CMSC427
Finishing basic 3D rendering

Credit: slides 9+ from Prof. Zwicker

Quick ideas

- What we don’t see: culling 3D polygons
  - Backface culling
  - Clipping to frustrum or viewport
  - Z-buffer
- Texture mapping
  - Image plus texture coordinates

Culling polygons

- When is a triangle visible? It is …

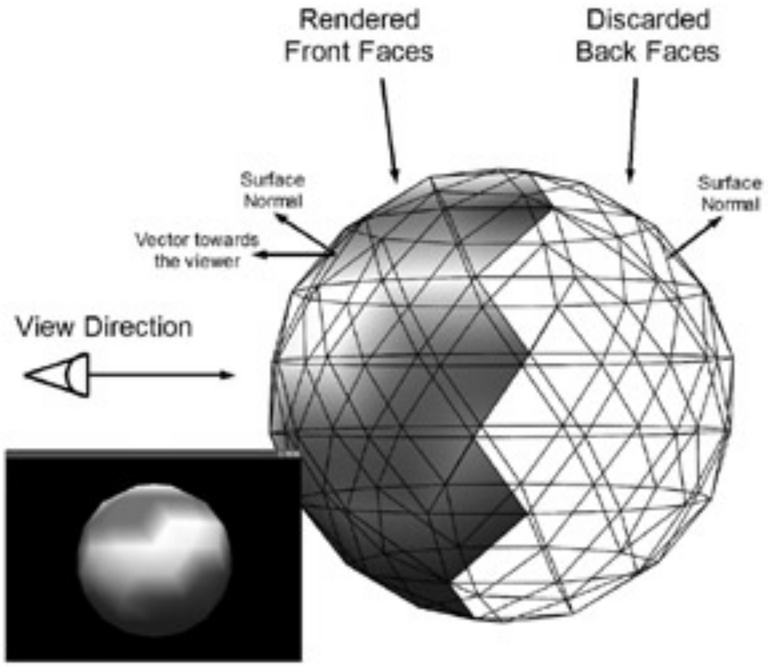
Culling polygons

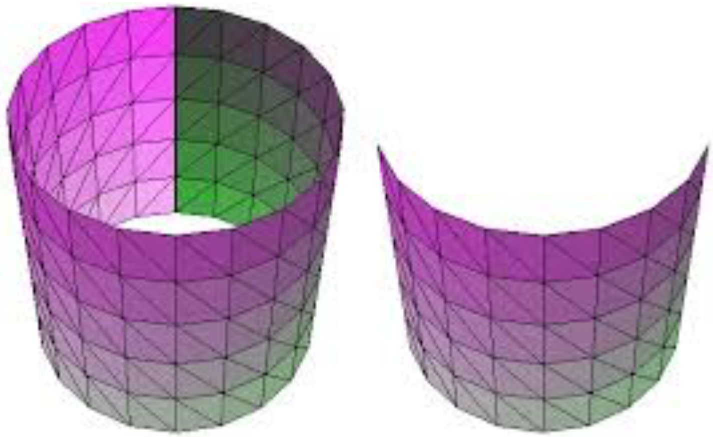
- When is a triangle visible? It is …
    - Facing the camera
    - Within the camera frustum or viewport
    - In front of other triangles

- ***Terminology:***
- Facing camera: *Backface culling*
- Within viewport: *Clipping*
- In front: *Z-buffering*

Backface culling

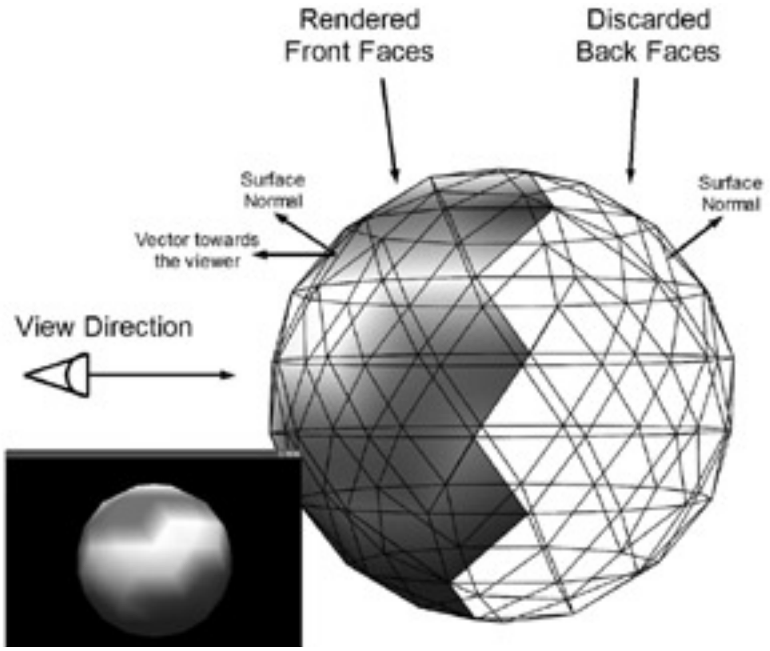
- Discard polygons facing away from camera
- How compute?

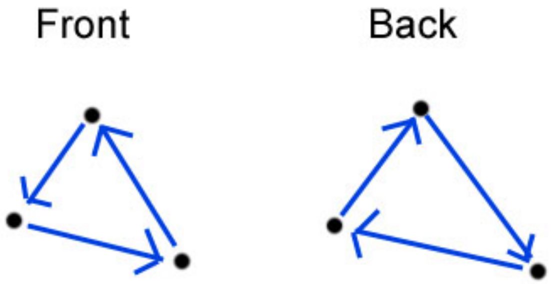




Backface culling

- Discard polygons facing away from camera
- How compute?
  - Angle between normal and view direction < 90
  - So N • VD > 0
  - Do *not* need to normalize
- Convention is to wind front face CCW so right hand rule faces out
- OpenGL has flag to cull back, front or neither





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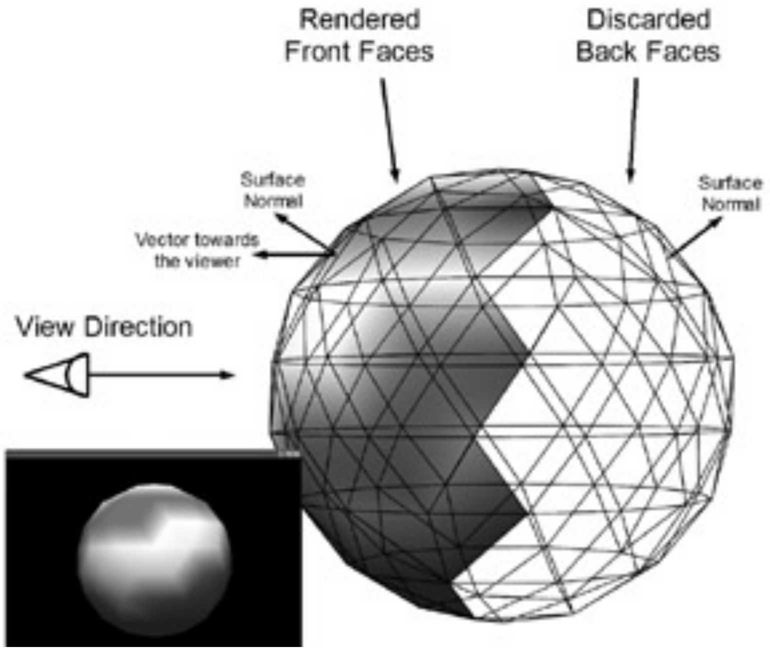
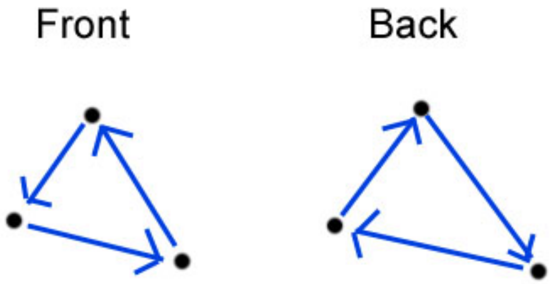
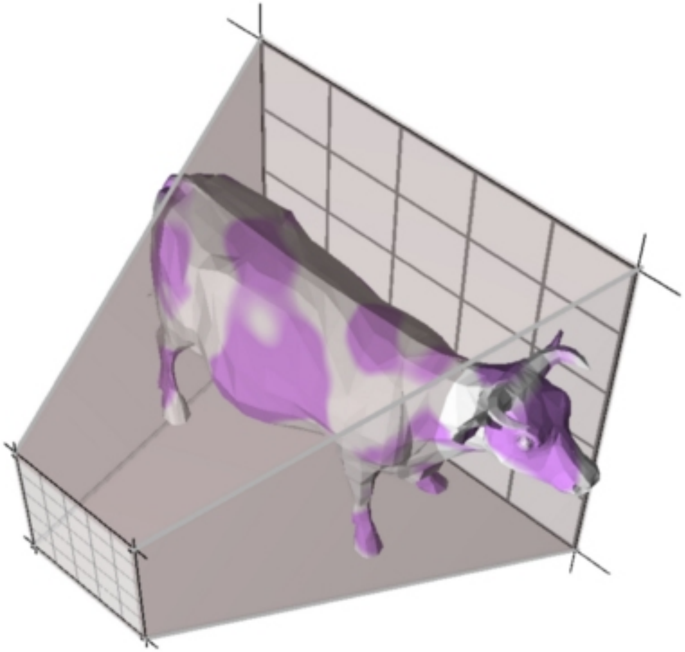


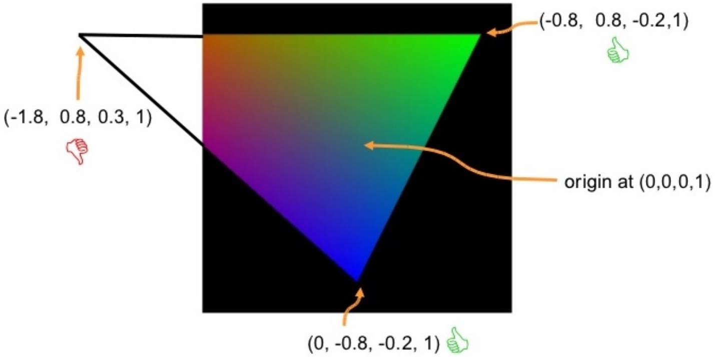


Clipping

- To frustrum (in 3D)



- To viewport (in 2D)



- Note: triangle clipped can become quad

Z-buffering

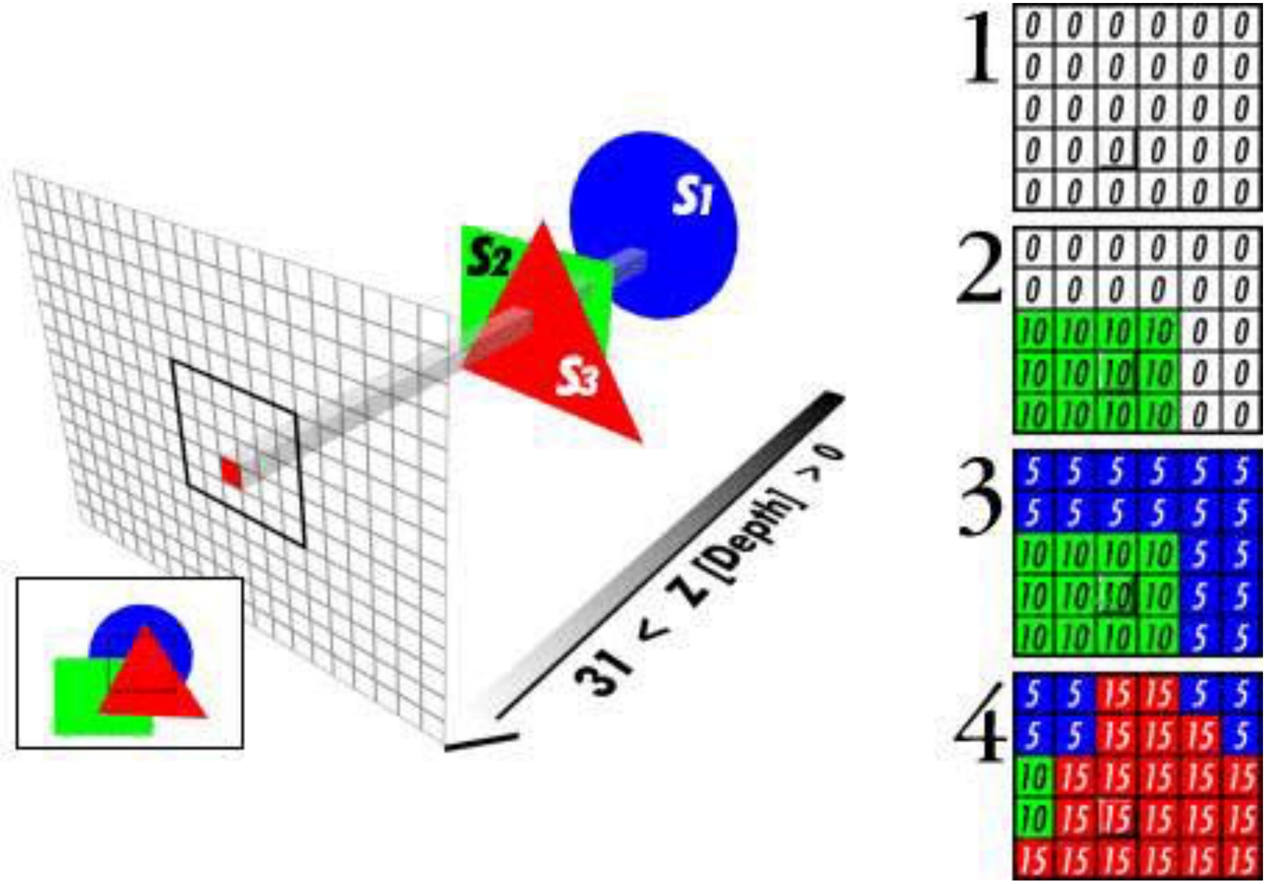
http://en.wikipedia.org/wiki/Z-buffering

- Store "depth" at each pixel
  - Store $1/w$ because we compute it for rasterization already
- Depth test
  - During rasterization, compare stored value to new value
  - Update pixel only if new $1/w$ value is larger

```
setpixel(int x, int y, color c, float w)
if((1/w)>zbuffer(x,y)) then
  zbuffer(x,y) = (1/w)
  color(x,y) = c
```

- In graphics hardware, z-buffer is dedicated memory reserved for GPU (graphics memory)
- Depth test is performed by GPU

Z-buffer



1

0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

2

0	0	0	0	0	0
0	0	0	0	0	0
10	10	10	10	0	0
10	10	10	10	0	0
10	10	10	10	0	0

3

5	5	5	5	5	5
5	5	5	5	5	5
10	10	10	10	5	5
10	10	10	10	5	5
10	10	10	10	5	5

4

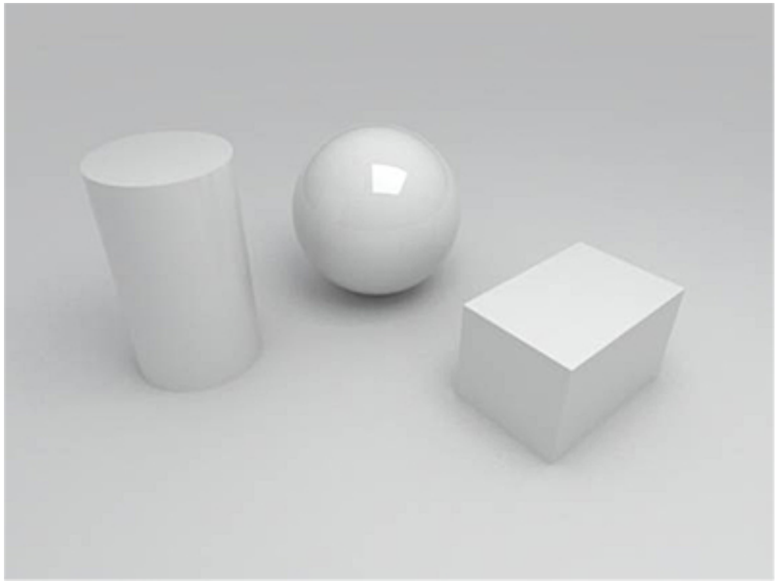
5	5	15	15	5	5
5	5	15	15	15	5
10	15	15	15	15	15
10	15	15	15	15	15
15	15	15	15	15	15

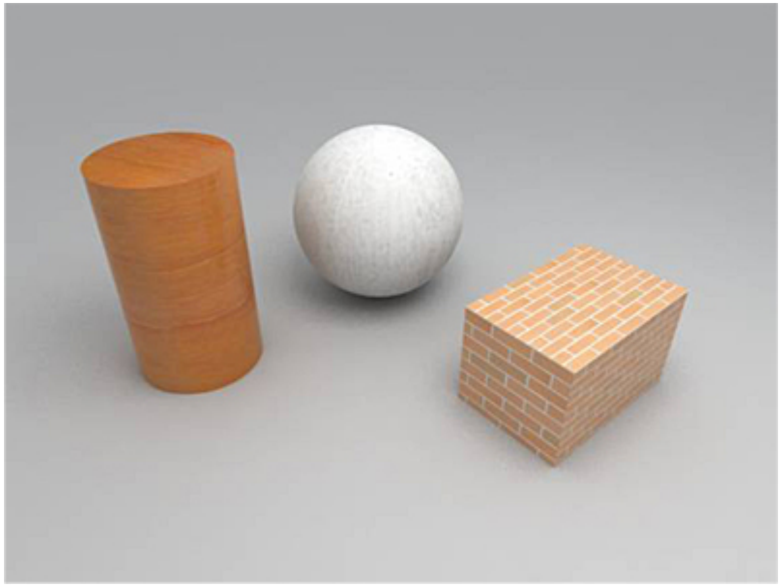
Texture mapping – quick version

- Basic shading – constant material objects

- Basic shading plus texture mapping – color varies over object

- How do?





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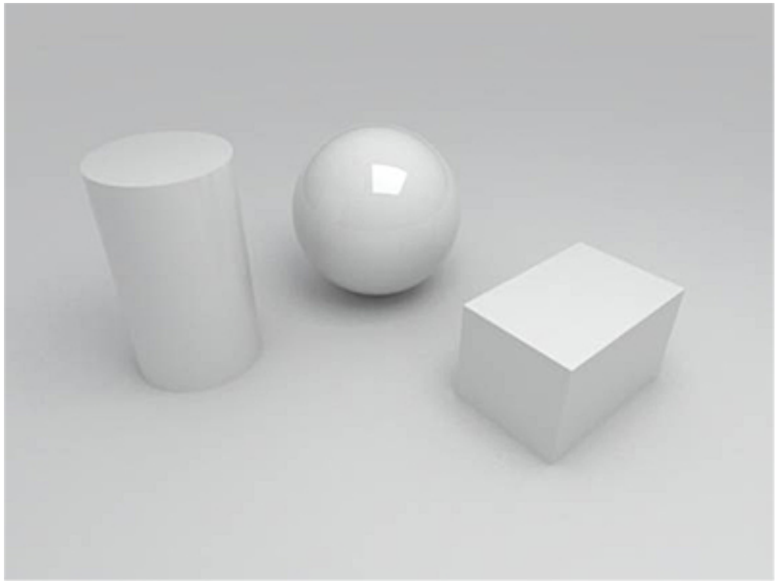
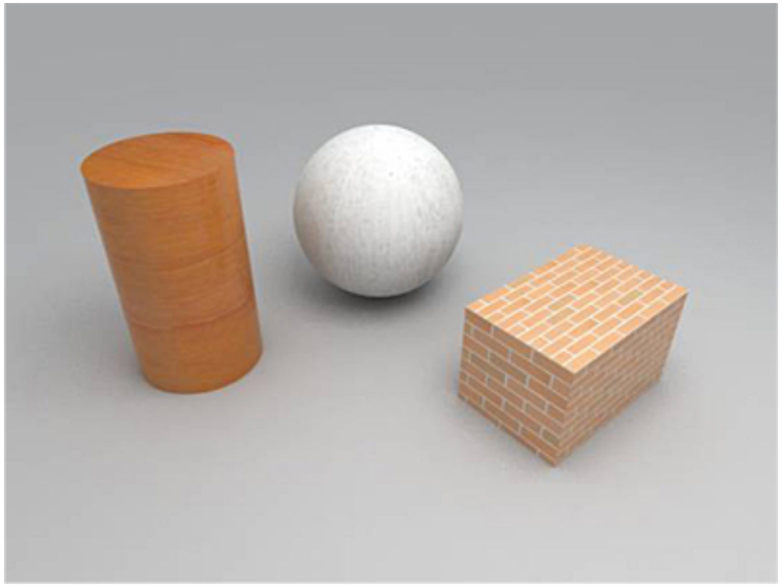
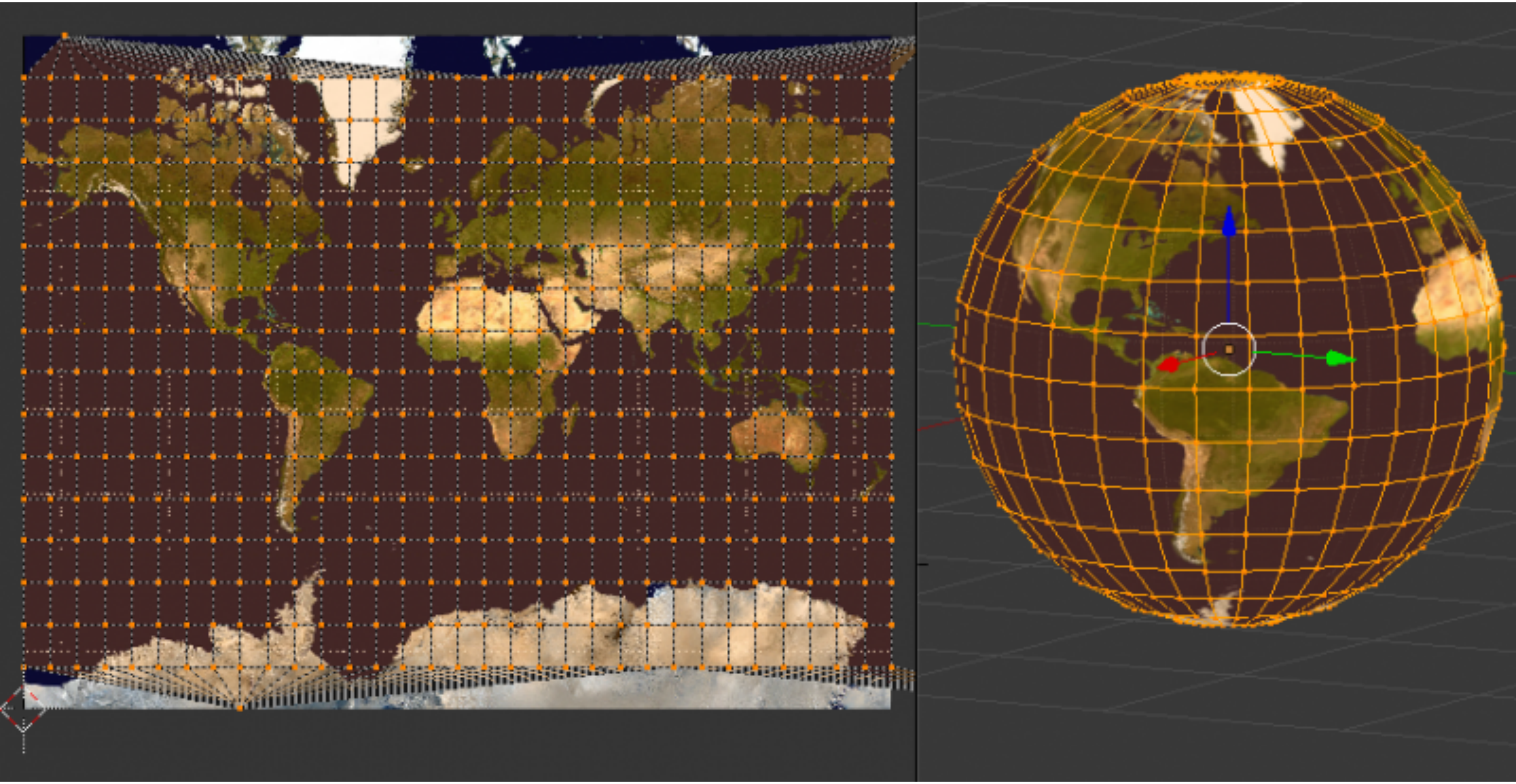


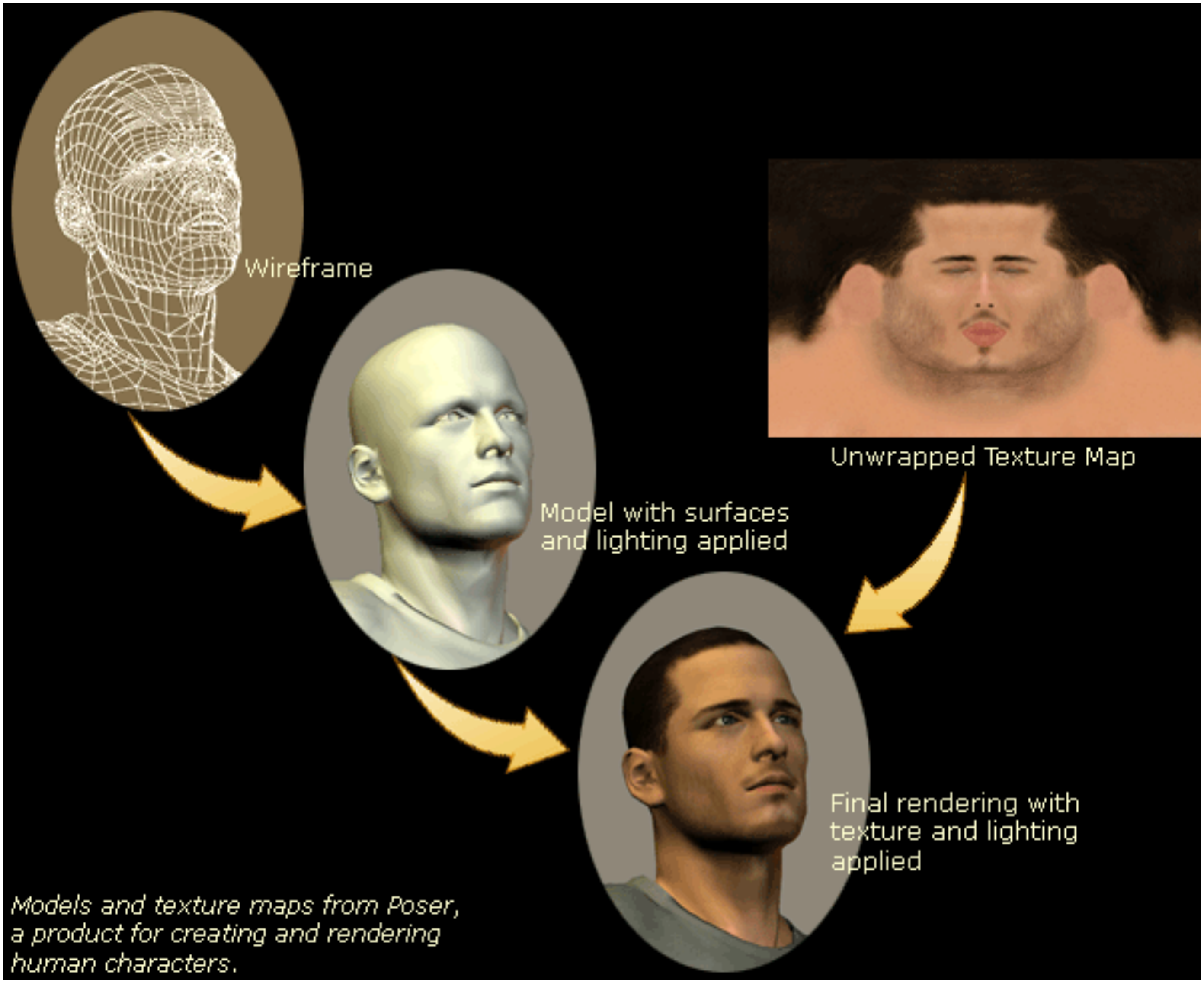


Texture mapping – texture coordinates

- Each vertex mapped to location in image
- Location interpolated inside polygon/triangle



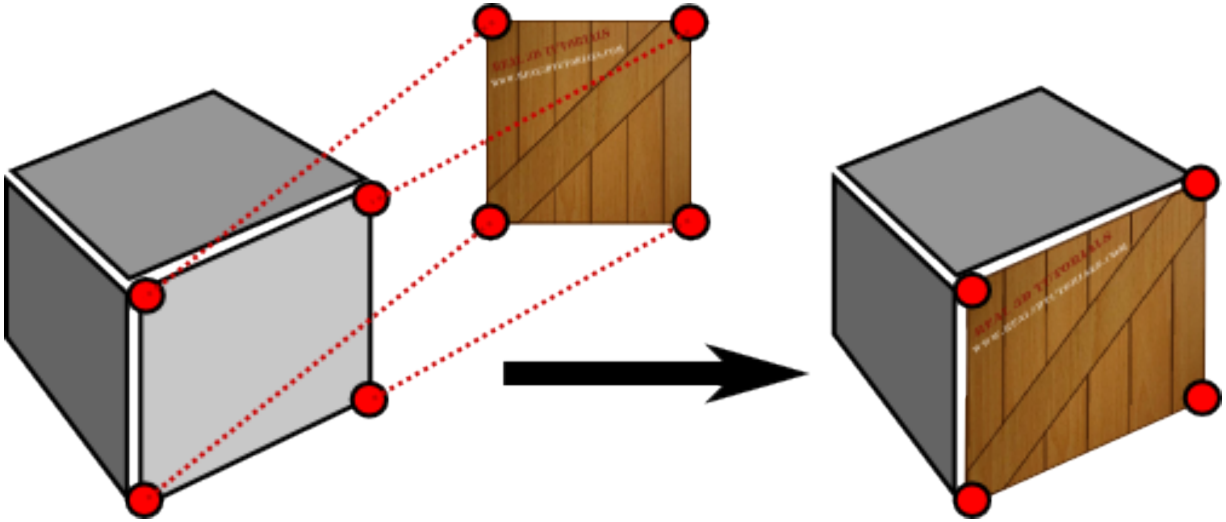
Texture mapping – can be complicated …


Wireframe
Model with surfaces and lighting applied
Unwrapped Texture Map
Final rendering with texture and lighting applied

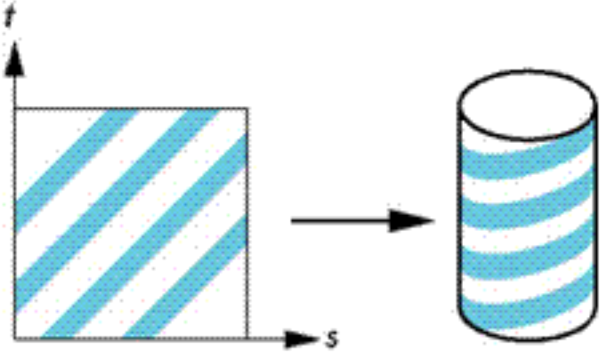
Models and texture maps from Poser, a product for creating and rendering human characters.

Texture mapping – can also be simple

- Cube



- Cylinder



Textures – in Processing

- Load image

```
Pimage tex = loadImage("berlin-1.jpg");
```

- Set texture image

```
texture(tex);
```

- Give texture coordinates per vertex (last two)

```
 vertex(-1, -1,  1, 0, 0);
```

- Texture coordinates can be in image coordinates (0 to w, 0 to h) or in normalized coordinates (0 to 1, 0 to 1)
- Examples: TextureCube and TextureCylinder

Texture coordinates and parametric meshes

- For polygon mesh vertices need:
- Location x,y,z
- Normal nx,ny,nz
- Texture coordinates u,v

- For cylinder?

Implications for OpenGL

- Backface
  - OpenGL lets you turn it off and on, and set frant facing winding direction
- Clipping
  - Built into rasterization stage and fixed
- Z-buffering
  - OpenGL lets you turn it off and on
  - A consideration in setting near and far plane (too far apart, you get precision errors in z)
- Texture mapping
  - Add to meshes texture coordinates and texture buffers

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