While you wait
read the Final Project description on the webpage

Today

- Quiz review
- Semester overview
- Final Project discussion
- Texture mapping
Class topics

- Before the midterm
  - Texture mapping
  - Image processing and convolution
  - Graphics pipeline
  - Ray tracing

Final Project

- Ray tracer
- Shader
- Particle system
- Game
- NPR
- Image processing
- 3DUI Contest
- Anything else
Texture mapping

- Objects have properties that vary across the surface

Texture Mapping

- So we make the shading parameters vary across the surface
Texture mapping

- Adds visual complexity; makes appealing images

Texture mapping

- Color is not the same everywhere on a surface
  - one solution: multiple primitives
- Want a function that assigns a color to each point
  - the surface is a 2D domain - that’s an image
  - can represent using any image representation
A definition

Texture mapping: a technique of defining surface properties (especially shading parameters) in such a way that they vary as a function of position on the surface.

- This is very simple!
- but it produces complex-looking effects

Examples

- Wood floor with smooth finish
- diffuse color $k_D$ varies with position
- specular properties $k_s$, $n$ are constant
**Examples**

- Glazed pot with finger prints
  - diffuse and specular colors $k_d, k_s$ are constant
  - specular exponent $n$ varies with position

**Mapping textures to surfaces**

- Usually texture is an image (function of $u, v$)
- the BIG question: where on surface does the image go?
- obvious only for a flat rectangle the same shape as the image
Mapping textures to surfaces

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Note that 3D textures also exist

- texture is a function of $(u, v, w)$
- can just evaluate texture at 3D surface point
- good for solid materials
**Texture coordinate functions**

- "Putting the image on the surface"
  - need a function $f$ that tells where each point on the image goes
  - this looks a lot like a parametric surface function

**Texture coordinate functions**

- Non-parametrically defined surfaces
  - need to have the inverse of the function $f$
- Texture coordinate fn.
  \[
  \phi : S \rightarrow \mathbb{R}^2
  \]
  - for a vtx. at $p$ get texture at $\phi(p)$
Texture coordinate functions

- 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

$\phi$ can be many-to-one, e.g. for a tiled texture.

Texture coordinate functions

- Define texture image as a function
  $$T : D \rightarrow C$$
  - where $C$ is the set of colors for the diffuse component
- Diffuse color (for example) at point $p$ is then
  $$k_D(p) = T(\phi(p))$$
Examples of coordinate functions

- A rectangle
  - image can be mapped directly, unchanged

Examples of coordinate functions

- For a sphere: latitude-longitude coordinates
  - $\phi$ maps point to its latitude and longitude
Examples of coordinate functions

- A parametric surface (e.g. spline patch)
  - surface parameterization gives mapping function directly

Examples of coordinate functions

- For non-parametric surfaces it is trickier
  - directly use world coordinates
Examples of coordinate functions

- Non-parametric surfaces: project to parametric surface

- Triangles
  - specify \((u, v)\) for each vertex
  - define \((u, v)\) for interior by linear interpolation
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 texture space

Texture coordinates on meshes

- How to come up with vertex \((u,v)\)s?
- Use any or all of the methods just discussed
Reflection mapping

- Early 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.

![Image of a shiny sphere](image1)

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.

Environment map

- Precomputed image of scene lighting from given point

![Image of a teapot](image2)
Spherical environment map

Hand with Reflecting Sphere. M. C. Escher, 1935. Lithograph

Environment Maps

[Paul Debevec]
Sphere Mapping Example

Cube environment map
Normal mapping

original mesh
4M triangles

simplified mesh
500 triangles

simplified mesh
and normal mapping
500 triangles

[Paolo Cignoni]

base subdivision surface

hand-painted displacement map (detail)

displaced surface
Bump mapping
Displacement mapping

Geometry  Bump mapping  Displacement mapping

Another definition

Texture mapping: a general technique for storing and evaluating functions.

- They’re not just for shading parameters any more!