Texture Mapping

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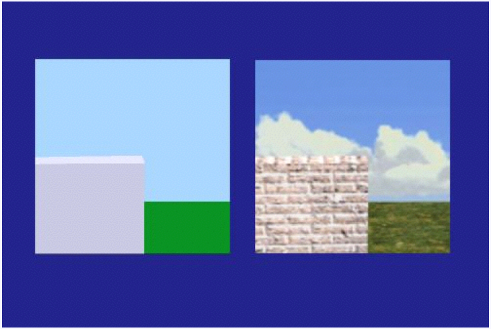
Limits of geometric modeling

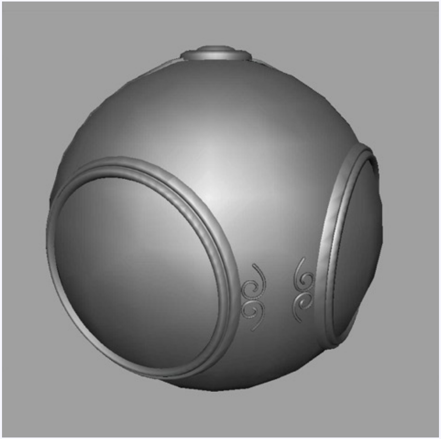
Although modern GPUs can render millions of triangles/sec, that's not enough sometimes. . .

Texture mapping for detail

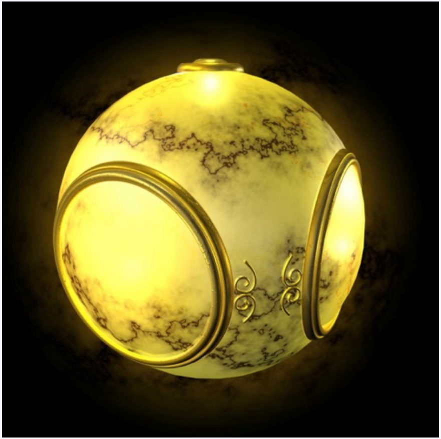


This image contains 8 polygons!

Texture mapping comparison



no texture

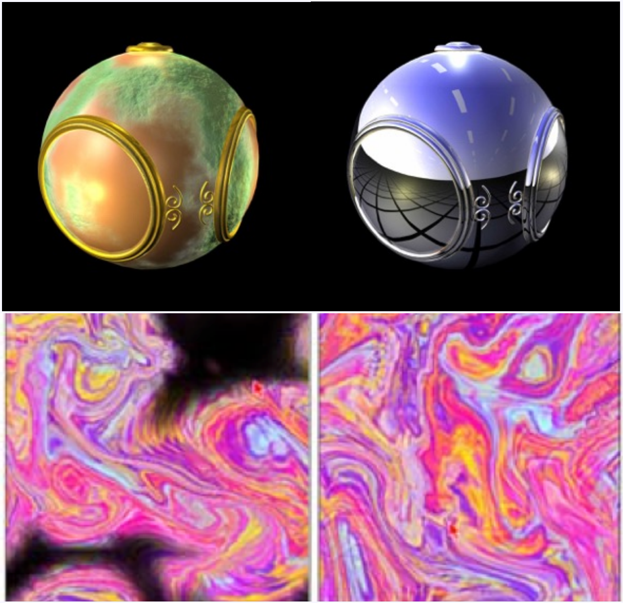


with texture

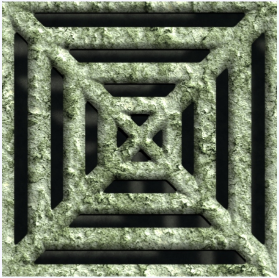
Pixar - Toy Story

Other uses of textures. . .

- Light maps
- Shadow maps
- Environment maps
- Bump maps
- Opacity maps
- Animation



Lookup reflectance in image



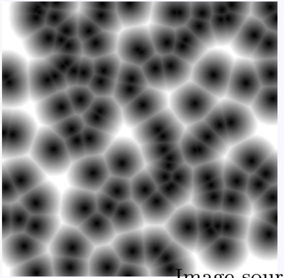
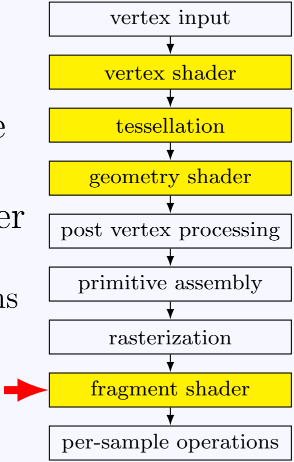


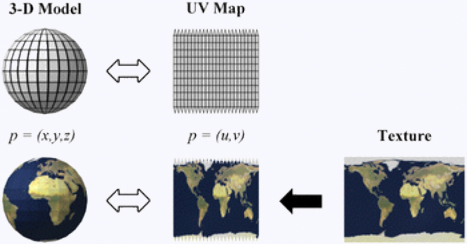
Image source: [1, 2]

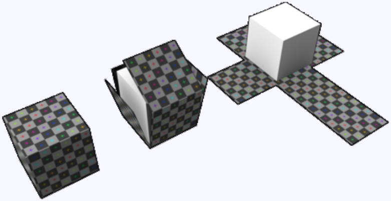
Texture mapping in the pipeline

- Geometry and pixels have separate paths through pipeline
- Textures applied in fragment shader
  - End of pipeline
  - Efficient since relatively few polygons get past clipper

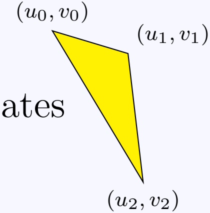


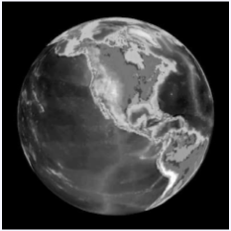
uv Mapping

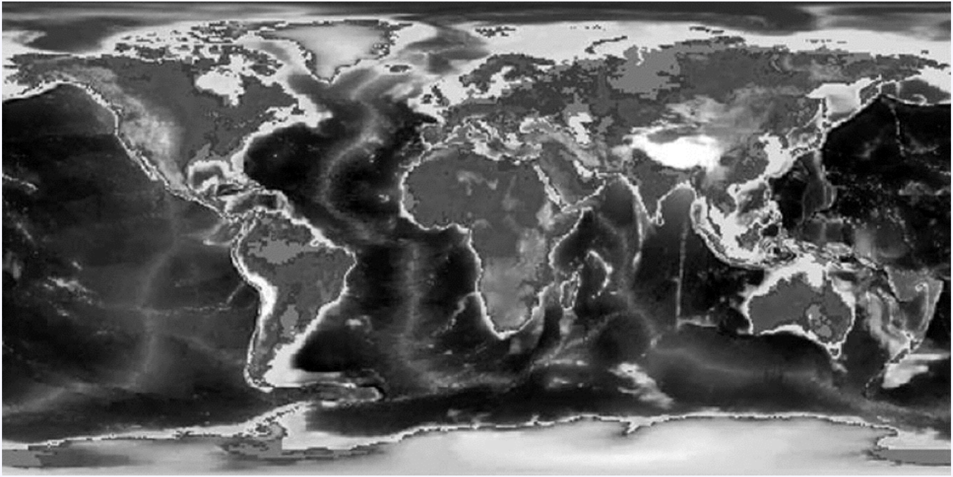




- 2D texture is parameterized by (u, v)
- Assign polygon vertices texture coordinates
- Interpolate within polygon

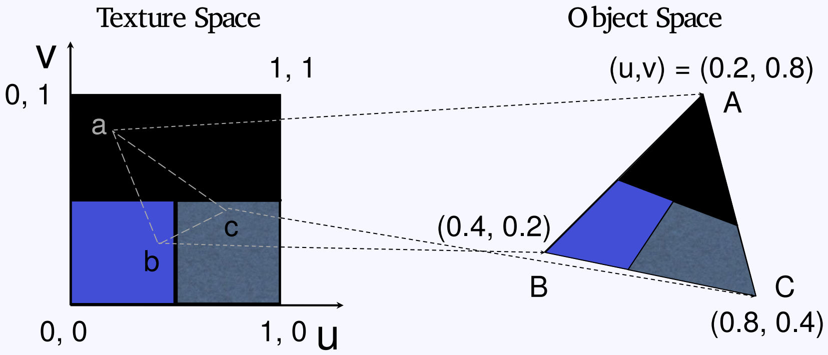






Texturing triangles

- Store (u, v) at each vertex
- Interpolate inside triangles using barycentric coordinates

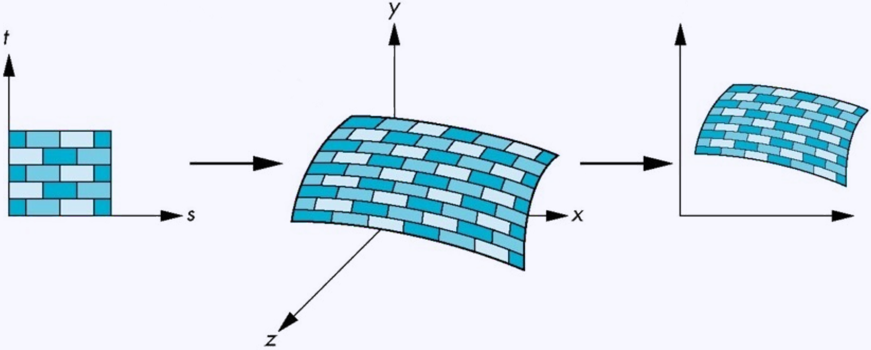


Texturing triangles

- Store (u, v) at each vertex
- Interpolate inside triangles using barycentric coordinates

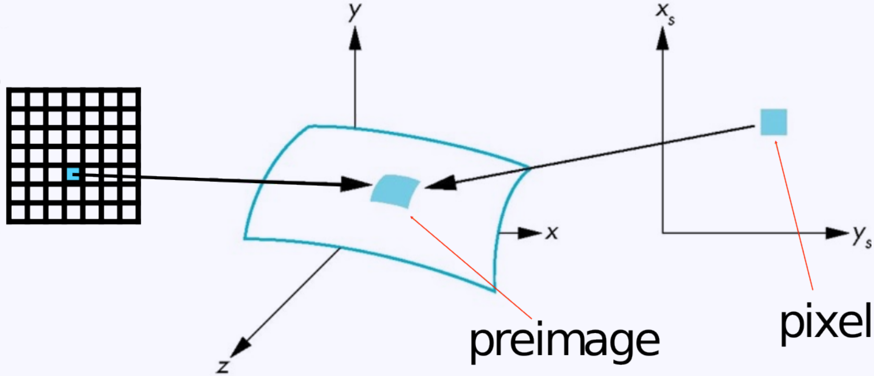
$$\begin{aligned}
\mathbf{p}(\beta, \gamma) &= \mathbf{p}_a + \beta(\mathbf{p}_b - \mathbf{p}_a) + \gamma(\mathbf{p}_c - \mathbf{p}_a) \\
u(\beta, \gamma) &= u_a + \beta(u_b - u_a) + \gamma(u_c - u_a) \\
v(\beta, \gamma) &= v_a + \beta(v_b - v_a) + \gamma(v_c - v_a)
\end{aligned}$$

Texture mapping



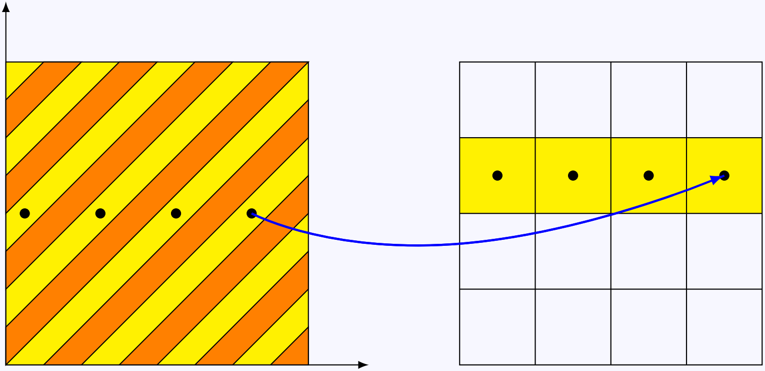
Point sampling

Map back to texture image and use the **nearest texel**

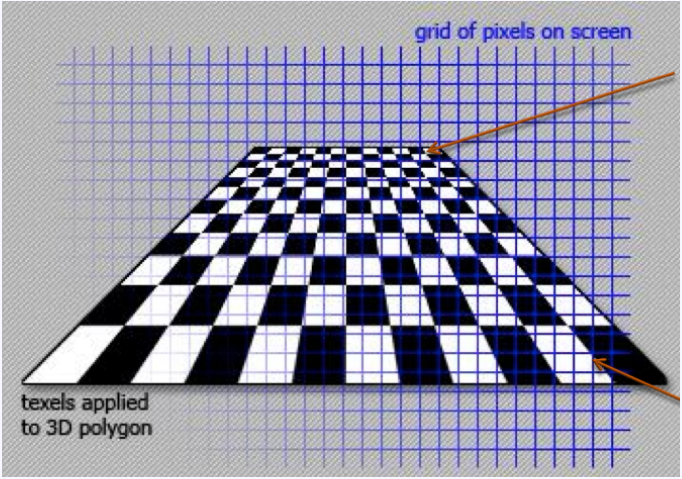


Aliasing

Point sampling textures can lead to aliasing artifacts



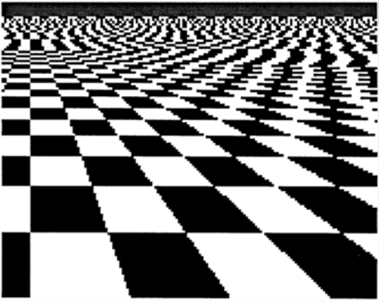
Magnification and minification

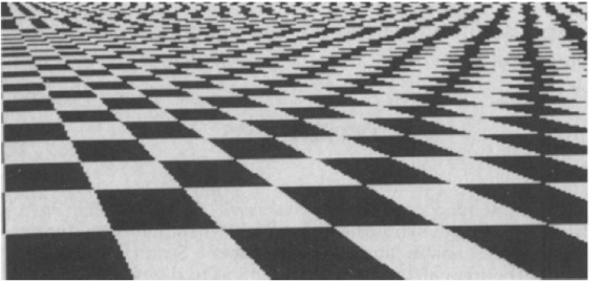


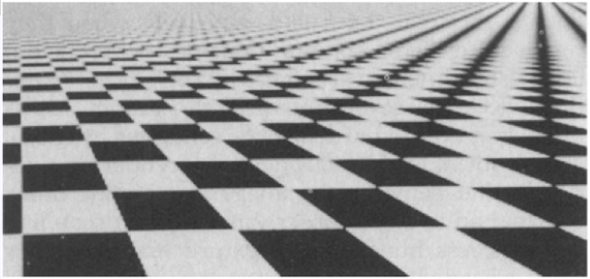
Minification

Magnification

Aliasing artifacts



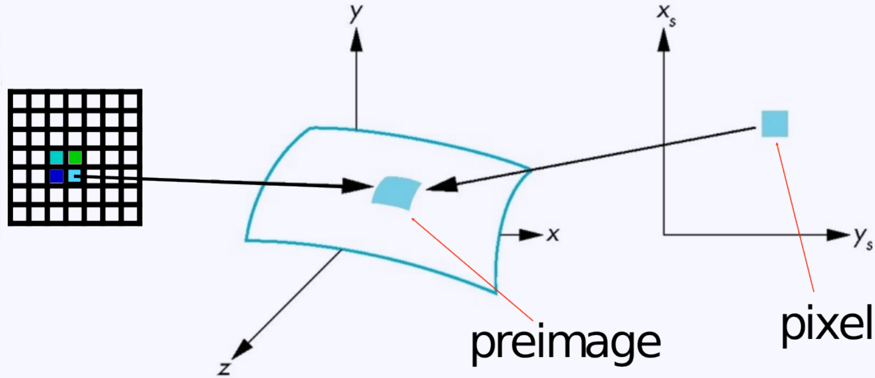




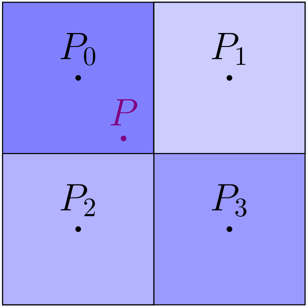
We apply **filtering** to reduce aliasing artifacts

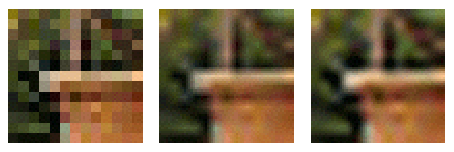
Area averaging

A better but slower option is to use **area averaging**



Use bilinear filtering





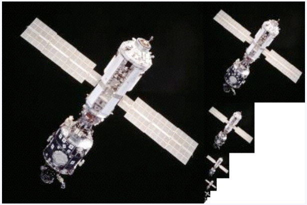
nearest neighbor

bilinear

bicubic

mitigate magnification artifacts

Mipmapping

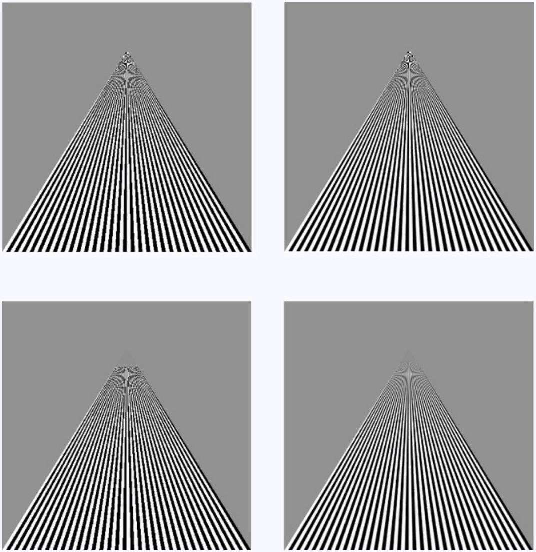


Reduce minification artifacts

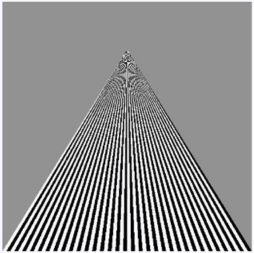
Prefilter the texture to obtain reduced resolutions

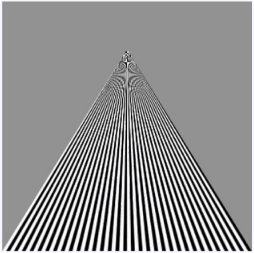
Requires $\frac{1}{3}$ more space

Get a texture hierarchy indexed by level



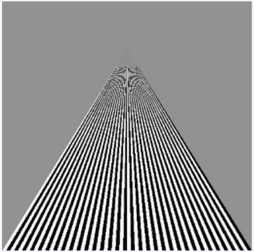
point sampling

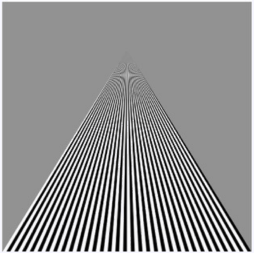




linear filtering

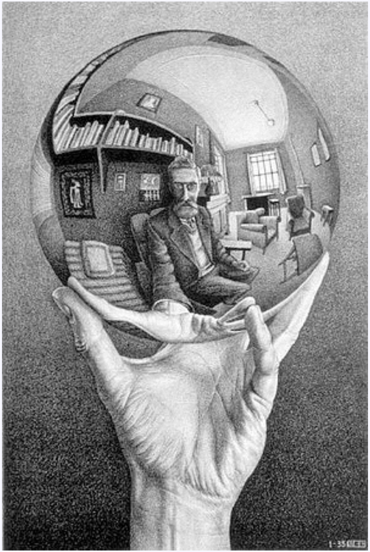
mipmapped point sampling





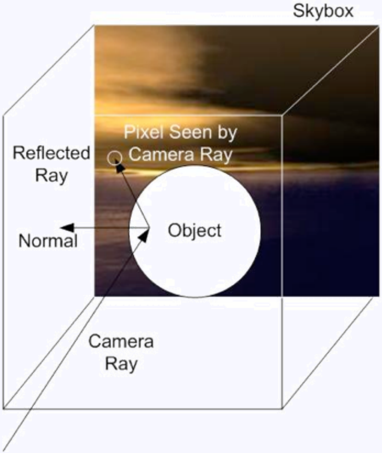
mipmapped linear filtering

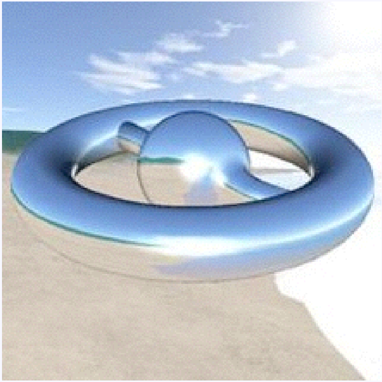
Environment mapping



Environment mapping

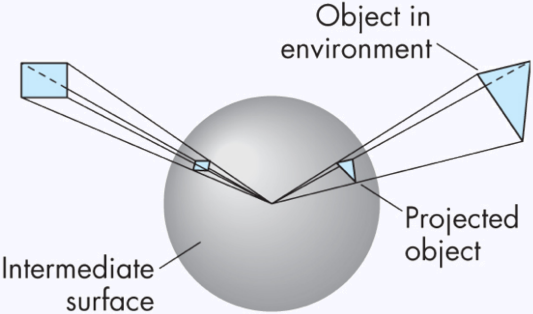
Use a texture for the distant environment
simulate the effect of ray tracing more cheaply





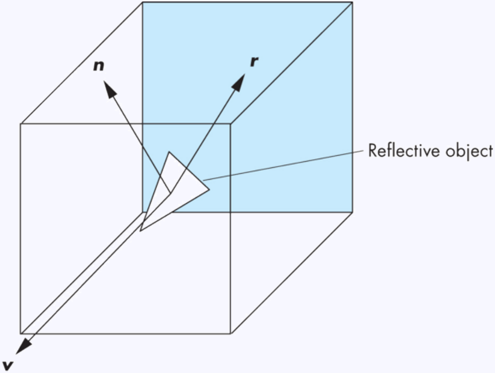
Sphere mapping

- Project objects in the environment onto sphere centered at eye
- Unwrap and store as texture
- Use reflection direction to look up texture value

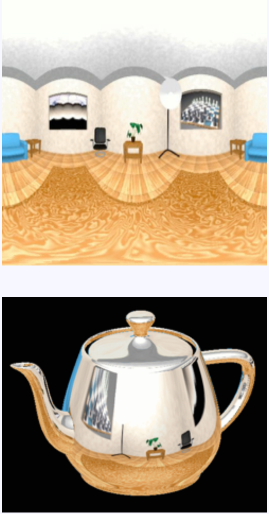


Cube mapping

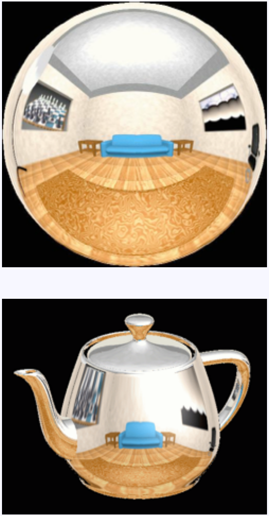
- Compute six projections, one for each wall
- Store as texture
- Use reflection direction to lookup texture value



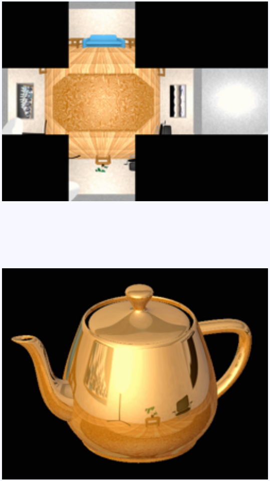
Different environment maps



Blinn/Newell latitude mapping



spherical mapping



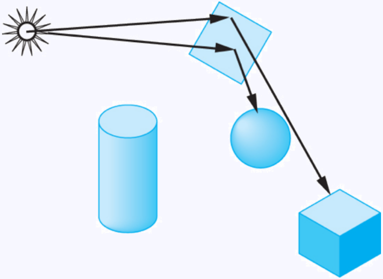
cube mapping

Environment mapping

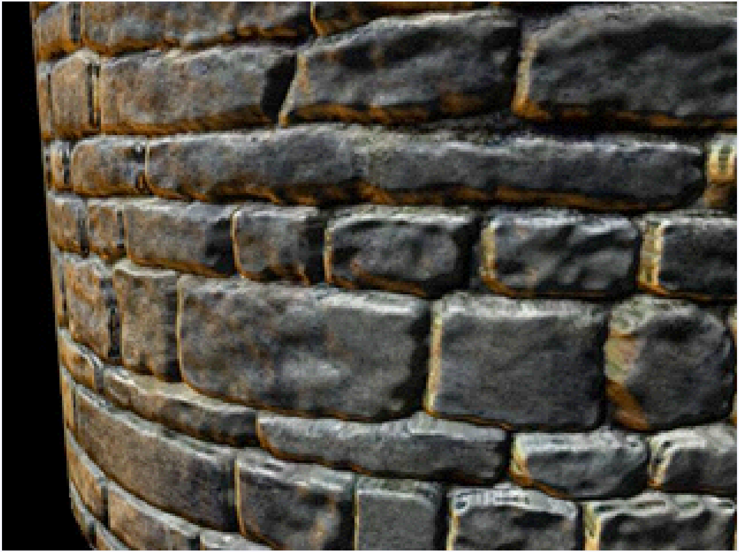
Create the effect of a mirror with two-pass rendering

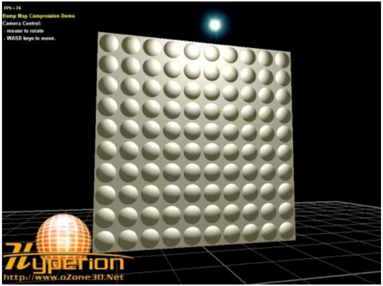
First pass: render the scene from the perspective of the mirror

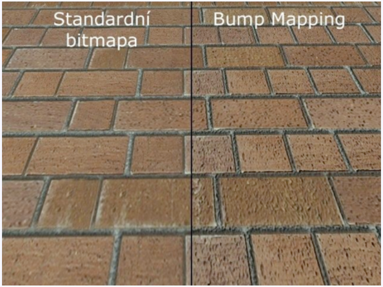
Second pass: render from original pov; use the first image as a texture for the mirror

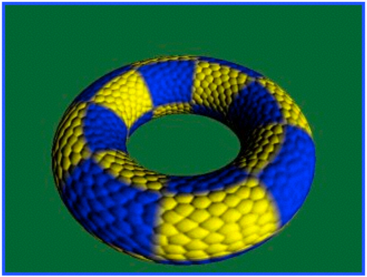


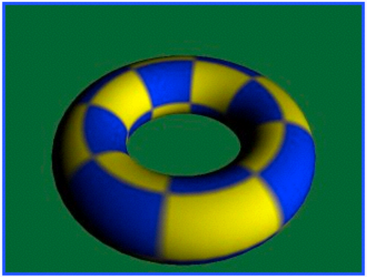
Bump mapping

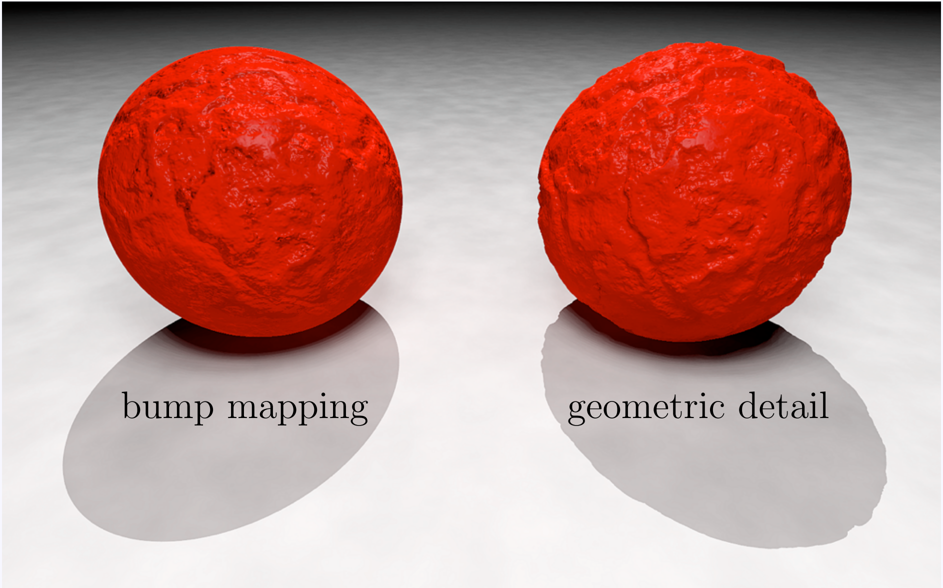



FPS = 74
Bump Map Compression Demo
Camera Control:
- mouse to rotate
- WASD keys to move.
Hyperion
http://www.oZone3D.Net

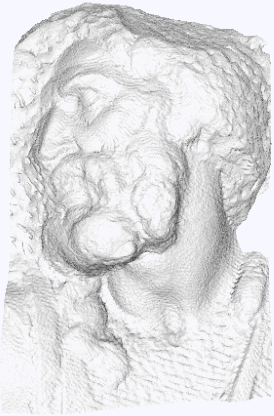

Standardní bitmapa
Bump Mapping



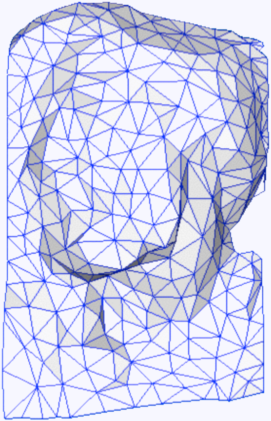



bump mapping
geometric detail

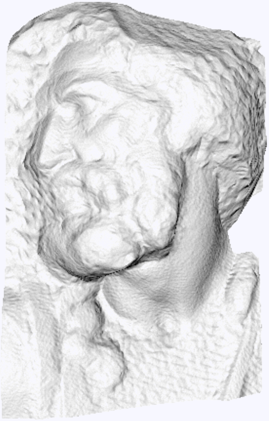
Normal mapping



original mesh
4M triangles



simplified mesh
500 triangles



simplified mesh
and normal mapping
500 triangles

Attribution

[1] vort. Cellulartexture.png. https://commons.wikimedia.org/wiki/File:CellularTexture.png. CC BY-SA 3.0.

[2] Wiksaidit. Procedural_texture.jpg. https://commons.wikimedia.org/wiki/File:Procedural_Texture.jpg. CC BY-SA 3.0.