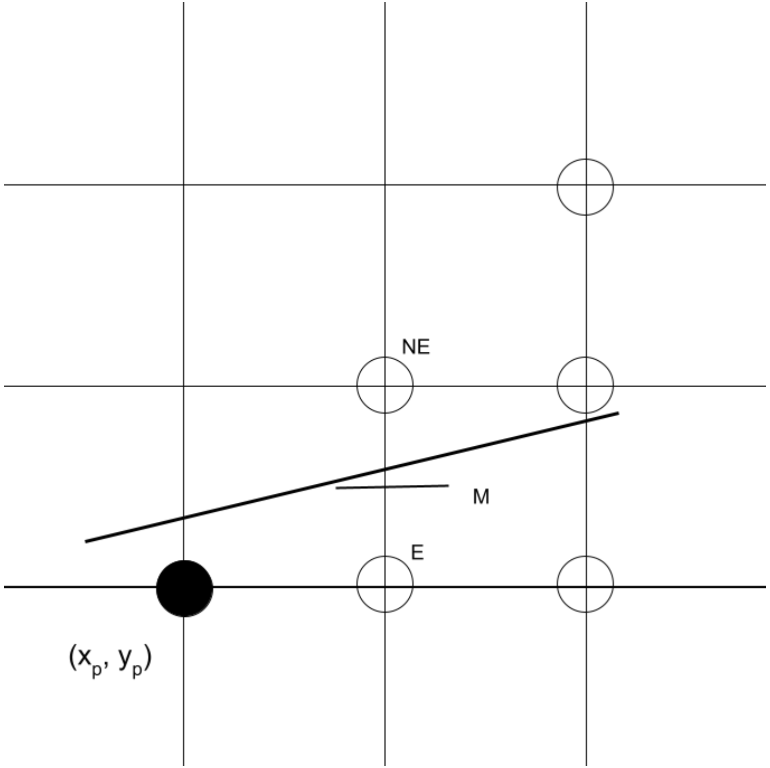
Rasterization: Lines

Bresenham’s Algorithm:

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

$y = mx + h$

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



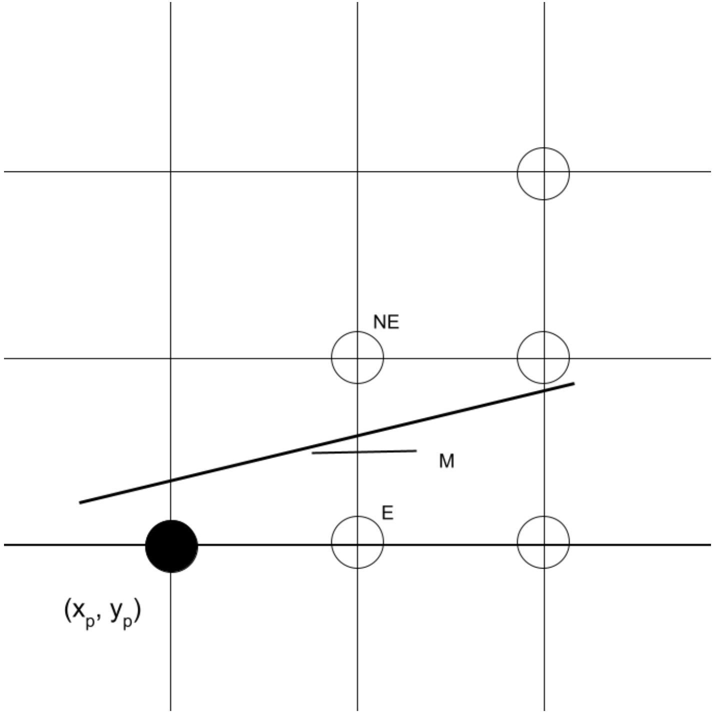
Rasterization: Bresenham's Algorithm

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

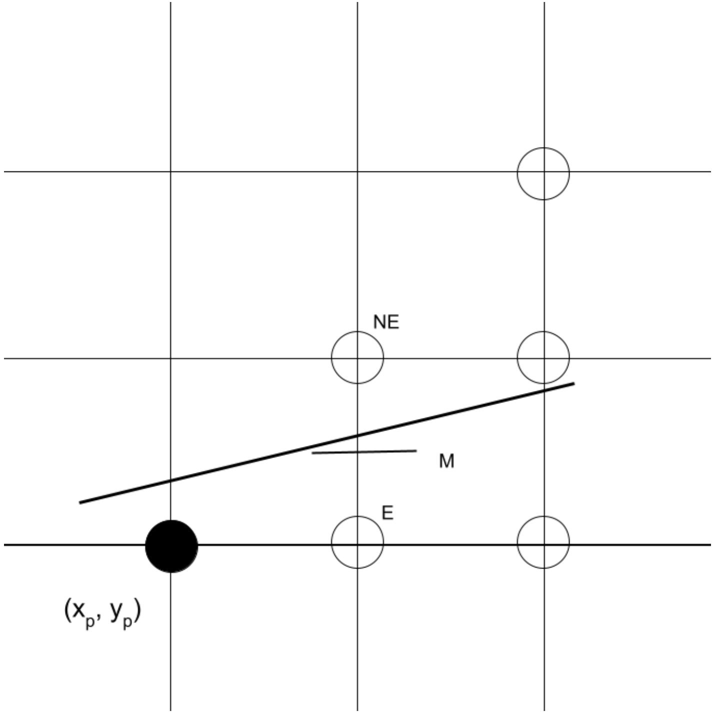
At the current iteration, the pixel at (x_p, y_p) is chosen. Now how to choose the next pixel?

The choice is between pixels E and NE.

Compute F(M), F(M) is the decision value ‘d’

$$d = A\,(x_p + 1) + B\,(y_p + ½) + C$$

If d > 0, choose NE, otherwise choose E

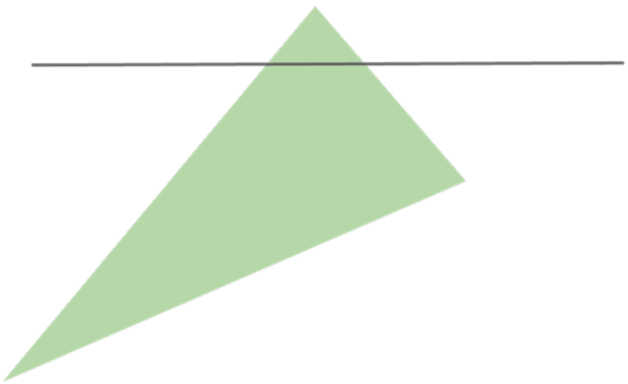


Rasterization: Filling

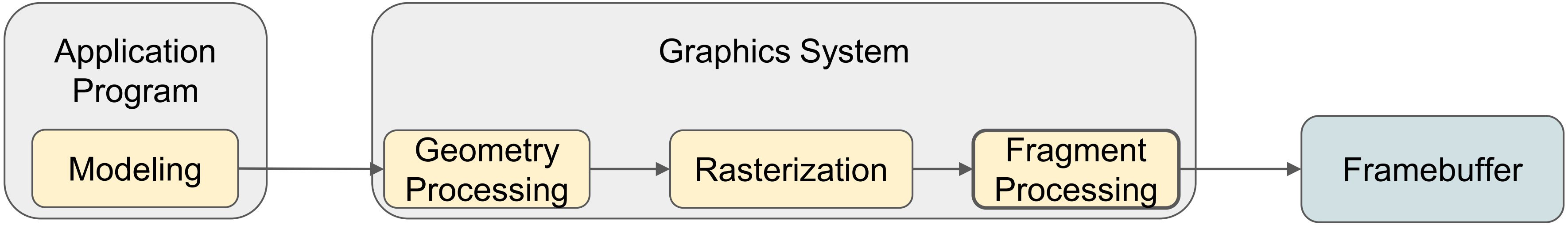
Primitive assembly information is utilized for filling.

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

- Crossing or odd-even test.



Hidden Surface Removal

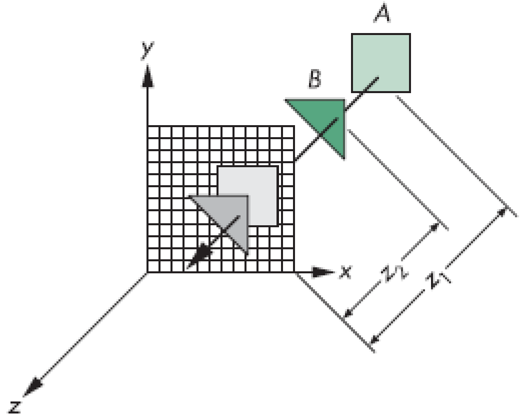


Hidden Surface Removal: The z-Buffer algorithm

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.

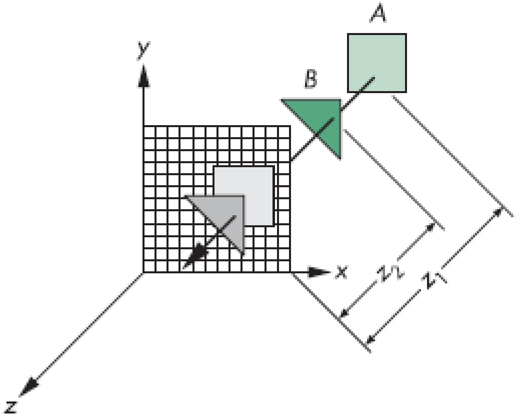


Hidden Surface Removal: The z-Buffer algorithm

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

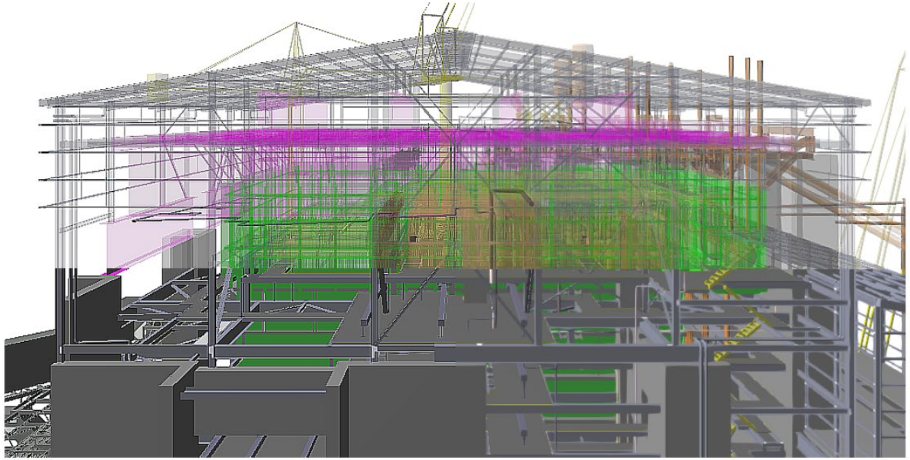
$Depth_{new} > Depth_{z\text{-}buffer}$ we have already rasterized a fragment that is closer to the viewer.

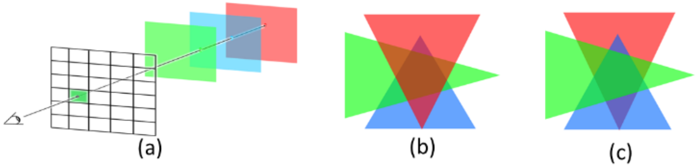
Otherwise the incoming fragment is placed in the color buffer and the z-buffer is updated.



Transparency

- Important to denote relationships among objects in a scene.
- One of the five major challenges in interactive rendering [Andersson,





If not all fragments are opaque, how can we blend them?

[Maule et al., 2012]

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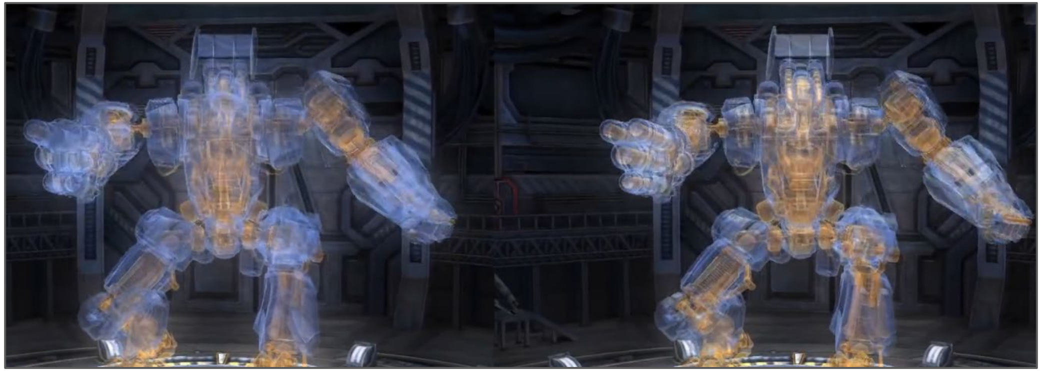
Transparency

- Blend fragment color and opacity such that the resulting pixel color is:

$$\mathbf{c} = \mathbf{c}_n + (1 - \alpha_n) \dots [\mathbf{c}_2 + (1 - \alpha_2)[\mathbf{c}_2 + (1 - \alpha_1)\mathbf{c}_0]]$$

- Order dependent: final pixel color depends of the fragment color.

Incorrect result as fragments are generated and blended in ‘random’ order.



Correct result, sorting fragments.

ATI Tech Demo

OpenGL pipeline