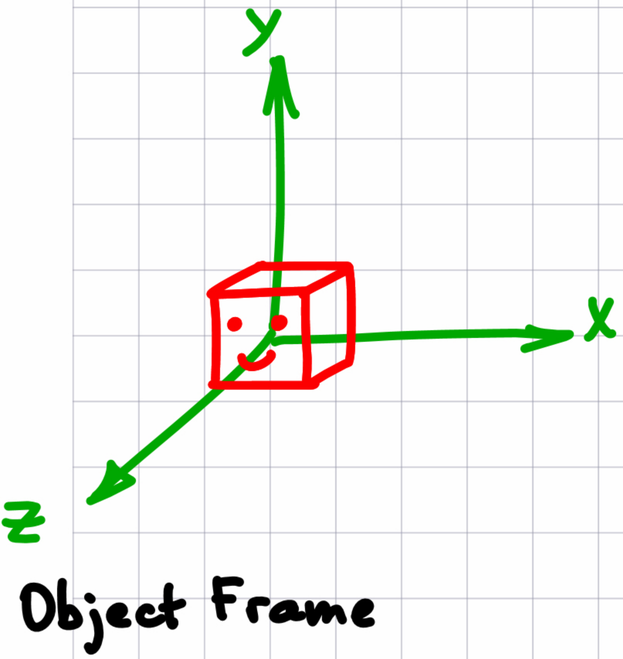
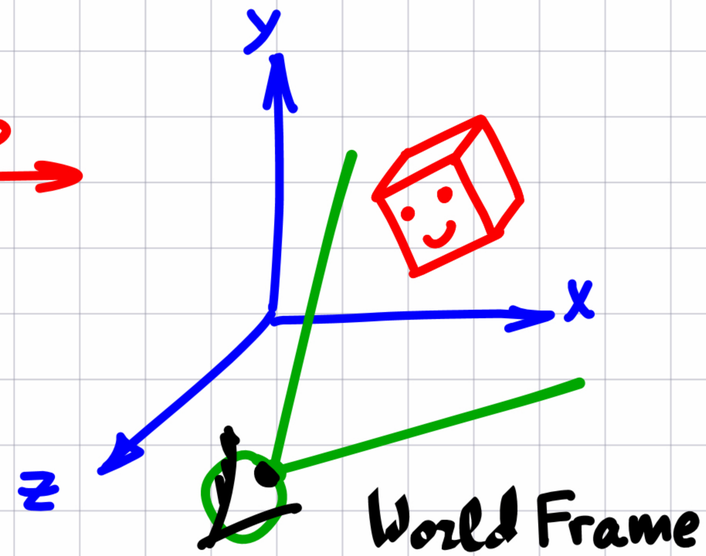
Announcements

- **Dec 16,** 7-11pm in Siebel 4240.
  Final project presentations and Open House for press!

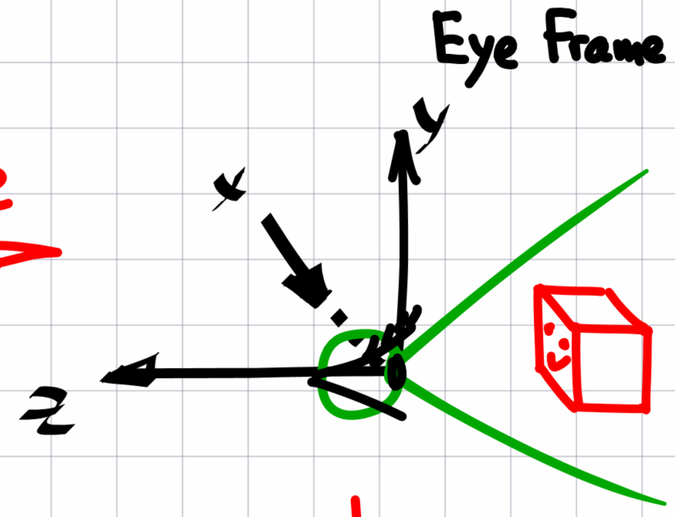
(Visual) Rendering



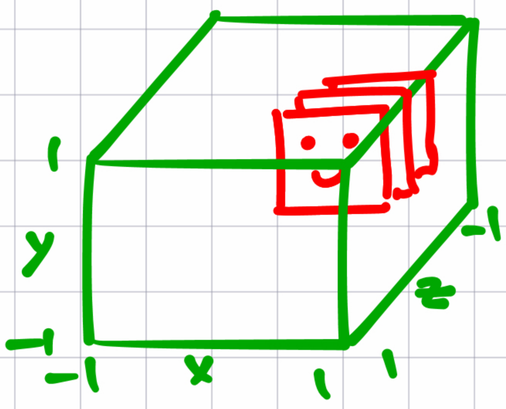
T_{rb}



T_{eye}

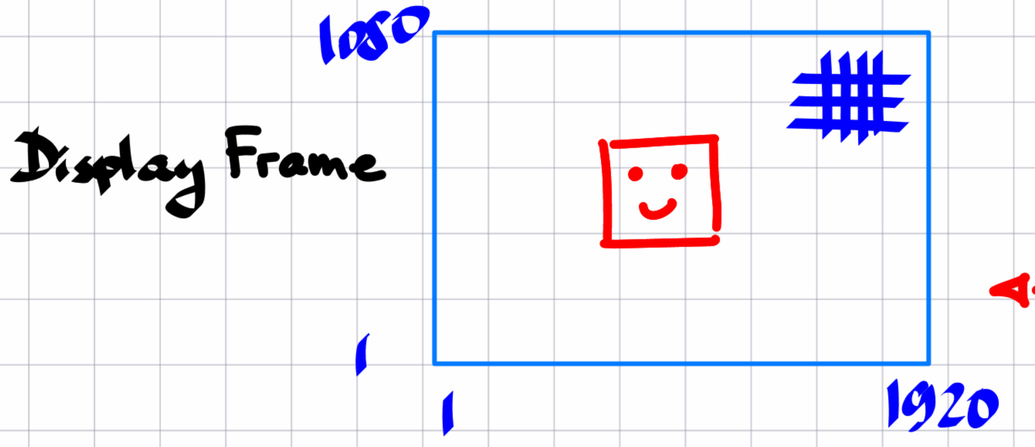


T_{can}



Canonical Frame

T_{vp}



$$T = T_{vp} \cdot T_{can} \cdot T_{eye} \cdot T_{rB}$$

(T_{vp}: T_{dist}; T_{can}: T_L or T_R)

Object-Order Rending

Image-order rendering stages:

1. Ray generation

2. Ray intersection

3. Shading: assign RGB values

Object-order rendering stages:

1. Rasterization

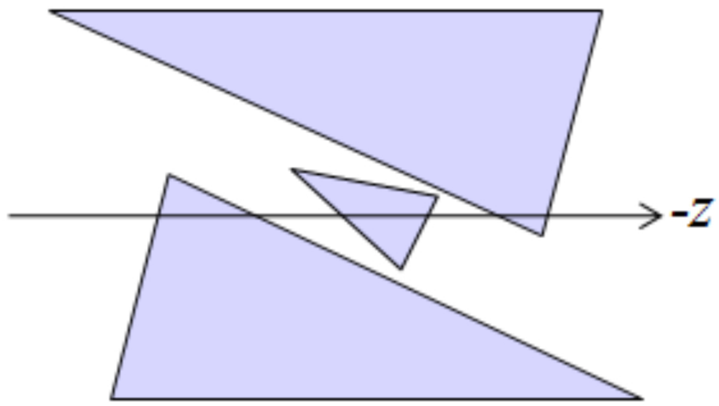
2. Depth order

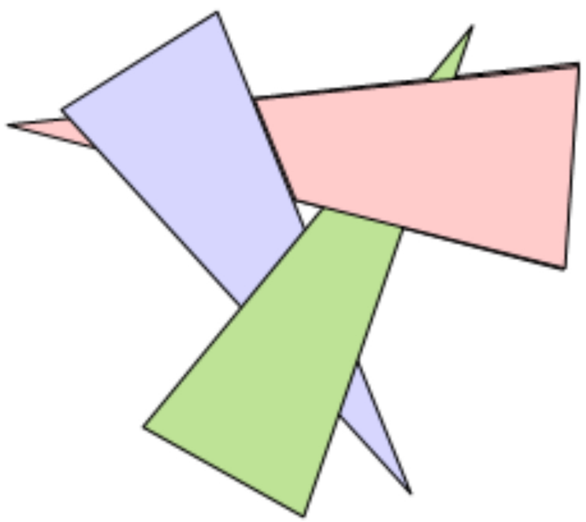
3. Shading: assign RGB values

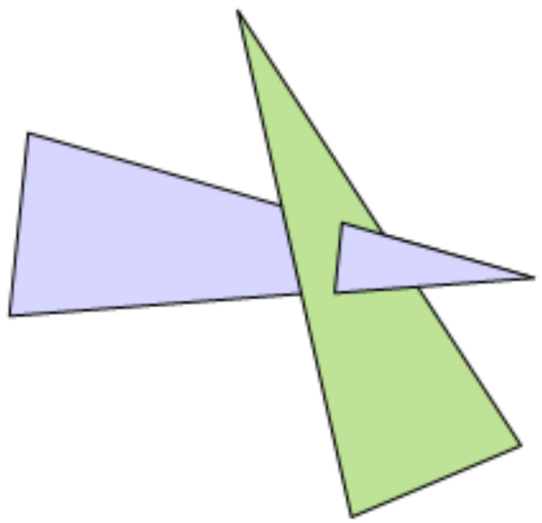
Rasterization:

Painter's Algorithm

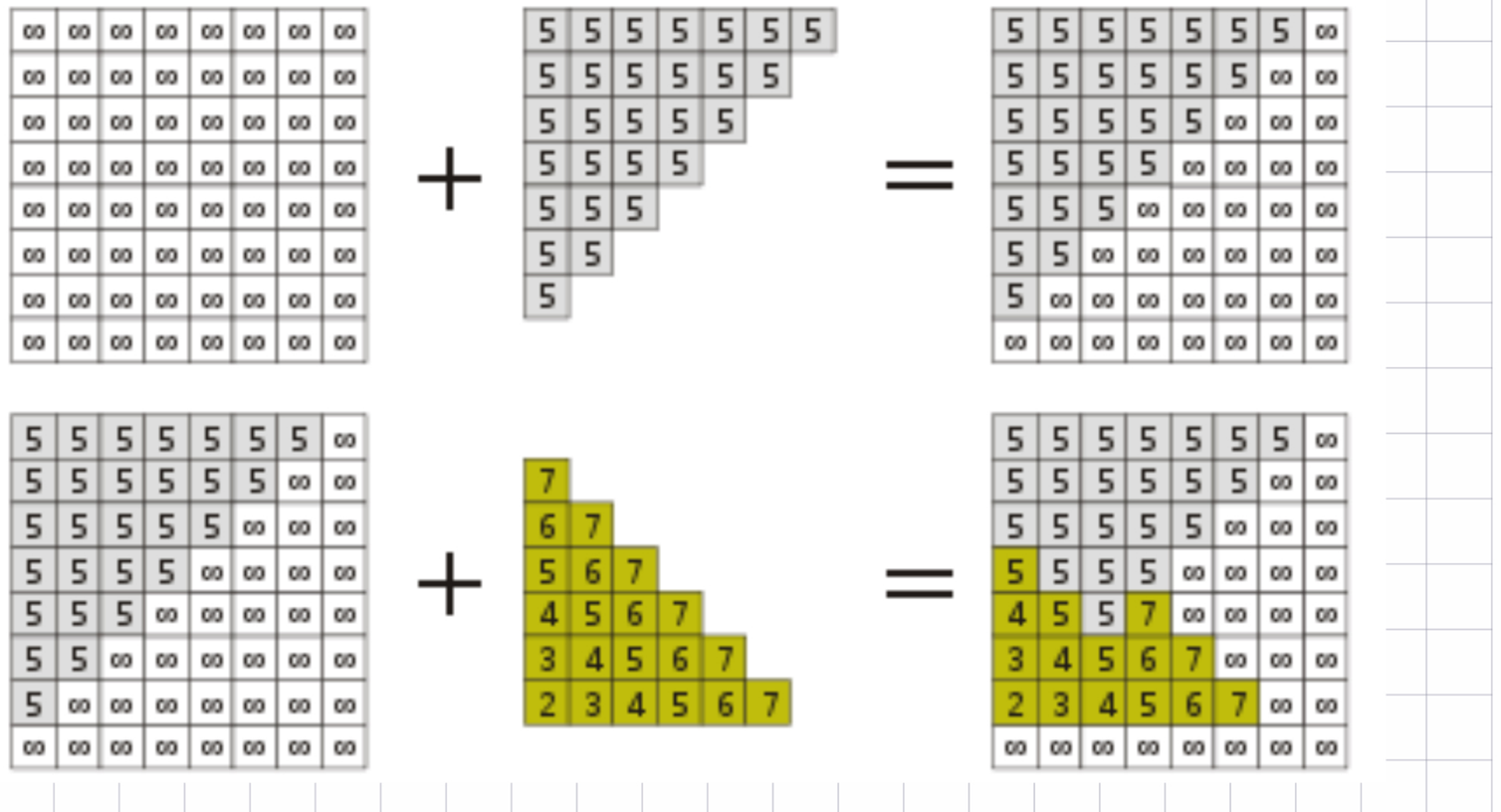
- Display polygons in back-to-front order
- Sort polygons by z-value
  - Which vertex?
  - $O(n \log n)$
- Problems…







Z-Buffer



Key Observation: Each pixel displays color of only one triangle, ignores everything behind it

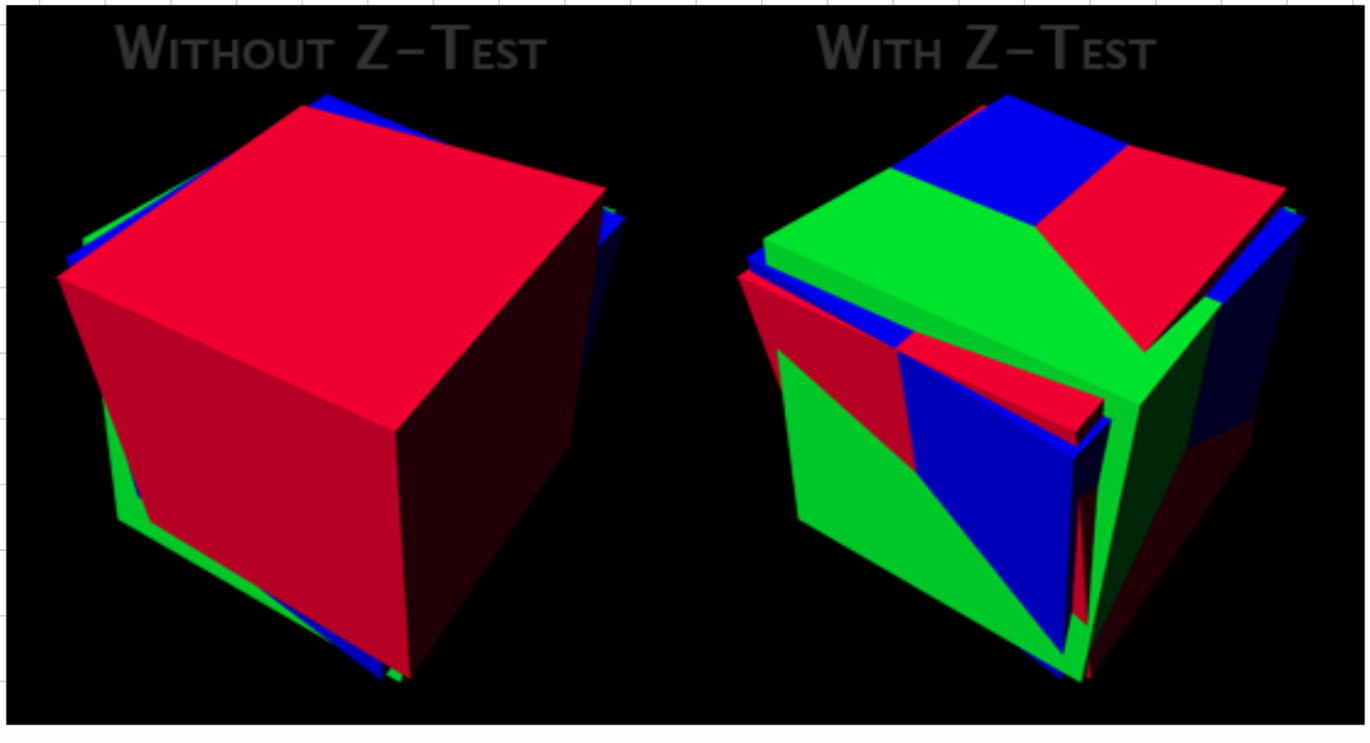
- Don't need to sort triangles, just find for each pixel the closest triangle
- Z-buffer: one fixed or floating point value per pixel
- Algorithm:

For each rasterized fragment (x,y)

If $z >$ zbuffer(x,y) then

framebuffer(x,y) = fragment color

zbuffer$(x,y) = z$



Clipping/Culling

Clipping:

- Remove triangles behind the eye

Culling:

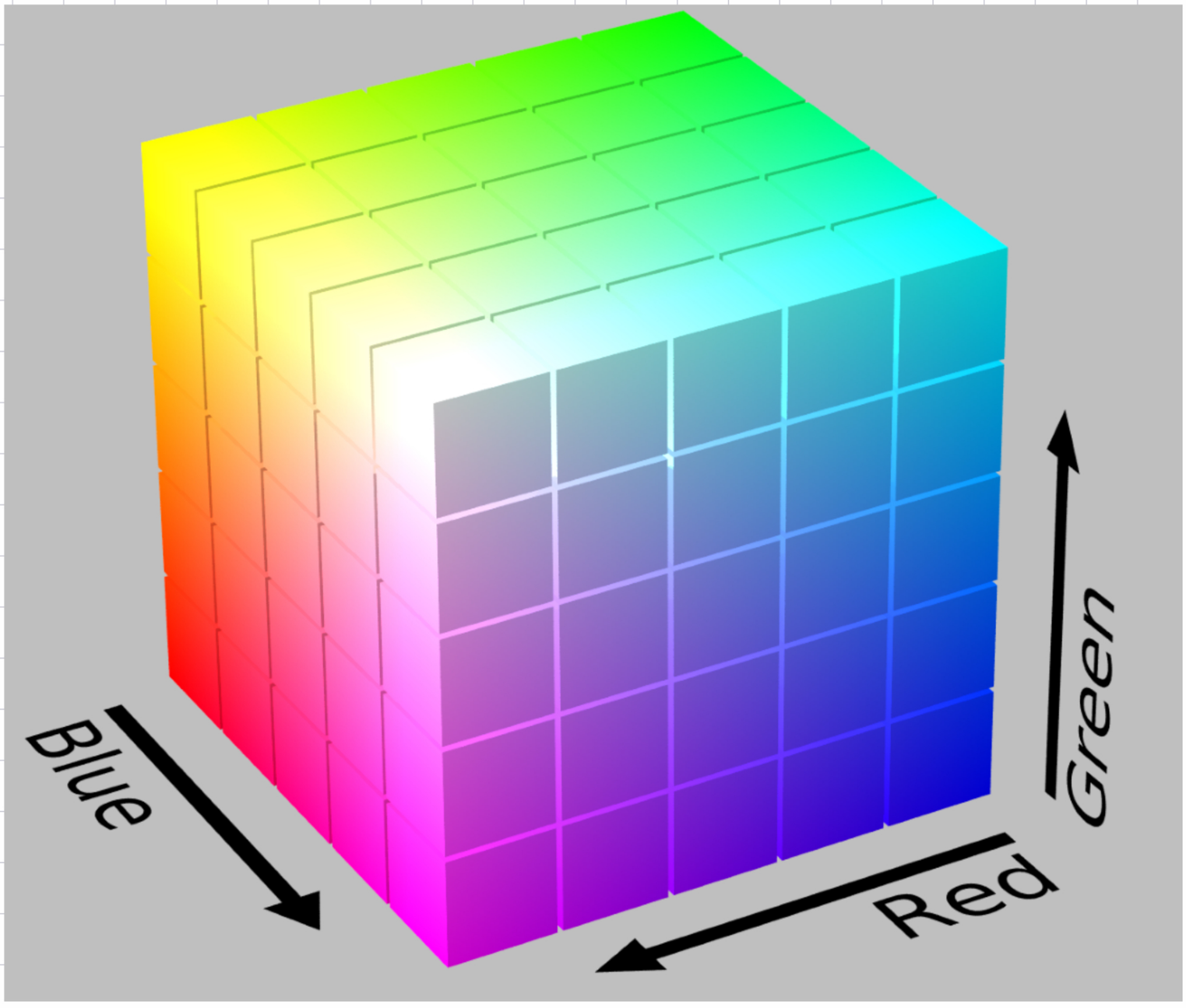
- View Frustum: Remove triangles outside of viewing frustum.

- Occlusion: Remove hidden triangles.

- Backface: Remove triangles on "back" of objects.

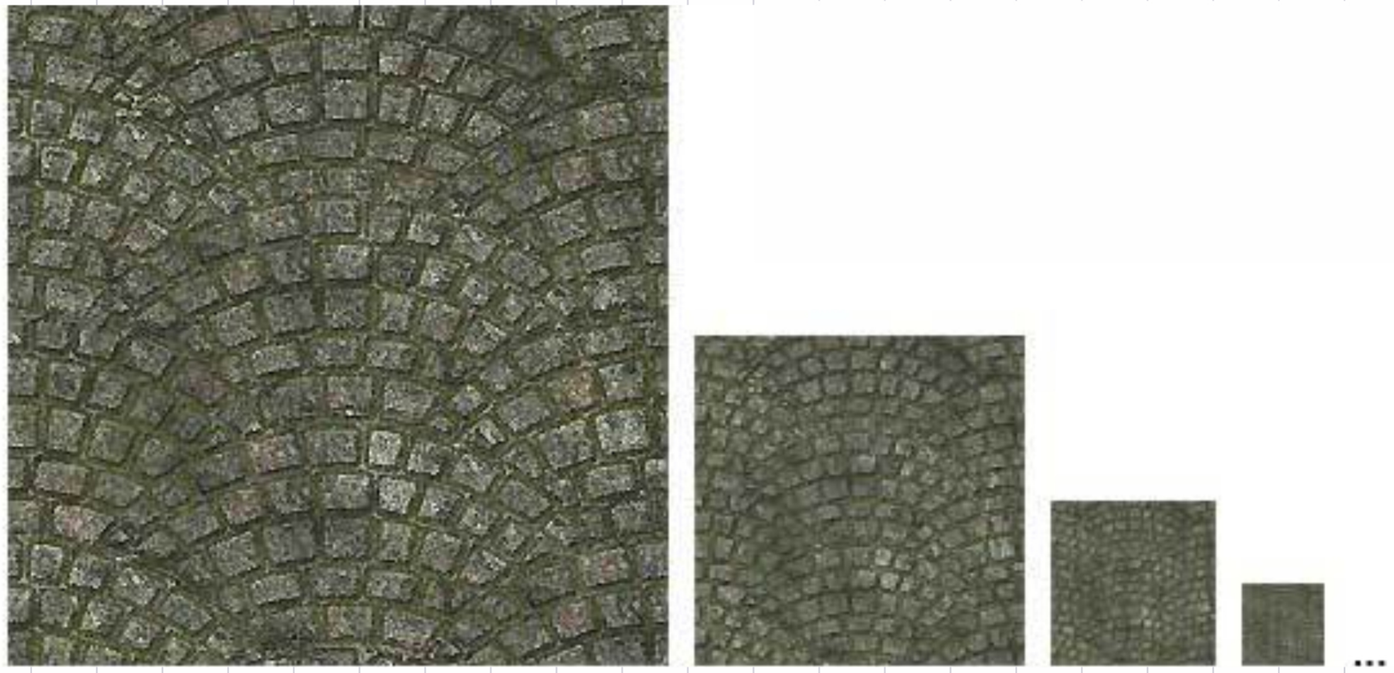
Interpolation and Barycentric Coordinates

RGB Mapping

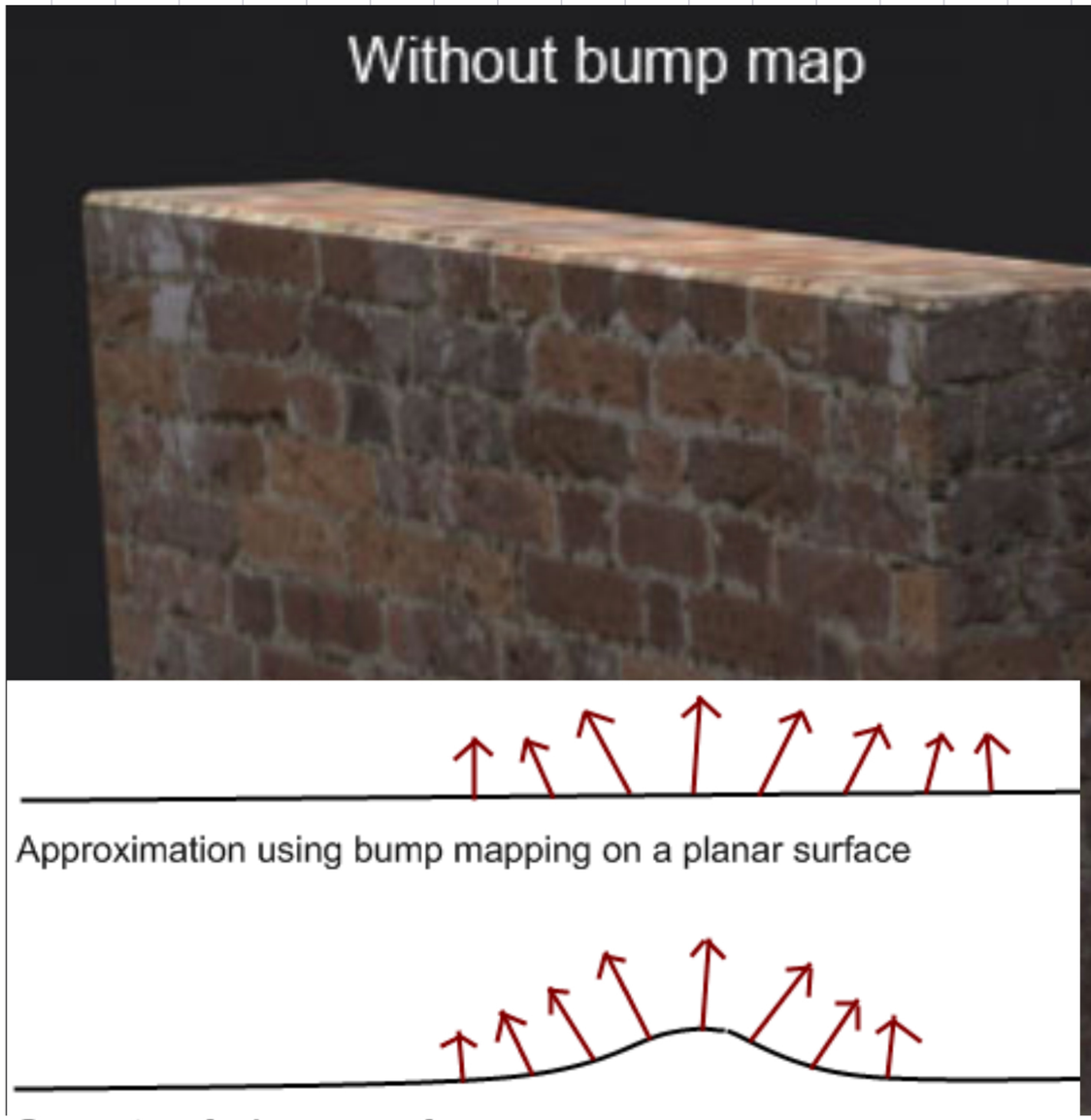


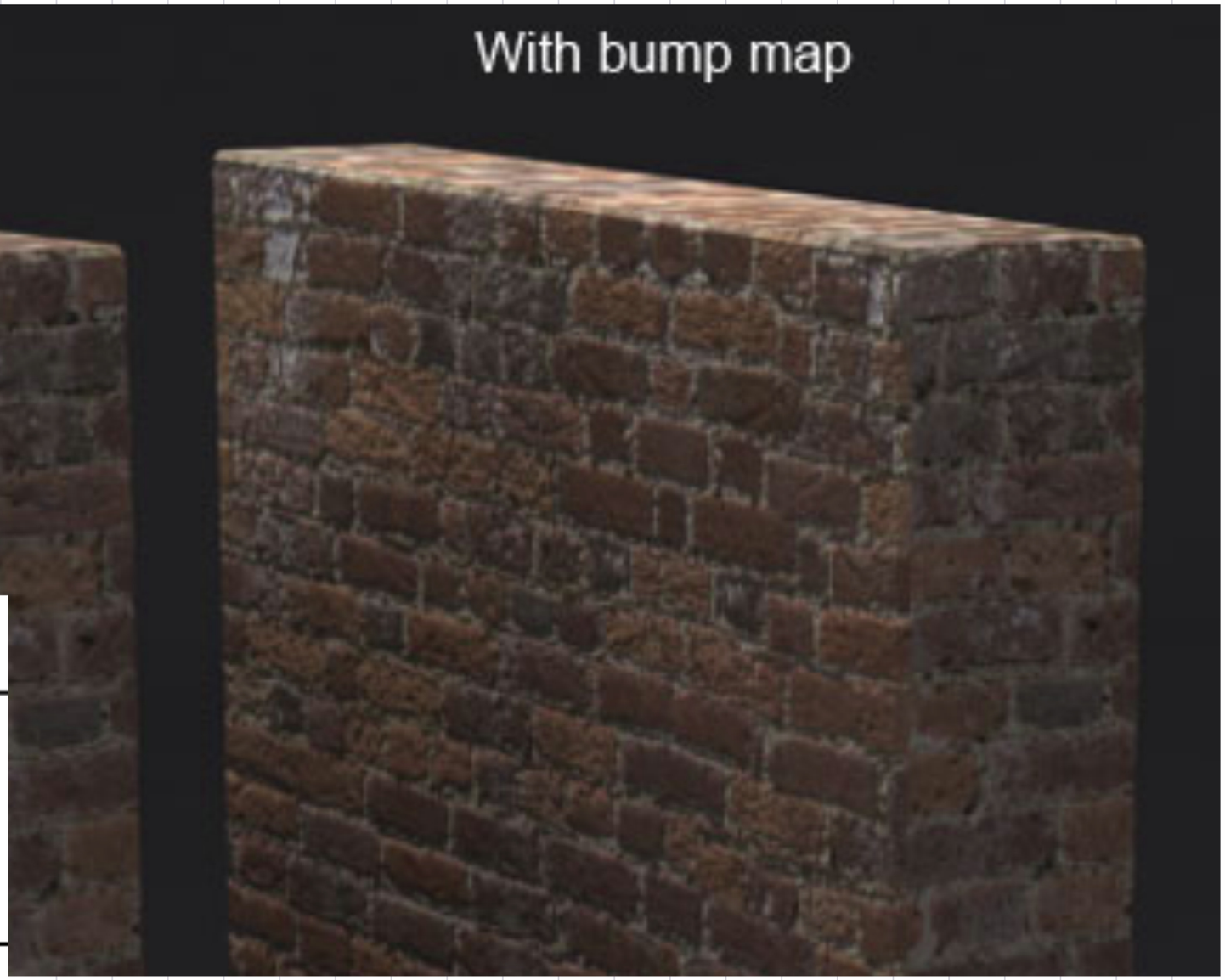
Texture Mappings

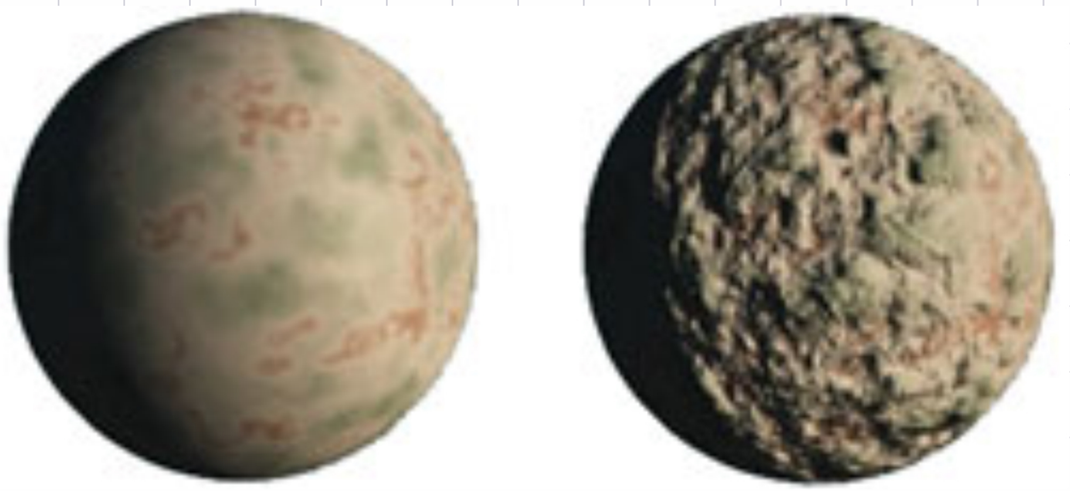
Mipmapping

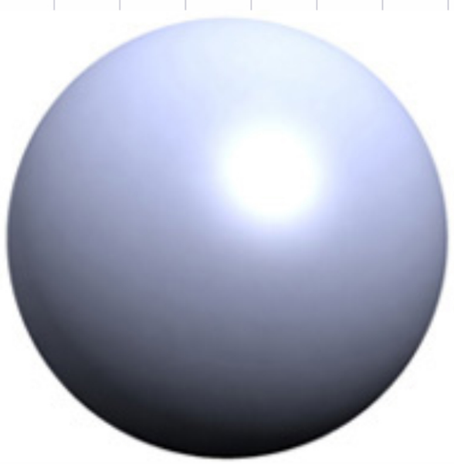


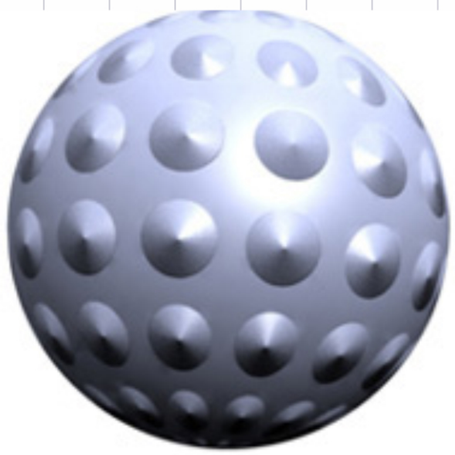
Bump Mapping











Normal Mapping

Example of a normal map (center) with the scene it was calculated from (left) and the result when applied to a flat surface (right).

Problems with Rendering for VR

Shading:

- Highlights need stereo perspective

- Texture maps look like painted cardboard

- Bump/normal maps look fake

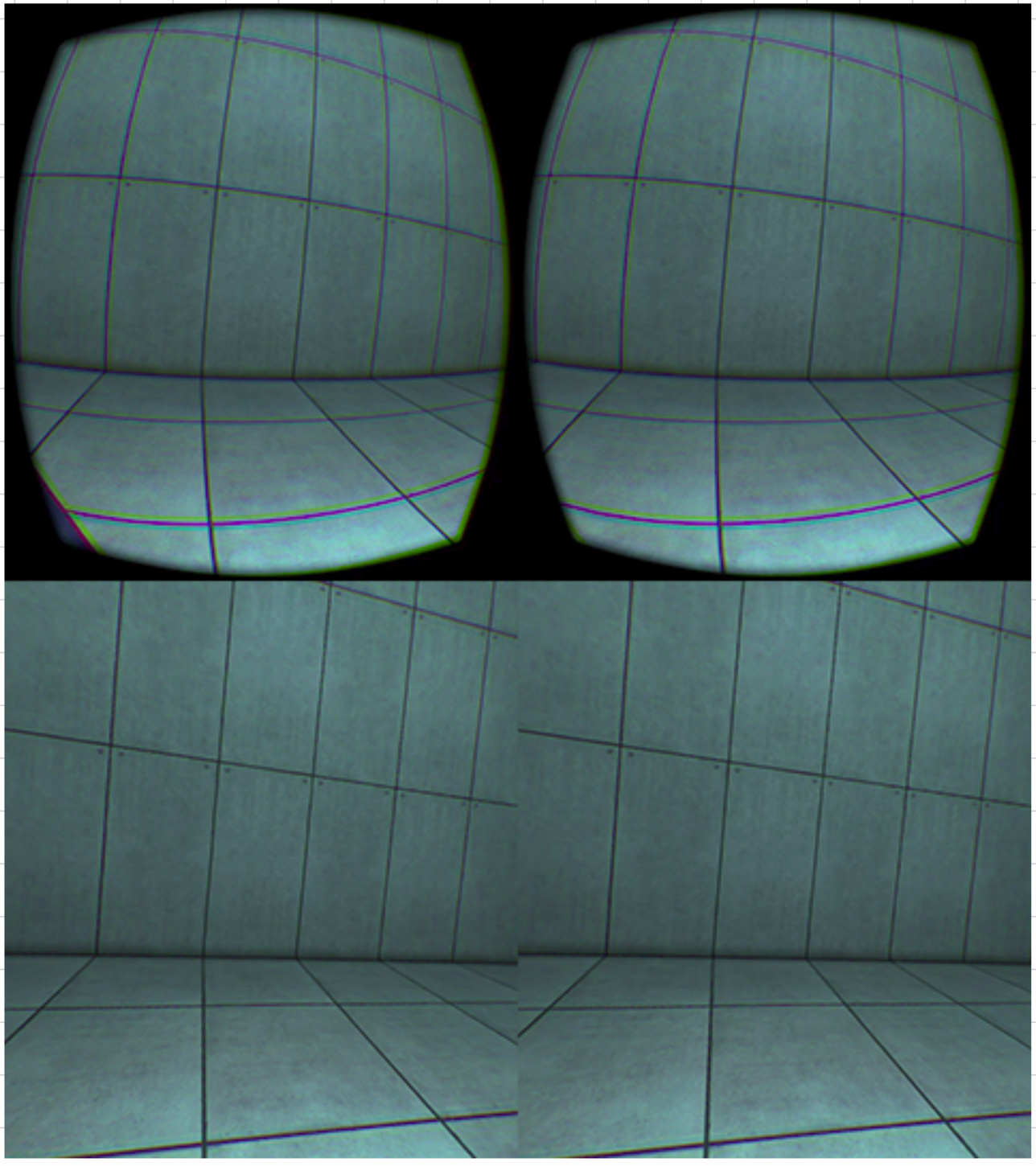
Problems with Rendering for VR

Aliasing:

- Need higher resolution than we ever needed before.
- Staircases become escalators.
- Stereo causes mismatched "escalators" for every edge.

Problems with Rendering for VR

Render target: Use stencil buffer in GPU



Problems with Rendering for VR

Correct for optical distortion.

Latency:

- GPU pipeline has been optimized for triangle throughput.
- Latency compensation
  - Post rendering image warp
  - Predictive tracking

Geometry errors:

- Thin objects look fake or implausible.
- Holes or isolated points become more noticable.

Some Solutions for Rendering for VR

Antialiasing

- Good but expensive.
- Use MSAA (multi sampling antialiasing) - shading calculations are not done for all of the samples.