CS4620/5620: Lecture 22

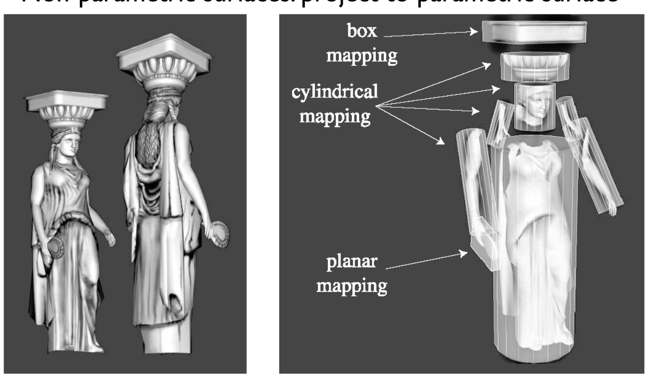
Texture Mapping

Announcements

- PPA 1
- Prelim

Projector Function: Arbitrary Surfaces

- Non-parametric surfaces: project to parametric surface

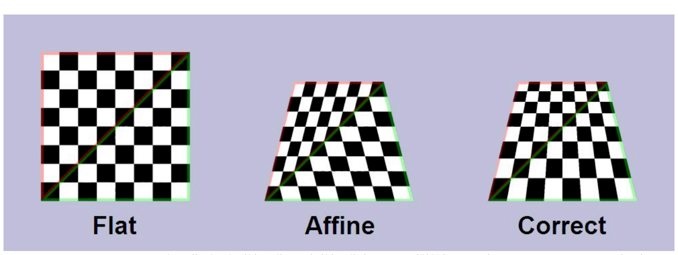


Images courtesy Tito Pagan

Texture coordinates on meshes

- Texture coordinates become per-vertex data like vertex positions
  - can think of them as a second position: each vertex has a position in 3D space and in 2D texure space
- How to come up with vertex (*u*,*v*)s?
  - use any or all of the methods just discussed
    - in practice this is how you implement those for curved surfaces approximated with triangles
  - use some kind of optimization
    - try to choose vertex (*u*,*v*)s to result in a smooth, low distortion map

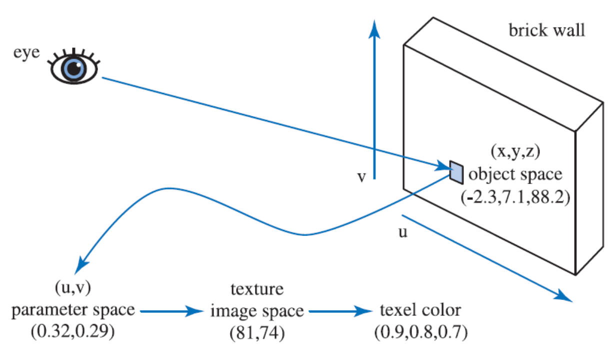
Perspective-Correct Texturing



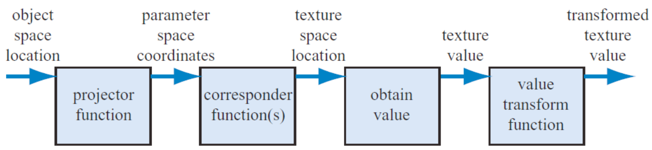
http://upload.wikimedia.org/wikipedia/commons/5/57/Perspective_correct_texture_mapping.jpg

- See section 11.3.1 "Perspective Correct Textures"
- Linearly interpolate (u,v)/depth not just (u,v)

How does it work?



Texture Pipeline

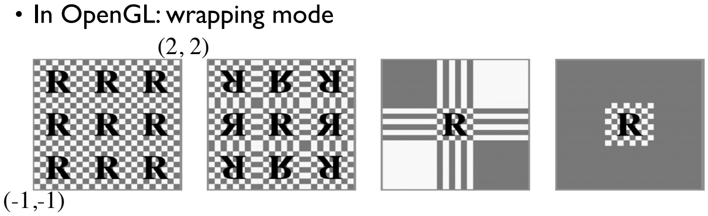


Corresponder Function

- Why?
  - Flexibility
- Examples:
  - Select a subset of the image for texturing
  - Decide what happens at boundaries

Corresponder Function

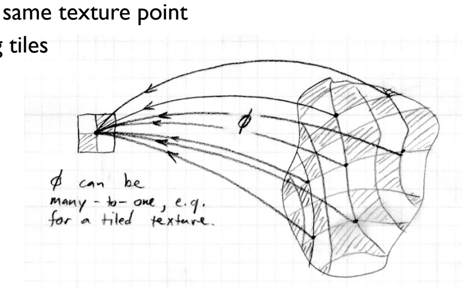
- In OpenGL: wrapping mode



- Wrap: Repeats
- Mirror
  - Repeats but mirrored every other time; continuity across edges
- Clamp: Clamped to edge of texture
- Border: Clamped to border color

Corresponder function example

- Mapping from *S* to *D* can be many-to-one
  - that is, every surface point gets only one color assigned
  - but it is OK (and in fact useful) for multiple surface points to be mapped to the same texture point
    - e.g. repeating tiles



Other uses of texture mapping

- Reflection maps
- Environment maps
- Normal maps
- Bump maps
- Displacement maps
- Shadow maps
- Irradiance maps
- ...

Reflection mapping

- Early (earliest?) non-decal use of textures
- Appearance of shiny objects
  - Phong highlights produce blurry highlights for glossy surfaces.
  - A polished (shiny) object reflects a sharp image of its environment.
- The whole key to a shiny-looking material is providing something for it to reflect.

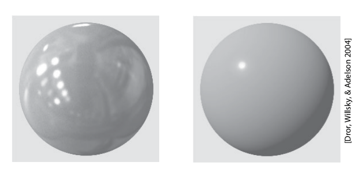
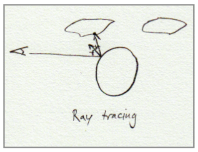


Figure 2. (a). A shiny sphere rendered under photographically acquired real-world illumination. (b). The same sphere rendered under illumination by a point light source.

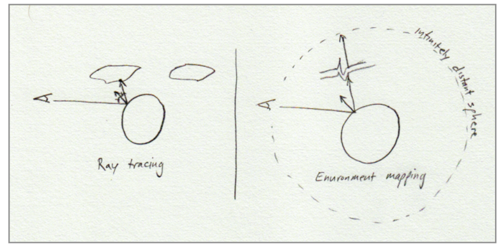
Reflection mapping

- From ray tracing we know what we'd like to compute
  - trace a recursive ray into the scene—too expensive



Reflection mapping

- From ray tracing we know what we'd like to compute
  - trace a recursive ray into the scene—too expensive
- If scene is infinitely far away, depends only on direction
  - a two-dimensional function



Environment Map

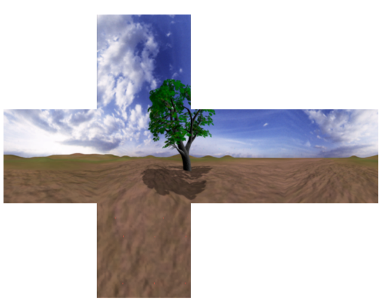
- Assumptions:
  - Environment Map represents objects at infinity
- Index into EM using reflection vector

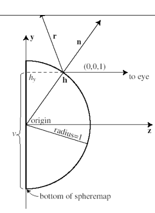
Environment map

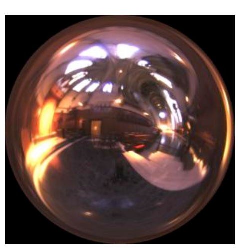
- A function from the sphere to colors, stored as a texture.

[Blinn & Newell 1976]

Types of Mappings





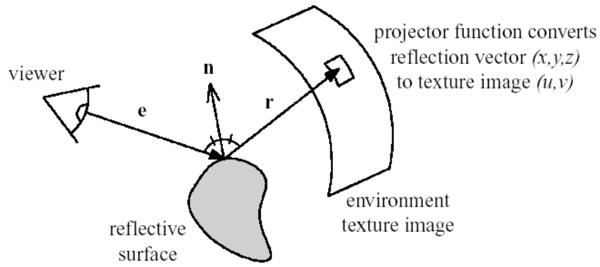


Cube mapping

Sphere mapping

Sphere Mapping Example

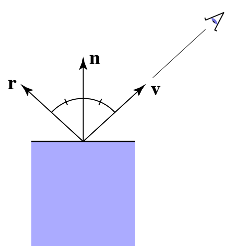
Environment Mapping



Env Map Algorithm

- Generate 2D environment map
  - Spherical, cubical, paraboloid
- For each pixel on a reflective object
  - Find N on surface of object
  - Compute R from V and N
  - Index into EM using R
  - Modulate pixel color

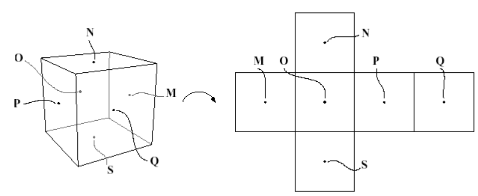
Review: Mirror reflection



$$\mathbf{r} = \mathbf{v} + 2((\mathbf{n}\cdot\mathbf{v})\mathbf{n} - \mathbf{v}) \\ = 2(\mathbf{n}\cdot\mathbf{v})\mathbf{n} - \mathbf{v}$$

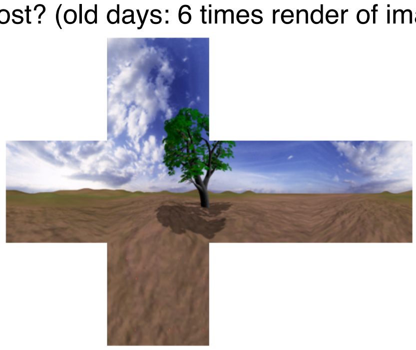
Cube Mapping

- The norm on modern hardware
- Place camera in center of the environment
- Project environment onto cube sides



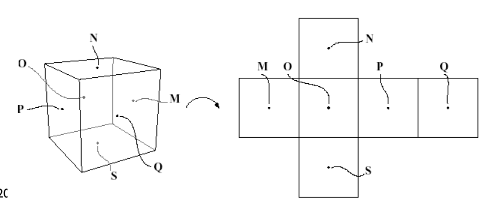
Cube Mapping

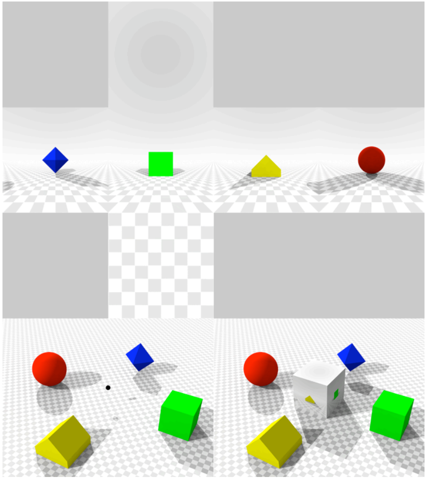
- Project environment onto cube sides
  - 90 degree field of view
  - Cost? (old days: 6 times render of image)



Picking the cube map

- Compute R
  - Don't need to normalize it
- Pick the largest component (magnitude)
  - What does it mean?
- Scale other two components to [0,1]





The lower left image shows a scene with a viewpoint marked with a black dot. The upper image shows the net of the cube mapping as seen from that viewpoint, and the lower right image shows the cube superimposed on the original scene.

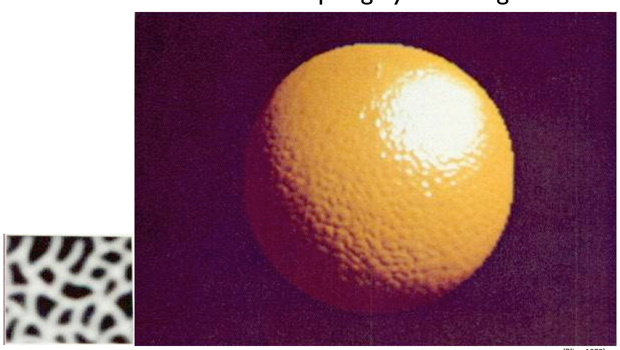
http://en.wikipedia.org/wiki/Cube_mapping

Issues

- EM good for reflections in curved surfaces
  - What about flat surfaces?
- What happens when triangle spans EM multiple faces
  - Per-pixel based

Bump mapping

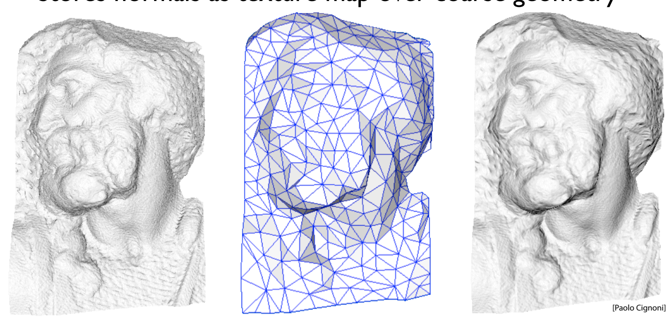
- Perturbs normal based on input grayscale height field



[Blinn 1978]

Normal mapping

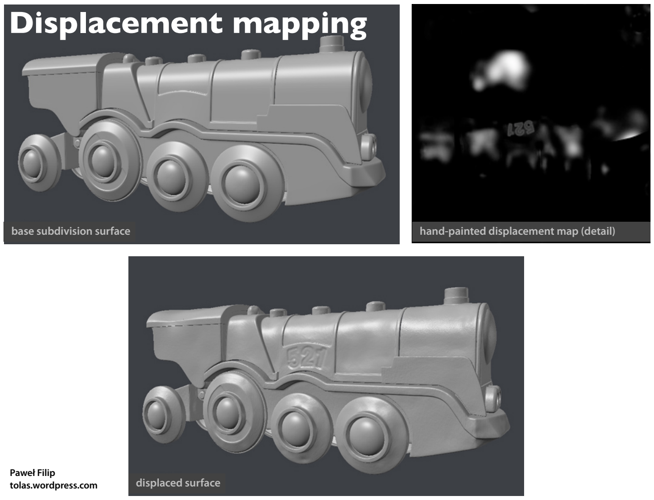
- Stores normals as texture map over coarse geometry



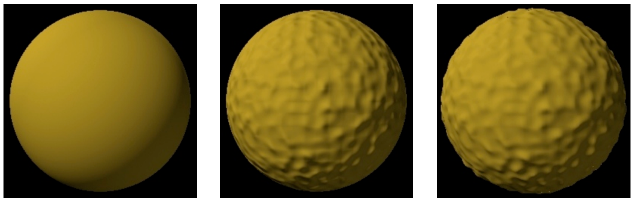
[Paolo Cignoni]

original mesh 4M triangles | simplified mesh 500 triangles | simplified mesh and normal mapping 500 triangles

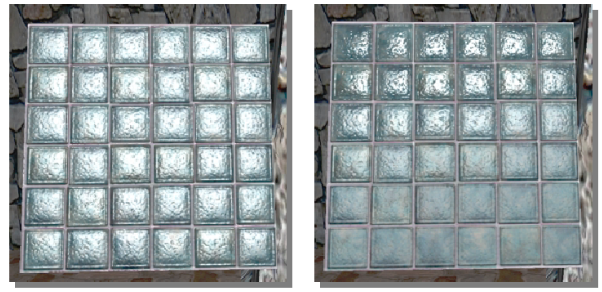
Displacement mapping



Paweł Filip
tolas.wordpress.com



Gloss Maps/Normal Maps



ATI Technologies, Inc.

n.l d + (n.h)^m g