CMSC 341

Asymptotic Analysis

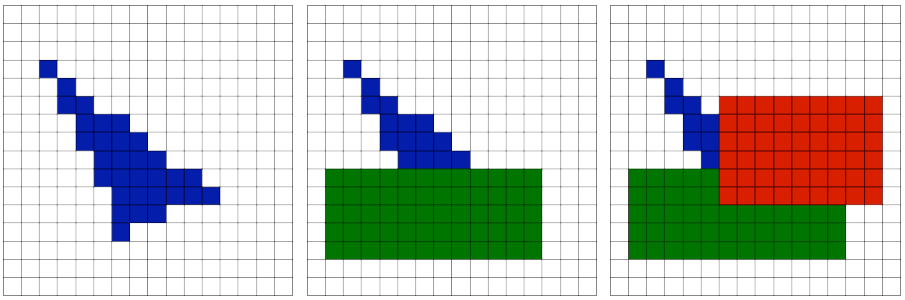
Application Example: Visibility

AA Example: Visibility

- The problem: Given a geometric model (list of polygons) and a view specification, generate the image which represents that scene viewed in that way
- Many ways to approach the problem
  - Ivan Sutherland, A Characterization of Ten Hidden Surface Algorithms, 1974
  - More approaches in the decades since

Painter's Algorithm

- Approach
  - Sort polygons
  - Draw polygons in order: furthest to closest



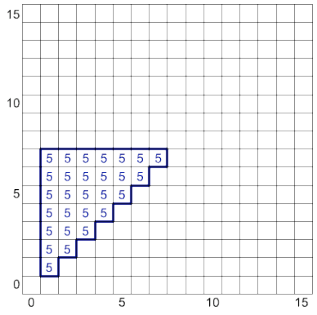
Painter's Algorithm

- Given
  - List of Polygons {P1, P2, … , Pn}
  - Array of Intensity [x, y]

```
Begin
  Sort polygon list on minimum z (largest z first)
  For each polygon P in selected list do
    For each pixel (x,y) that intersects P do
      Intensity [x,y] = intensity of P at (x,y)
  Display Intensity array
```

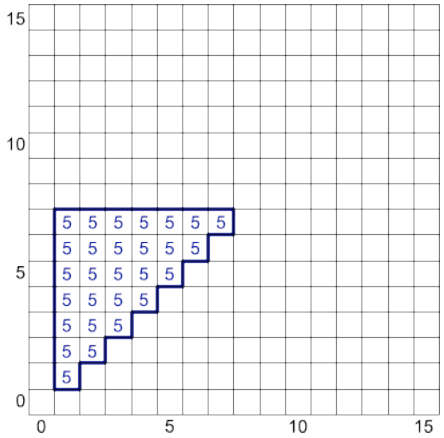
Z-buffer

- Approach
  - Draw polygons in arbitrary order: store depth
  - At each pixel, overwrite if new pgon closer
  - Pgon: (1,1,5), (7,7,5), (1,7,5)



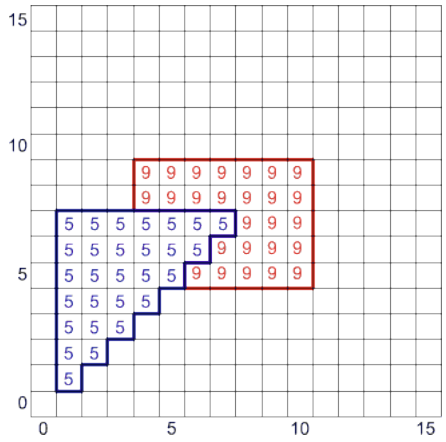
Zbuffer Example (1)

- Pgon: (1,1,5), (7,7,5), (1,7,5)



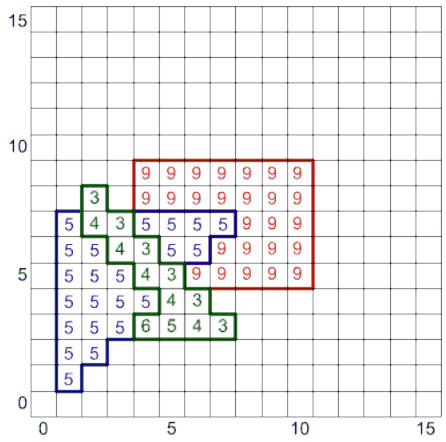
Zbuffer Example (2)

- Pgon: (3,5,9), (10, 5, 9), (10,9,9), (3,9,9)

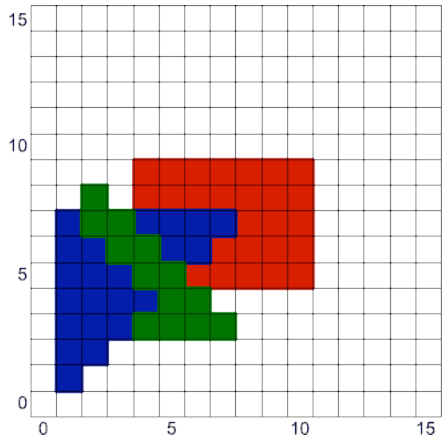


Zbuffer Example (3)

- Pgon: (2,6,3), (2,3,8), (7,3,3)



Zbuffer Example (4)



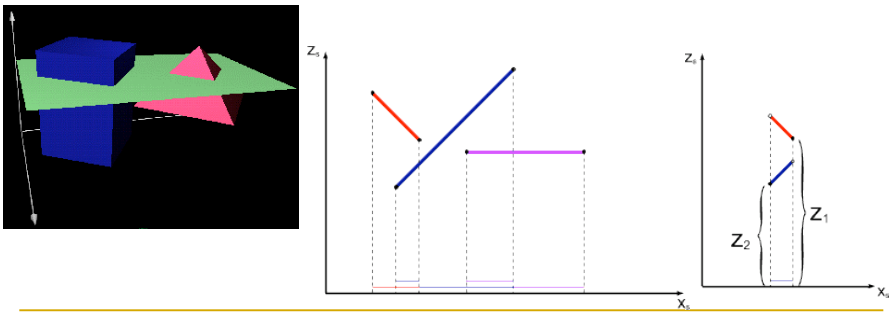
Zbuffer Algorithm

- Given
  - List of Polygons {P1, P2, … , Pn}
  - Array of Intensity [x, y]
  - Array z-buffer [x,y], initialized to +infinity

```
Begin
  For each polygon P in selected list do
    For each pixel (x,y) that intersects P do
      Calculate z-depth of P at (x,y)
      If z-depth < z-buffer[x,y] then
        Intensity [x,y] = intensity of P at (x,y)
        z-buffer[x,y] = z-depth
  Display Intensity array
```

Scanline Algorithm

- Approach
  - Consider one row of image (scanline) at a time
  - Identify coherent runs in scanline



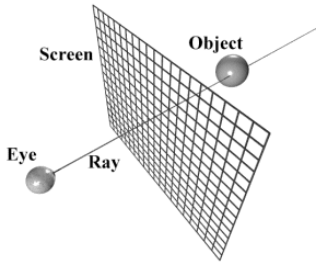
Scanline Algorithm

- Given
  - List of Polygons {P1, P2, … , Pn}
  - Array of Intensity [x, y]

```
Begin
   Sort pgons into sorted surface table (SST) on y
   Initialize y and active surface table (AST)
   Repeat until AST and SST empty
      identify spans for this scanline (sorted on x)
      for each span
        determine visible element (based on z)
        fill pixel intensities with values from element
      update AST: y++
        remove exhausted edges
        update x intercepts
        resort AST on x
        add entering pgons
   Display Intensity array
```

Ray Casting

- Approach
  - Project sight rays from eye point through pixel into scene
  - Draw thing found at first intersection of each pixel



Ray Casting Algorithm (1)

- Given
  - List of Polygons {P1, P2, … , Pn}
  - Array of Intensity [x, y]

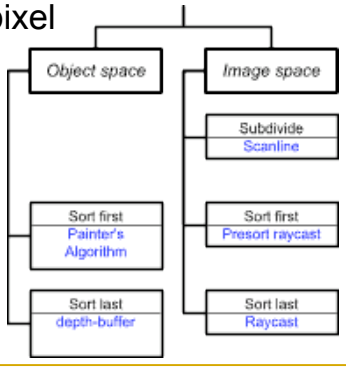
```
Begin
   For each pixel (x,y) {
      form a ray R in object space through the camera
         position C and the pixel (x,y)
      Intensity [x,y] = trace(R)
      }
   Display array Intensity
```

Ray Casting Algorithm (2)

```
Intensity trace(Ray) {
  for each polygon P in the scene
     Calculate the intersection of P and R
  If ( R hit no pgon)
     return (background intensity)
  Else {
     Find pgon P with closest intersection
     Calculate intensity I at intersection point
     Return (I)
     }
```

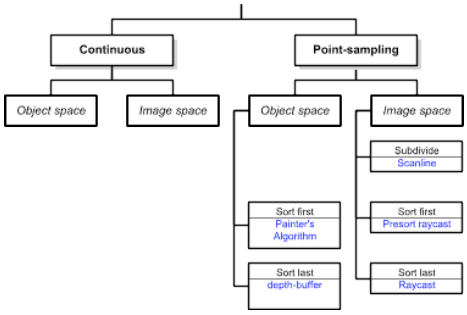

Visibility Algorithm Taxonomy

- Basic design choice
  - Object space: organize by pgon
  - Image space: organize by pixel

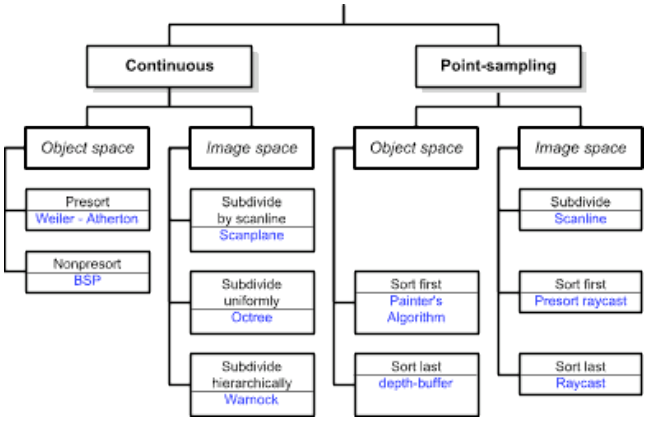


Visibility Algorithm Taxonomy

- Also consider continuous output



Visibility Algorithm Taxonomy



Reviewing the Code

Painter's Algorithm

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Zbuffer Algorithm

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      If z-depth < z-buffer[x,y] then
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```


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Looking at Performance

	Approach	TIme	Space
Painter's			
Z-buffer			
Scanline			
Raycast