MATERIALS REVISITED

This week's objectives

The main goal is to get up to scratch with 3DS Max and do a few things we explored in POVray:
1. CSG
2. Material and Texture:
   a) Material properties
   b) Texture maps
   c) Image Maps
   d) Global Illumination
   e) Environment Maps
3. Lights

MATERIALS MODELLING

Visual appearance of objects depends on properties of the materials they are made of.

How we represent materials depends on the rendering technique used
- Realistic techniques require physical parameters e.g. density, index of refraction, etc.
- Often, intermediate information is used ("colour") to allow more direct control over appearance

TEXTURES

Textures add complexity to scenes without additional geometry
- Approximate using an image how additional geometry will affect the final rendering

Many different types:
- Diffuse map (most common, this is what we've used): assigns colours to points on an object
- Ambient, specular, gloss maps: assigns different illumination parameters (as in Phong Model)
- Bump, normal, displacement maps: affects the illumination by modifying normal etc.
- Reflection, refraction maps (approximating more complex global illumination effects)

RECAP: PHONG ILLUMINATION MODEL

Light reflected off a point always depends on some (or all) of the following vectors:

- Normal to surface $\mathbf{n}$
- Light direction $\mathbf{l}$
- Viewer direction $\mathbf{v}$
- Direction of reflection $\mathbf{r}$

$\mathbf{I}_d = R \cdot k_d \cdot \cos \theta$
$\mathbf{I}_s = R \cdot k_s \cdot \cos \alpha$
$\mathbf{I}_a = R \cdot k_a \cdot \cos \phi$

DIFFUSE REFLECTION is the main contributor to the colour of an object. The colour of diffuse light comes from

- Light intensity $R$
- Diffuse reflectance of material $k_d$
- Angle between surface normal and light direction $\theta$

SPECULAR REFLECTION causes small glossy highlights on the surface of smooth objects.

- Light intensity $R$
- Specular reflectance of material $k_s$
- Specular reflection of viewer in light source $\alpha$
- Angle between viewer and direction of reflection $\phi$

AMBIENT ILLUMINATION refers to the light from evem in the scene. Multiply ambient light in scene $R \cdot k_a$ with ambient reflectivity $k_a$
SHADING ALGORITHM (A.K.A. SHADER)

Repeat the process of calculating illumination across the surface of each object – we can take shortcuts by calculating lighting just once for each vertex – and then interpolating between vertices.

RECAP: RENDERING EQUATION

A. No need to understand this equation, but it is important to know what factors affect it.

\[ I(x',x'') = g(x,x')I(x',x'') + p(x,x',x'')(x',x'') \, dx'' \]

DIFFUSE MAP

Simplest texturing directly applies a colour to object
- In basic illumination colour is mostly based on diffuse component

SPECULAR MAP

Specular level + Specular color
- Controls the intensity of specular highlights

Glossiness ("Gloss Map") / Shininess
- Control the specular exponent in Phong light model
- Or roughness in other light models

SPECULAR+ GLOSSINESS MAP

Self-Illumination Map

A.K.A. Emission
- Models light sources on a surface
- Does not depend on surface normal or light sources.
**VISIBILITY MAPPINGS**

**Displacement Map**
- Shift in texture lookup based on view-ray intersection with heightfield
- Can account for occlusions

**Opacity Map**
- Transparency mapping across primitive

**BUMP MAP**

Use texture as an input to perturb geometric representation

**LIGHT MAPS**

Approximation of complex lighting in scene

- Pre-computed incident light across 2D surfaces
- When there are multiple light sources it can be too complex to calculate how they illuminate surfaces
- If the light and object are not expected to move, we can use static textures that capture the effect of lighting the object
- Very popular technique in computer games

**ENVIRONMENT MAPPING**

Approximation of incoming light from scene

- Global effects, such as reflection and refraction require information on light coming in from the scene
- But it usually too expensive to illuminate the whole scene
- Approximate “the rest of the scene” as images

**TEXTURE MAPPING**

For 2D textures, we need a 3D to 2D mapping

- Sometimes called a “projector function”
- Each vertex in the model will need a (u,v) co-ordinate
- Normally defined by the artist and added to the vertex stream

**UV-MAPPING**
UV MAPPINGS

Spherical  Cylindrical  Box  Planar  Wrap

Uses multiple mappings

E.g. main body uses cylindrical

LIGHTS

Positional Light Source: Angle of incoming light changes across a surface; This in turn alters color at different points.

Directional Light Source: Source is very distant thus the angle of incoming light remains (almost) constant.

POSITIONAL/POINT LIGHT:

- Light source is near – distorts shadow

DIRECTIONAL LIGHT:

- Light source is far away

LIGHTING

On the Command Panel:
- Under the “Create” tab
- Select Lights
- Start with “Standard” Lights for now

- Spot and Omni are Positional lights
- “Direct” indicates a Directional light

Target and Free simply refer to how the light can be moved (transformed) in max

- Target remains aimed at a certain point when you translate it
- Free remains facing a certain direction when you translate it

LIGHT AND SHADOW

When you create a light source, you can choose to let it cast shadows (by default this is off for some lights)

The choice of the shadow renderer affects the quality of the shadow

- Some are more realistic but conversely cause the rendering to take a longer time
MATERIALS

Press M or click on the material icon to bring up the material editor window.
- This stores all current materials used in your scene.
- You can drag any existing material onto objects in your scene.
- You can also load in materials from other .MAT libraries.

BASIC SHADERS

Shader Basic Parameters
Choose types:
- Phong – we know this one already
- Blinn – a more accurate version of Phong
- Strauss – metallic objects
- Oren-Nayer-Blinn – matte surfaces

Selecting any shader changes the nature of the Basic Parameters and Extended Parameters.

THE MAPS ROLLOUT

Maps allow you to apply a filter or pattern to some of the objects properties.
- The Map will decide which colors (or distortions in the case of some mappings).
- The map can be derived from an image or procedurally (from some mathematically defined function).

TEXTURES

To Texture Map an object, most frequently we change its diffuse mapping.
- Recall that diffuse is what mostly affects an object’s colour.
- In effect, we give MAX a function which will decide the colour of individual points on the object.

MATERIAL BROWSER

- The Material/Map Browser gives you a list of existing functions you can map to a material.
- Additional ones can be generated or imported from outside sources.
- Most of these are procedural and can apply to both texture and bump/normal maps.
- To add your own image use BITMAP.

Once you select a map the material Editor window changes.
- Here we selected marble so the editor shows options for affecting the marble procedure.
- To go back to the original object (and perhaps add other effects, click “Go To Parent”.)
HIGHLY REFLECTIVE OBJECTS

Tick reflection – click on the map button to bring up the Material/Maps browser

Select Raytrace

REFRACTION

For refraction choose a Refraction map and in the Maps window choose Raytrace

The index of refraction (IOR) value can be changed under Extended Parameters (you may have to click "Go to Parent" to get there)

If you don’t see this select a Blinn or Phong Shader

BUMP MAPS

Tick Bump under the Maps rollout.

Click on the Map to open the Material/Map Browser

In the Material/Map Browser, select a preset pattern or Load one from an image file by selecting Bitmap

DISPLACEMENT MAPPING

Displacement mapping actually changes the geometry before rendering – displaced “bumps” can actually occlude and cast shadows on other objects.

ENVIRONMENT MAP

An environment map (similar to the sky_sphere in POV-Ray) adds a background texture which can add an extra touch of realism to your reflective/refractive (ray-traced) objects.

Select an empty slot. Then click on Get Material.

Double click Bitmap

Under the co-ordinates rollout, Click Browse.

In the Menu – Click "Rendering \ Environment" and then select your environment map
ENVIRONMENT MAP EXAMPLE

With Environment Map

Without Environment Map

CUBE MAPPING