Computer Graphics (CS 4731)
Depth

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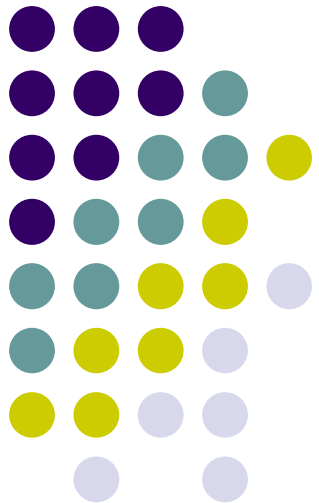


Slides Courtesy of Emmanuel Agu (WPI) and Matt Stoker (Utah)

Depth

Depth

Ordering?

Depth

Ordering?

Painter's Algorithm

What gets drawn **last** ends up being shown.

Painter's Algorithm

Order the objects in the scene by Z

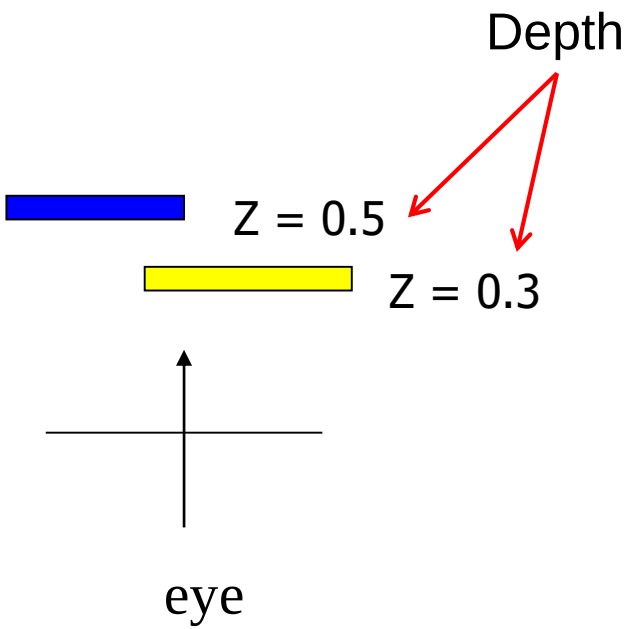
Painter's Algorithm

Now what?

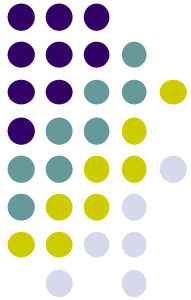
WebGL Depth Buffer (Z Buffer)

- **Depth:** While drawing objects, depth buffer stores distance of each polygon from viewer
- **Why?** If multiple polygons overlap a pixel, only closest one polygon is drawn

1.0	1.0	1.0	1.0
1.0	0.3	0.3	1.0
0.5	0.3	0.3	1.0
0.5	0.5	1.0	1.0



Setting up WebGL Depth Buffer

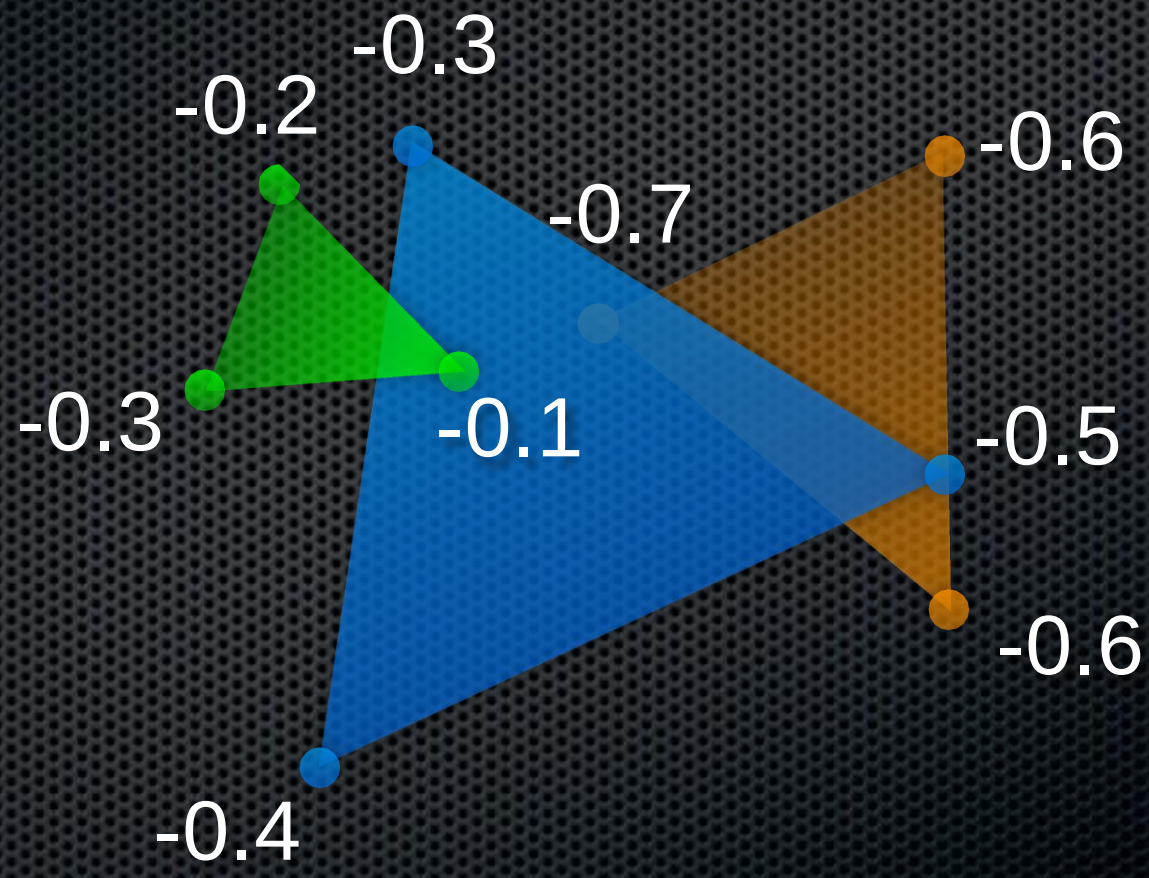


1. `gl.enable(GL_DEPTH_TEST)` enables depth testing

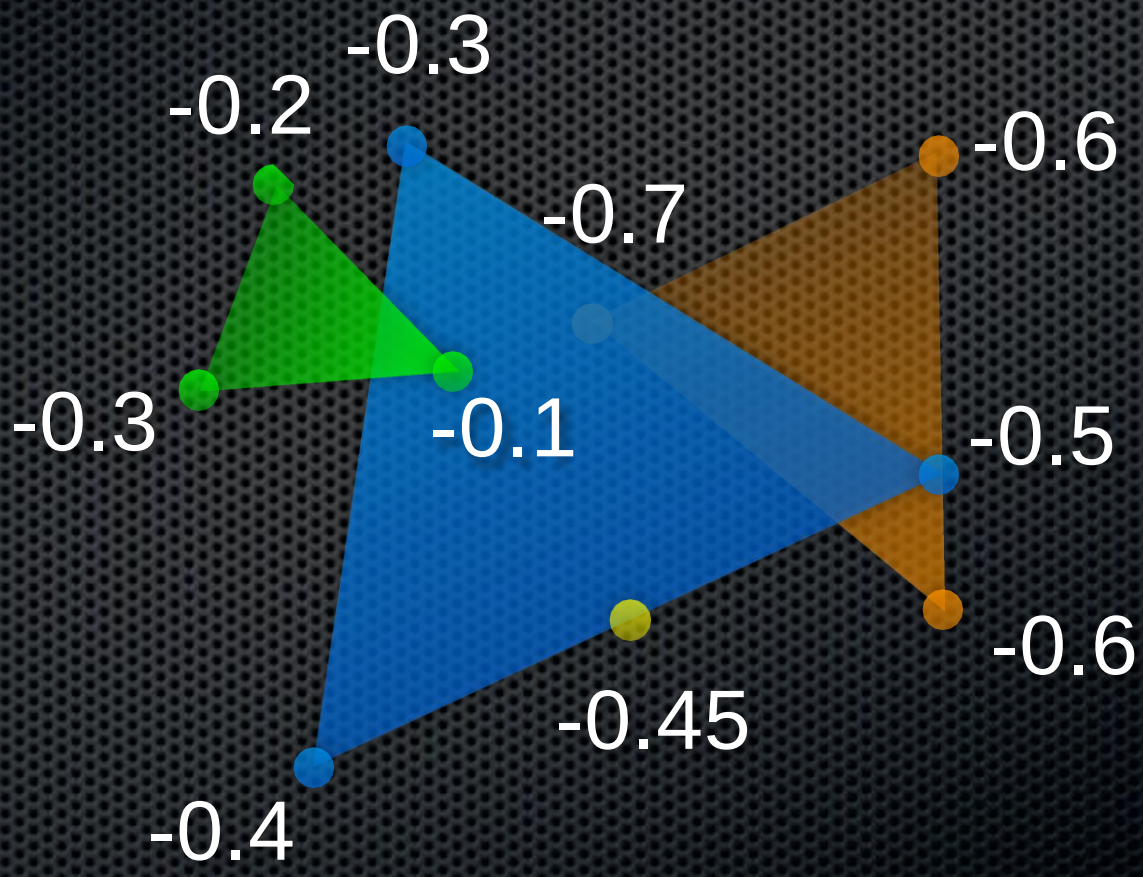
2. `gl.clear(GL_COLOR_BUFFER_BIT | GL_DEPTH_BUFFER_BIT)`

   Initializes depth buffer every time we draw a new picture

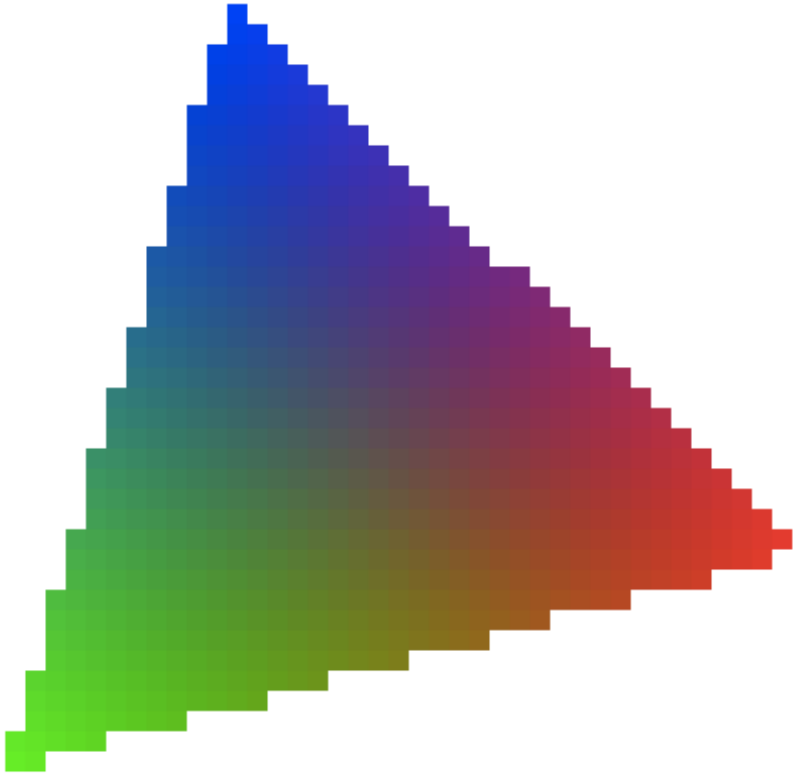
Per-Pixel Ordering



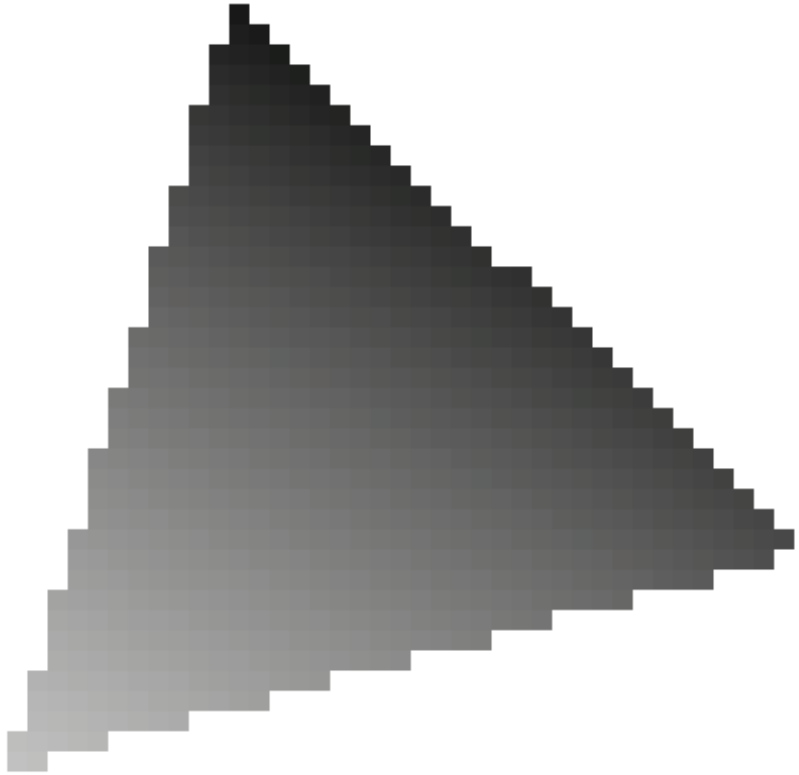
Per-Pixel Ordering



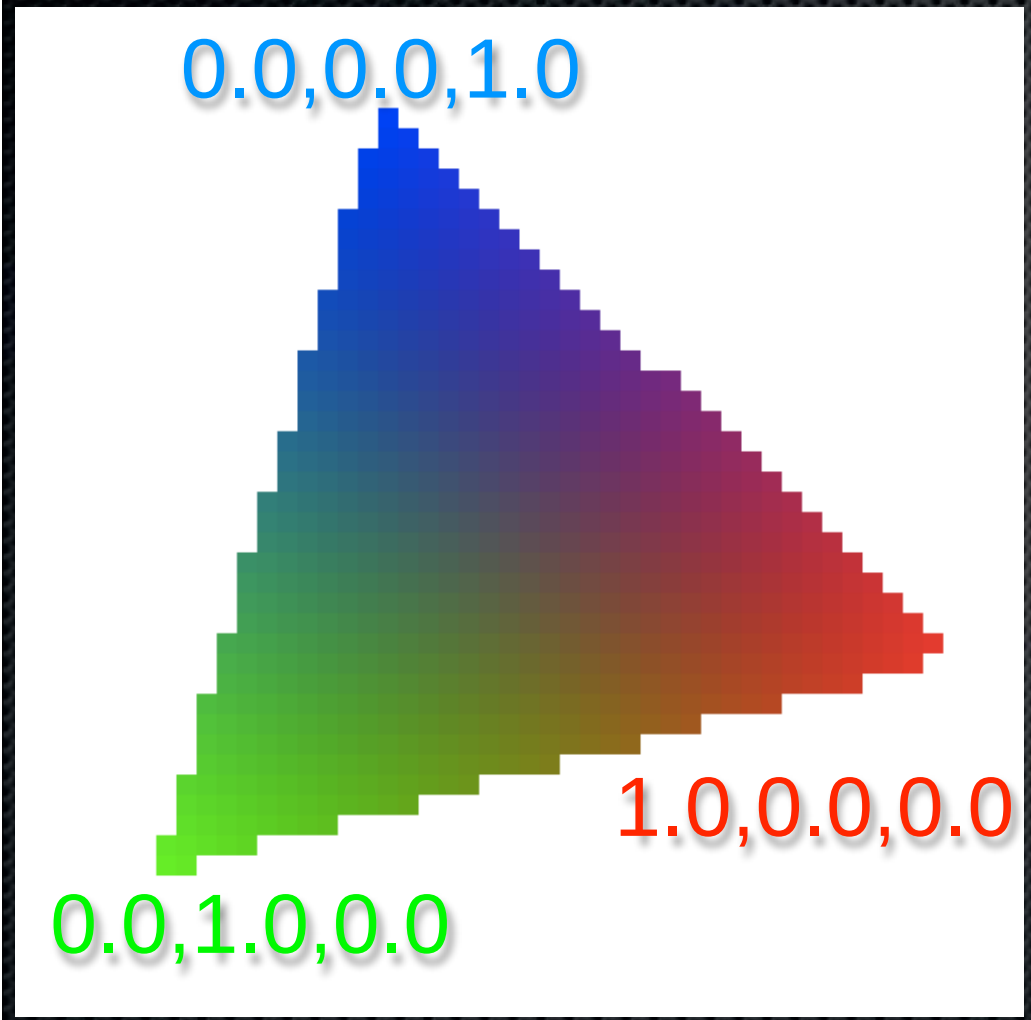
Color Buffer



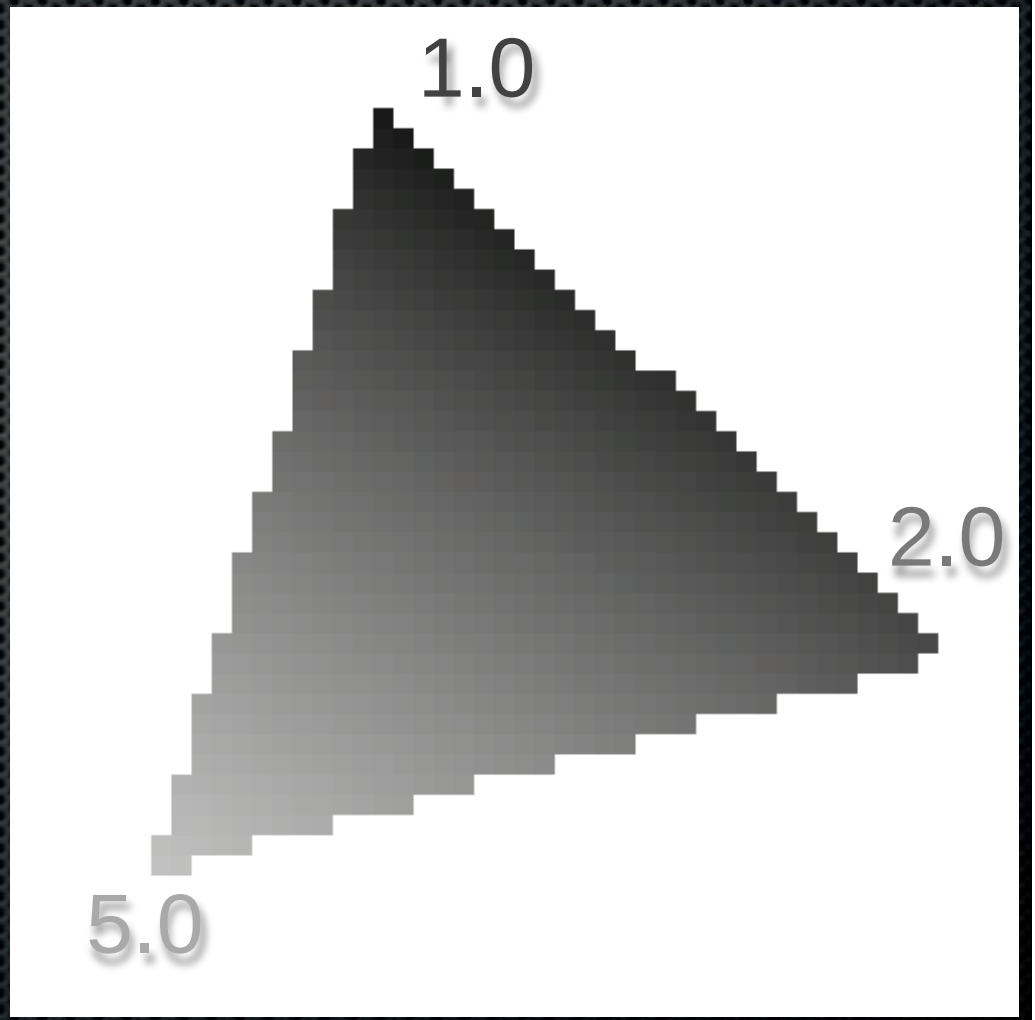
Z-Buffer



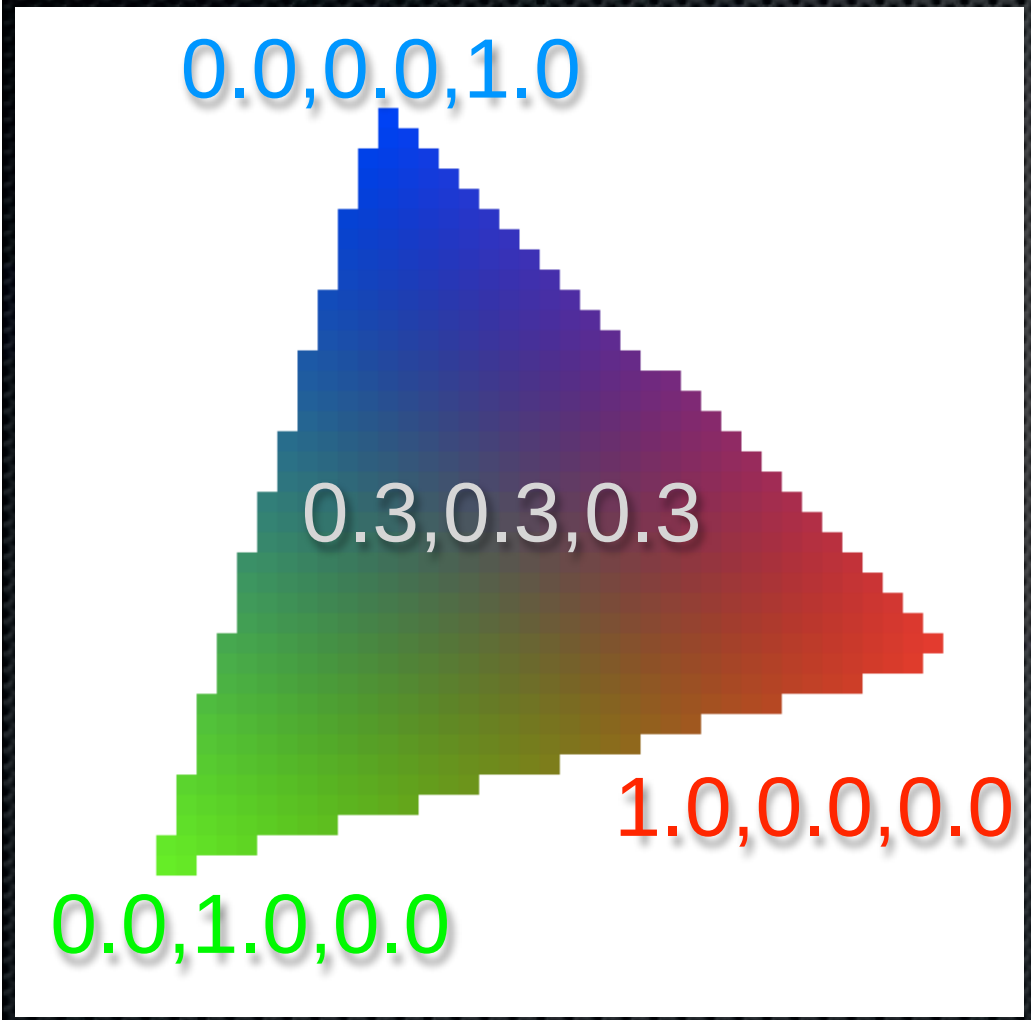
Color Buffer



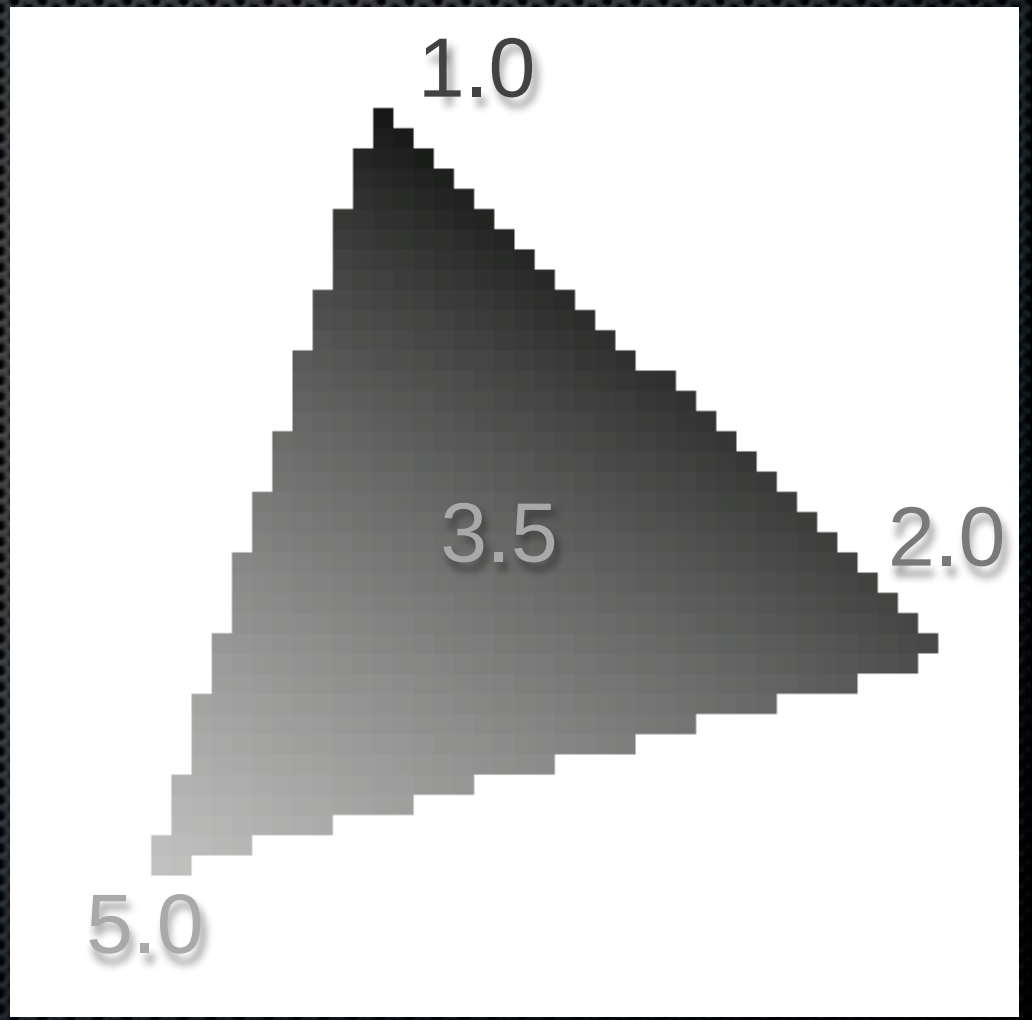
Z-Buffer



Color Buffer

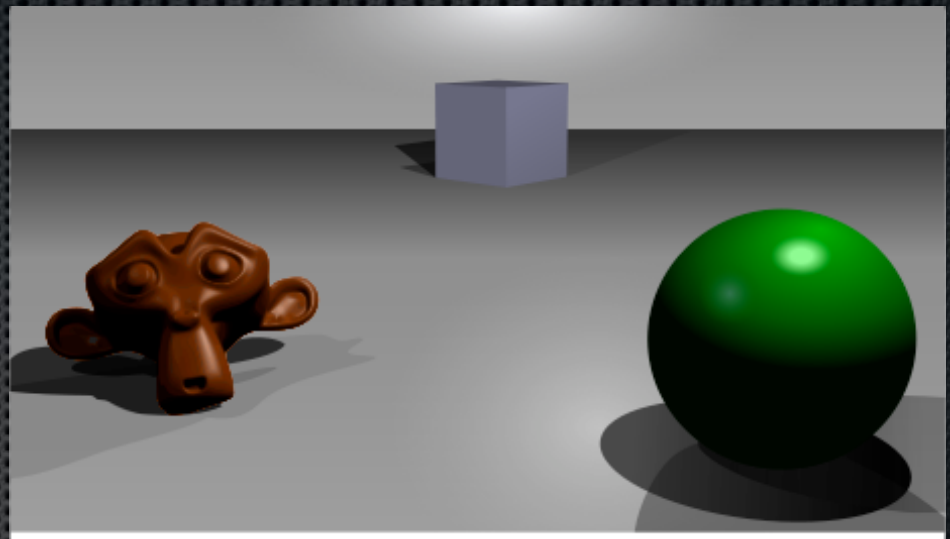


Z-Buffer

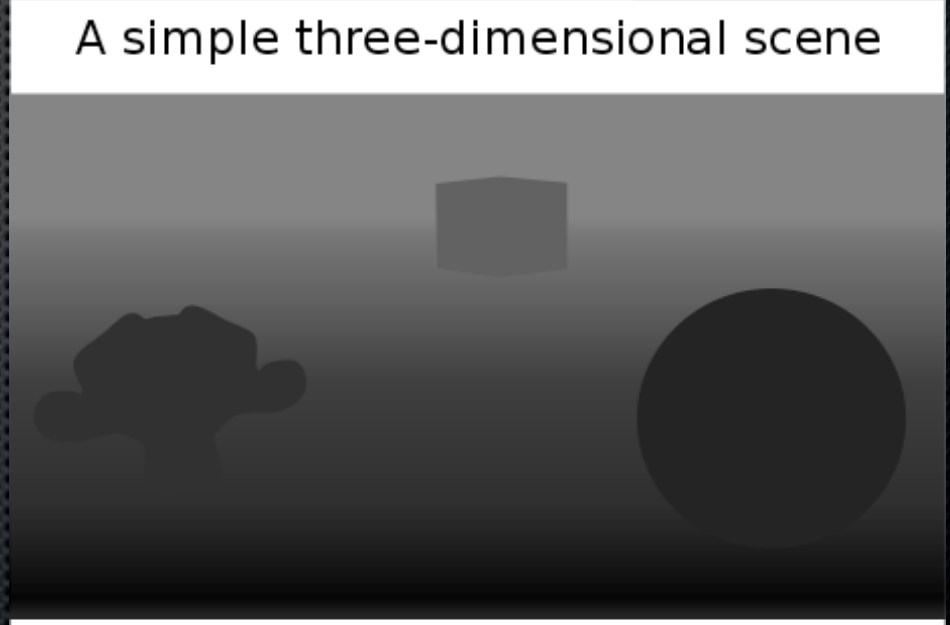


Z-Buffer

for pixels in triangle
  calculate $\lambda_1,\lambda_2,\lambda_3$
  if $\lambda_1>0$ & $\lambda_2>0$ & $\lambda_3>0$
    interpolate z-value
    if z-value < z-buffer
      update z-buffer
      interpolate color
      store color in raster



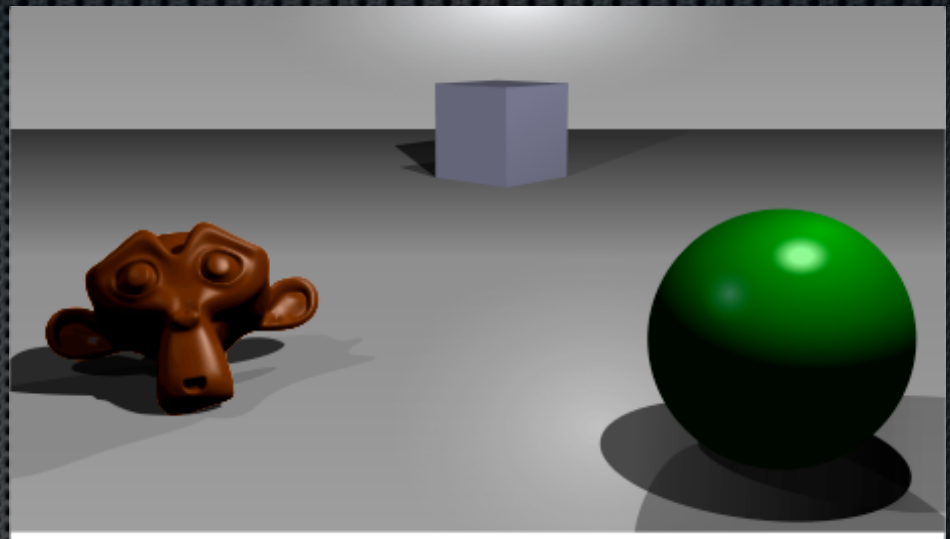
A simple three-dimensional scene



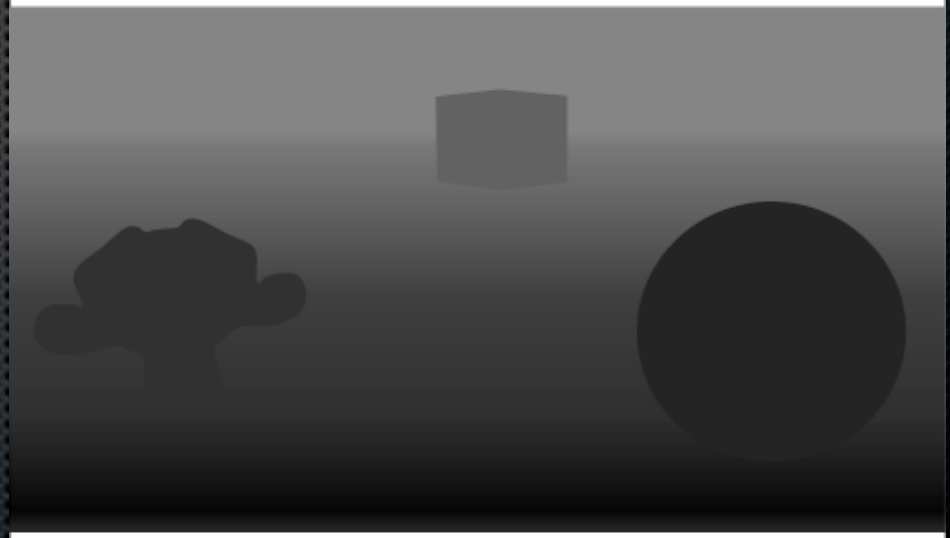
Z-buffer representation

Z-Buffer

- Issues
  - What is the sign of data in the Z-buffer?
  - What does a “clear” z-buffer look like
  - What data type should a z-buffer use? Float?

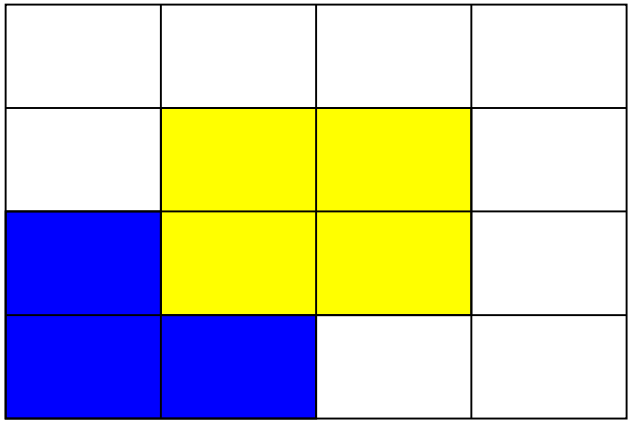


A simple three-dimensional scene

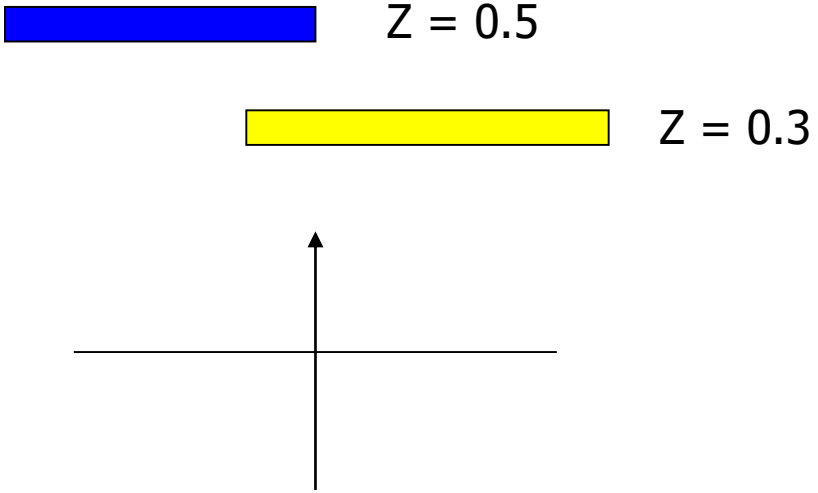


Z-buffer representation

Z buffer Illustration



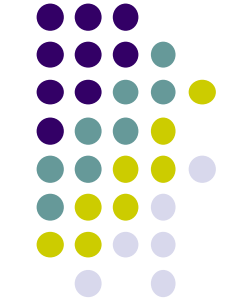
Correct Final image



eye

Top View

Z buffer Illustration



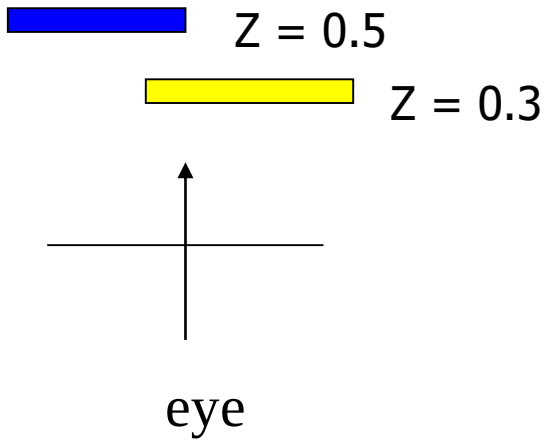
Step 1: Initialize the depth buffer

1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0

Z buffer Illustration

Step 2: Draw blue polygon
(order does not affect final result)

1.0	1.0	1.0	1.0
1.0	1.0	1.0	1.0
0.5	0.5	1.0	1.0
0.5	0.5	1.0	1.0

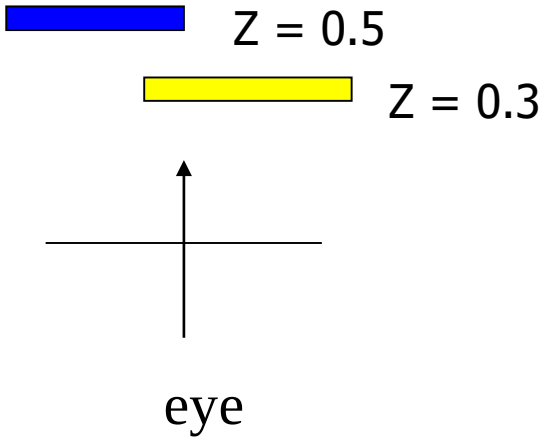


1. Determine group of pixels corresponding to blue polygon
2. Figure out z value of blue polygon for each covered pixel (0.5)
3. For each covered pixel, compare polygon z to current depth buffer z
    1. z = 0.5 is less than 1.0 so smallest z so far = 0.5, color = blue

Z buffer Illustration

Step 3: Draw the yellow polygon

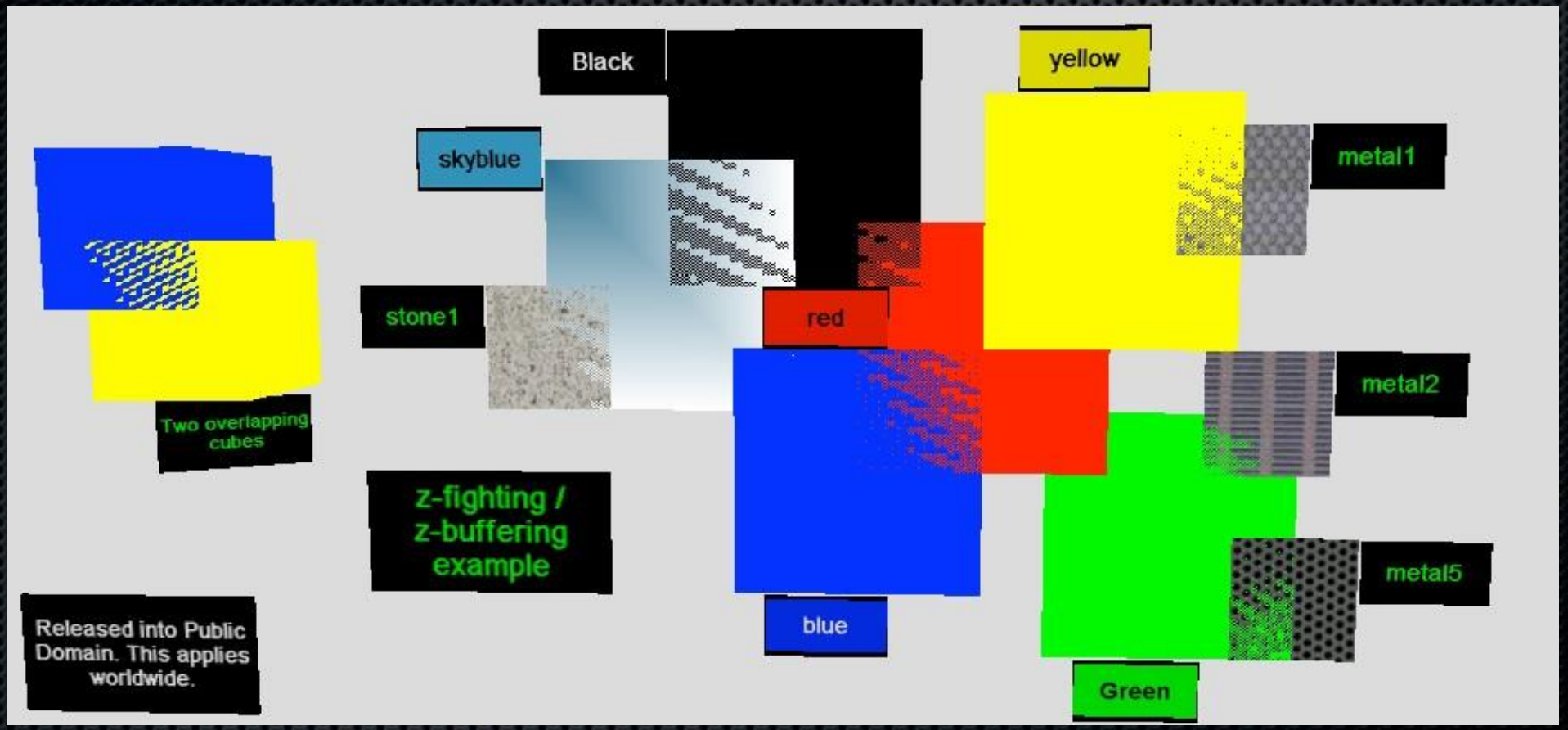
1.0	1.0	1.0	1.0
1.0	0.3	0.3	1.0
0.5	0.3	0.3	1.0
0.5	0.5	1.0	1.0



1. Determine group of pixels corresponding to yellow polygon
2. Figure out z value of yellow polygon for each covered pixel (0.3)
3. For each covered pixel, z = 0.3 becomes minimum, color = yellow

z-buffer drawback: wastes resources drawing and redrawing faces

Z-Fighting


Black
yellow
skyblue
metal1
stone1
red
metal2
Two overlapping cubes
z-fighting / z-buffering example
metal5
blue
Green
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Typical Matrices