Lighting Models

CS116A
Chris Pollett
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Outline

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- Surface Lighting Effect
- Basic Illumination Models

Overview

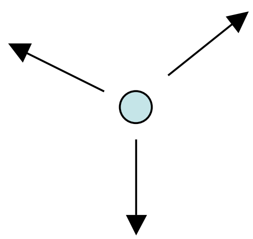
- An **illumination model** (lighting model) is used to calculate the color of the illuminated positions of an object
- The procedure for applying a lighting model to obtain a pixel colors for all projected surface positions is called **surface rendering**.
- In computer graphics, illumination models are usually easy to compute approximations of physical laws that describe surface-effect lighting.

Light Sources

- Any object that is emitting radiant energy is a **light source** that contributes to the lighting effect of the scene.
- Usually light sources will be treated as only emitters, but can also be reflectors. Ex: flourescent light panel.
- We can specify a light source’s: position, color of its light, light emission direction, shape, and reflectivity.

Point Light Sources

- Point light sources consist of a position and an RGB value of the light emitted.
- Light is modeled as coming from this source in radially diverging lines



- This is a reasonable model for light sources whose size is small compared to the dimensions of the scene.

Infinitely Distant Light Sources

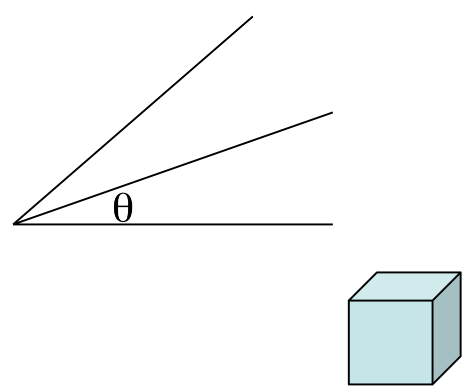
- A large light source which is very far from the scene can also be modeled as a point light source.
- In contrast to a close emitter a distant emitter illuminates object is the scene from only one direction
- Light paths for distant objects are nearly parallel.
- So can assign a color, and direction light is coming from. Don't need position of source.

Radial Intensity Attenuation

- As radiant energy from a light source travels outward, its amplitude at a distance d falls off as 1/d^2.
- So to produce realistic lighting effects should take this into account.
- Unfortunately, for objects close to a point source, this does not look realistic (basically because things in real-world not point sources).
- So a model of the form 1/(a +bd +cd^2) is used with a,b,c being adjustable parameters.
- If the light source is really distant, the source should not attenuate much within scene so in this case ignore attenuation factor.

Directional Light Sources and Spot Light Effects

- To make a light source directional, we can assign an angle θ to the source so that if the object is outside this angle and the direction the source is pointing, it does not get illuminated



Angular Intensity Attenuation

- Within a light can also attenuate the signal based on angle to get a more realistic directional lighting effect.
- For example, we can multiply the intensity by $\cos^a\varphi$ for $\varphi < \theta$ and where a is some positive exponent we hand-tune

Extended Light Source and the Warn Model

- To approximate large non-point sources close to objects in a scene, one can use several point sources arranged in a grid.
- The **Warn model** does this and also allows one to specify ``flaps'' on the sides of the lighting region to give the light more directionality.

Surface Lighting Effects

- In a lighting model we usually assign surfaces materials which have certain properties of transparency, color reflectance, and texture.
- When light hits an opaque surface part of it is reflected part is absorbed.
- Shiny materials reflect more light; dull materials absorb more.
- Transparent materials also transmit light.
- Rough, or grainy surfaces reflect light in all directions. (**Diffuse reflection.)**
- Some of this light gets concentrate in a bright spot called a **specular reflection**
- A scene might also be exposed to background light also called ambient light

Basic Lighting Models

- We are now ready to give a rough model for how to do lighting for point sources.

Ambient Light

- Ambient light in a scene will be incorporated by setting a general brightness level for the scene.
- To keep things simple we assume this affects all colors equally and can be specified by an intensity parameter I_a

Diffuse Reflection

- Diffuse lighting can be modeled using Lambert's cosine law.:
  - Intensity of radiant energy from any small surface dA in a direction θ relative to the surface normal is proportional to cos θ.
- Using this can model diffuse light as:

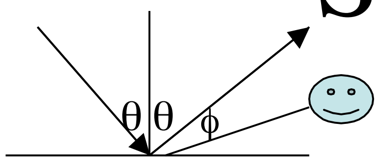
  $I_{diff} = k\, I \cos\theta$

  where k is a tweakable constant for the whole scene. Can calculate θ using dot product.
- So model so far is

  $k_a * I_a + I_{diff} = k_a * I_a + k_d * I_d(\mathbf{N.L})$

  if $\mathbf{N.L>0}$ and $k_a I_a$ otherwise.

Specular Reflection and the Phong Model



- Phong has proposed the following model for specular lighting effects :

  I_spec= $W(\theta)I\cos^n\phi$.

  Here $W(\theta)$ is called the specular reflection coefficient and its value changes with the angle of incidence (book plots function for some common materials). I.e., θ is the angle the light hits the surface and is reflected by on other side of normal. ϕ is the angle we are from where this reflected incident light is supposed to appear. n is bigger for shinnier materials.

Combined Diffuse and Specular Reflections

- Model for Fall 2004 is I = k_a*I_a+ I_diff + I_spec
- Will say more in the Spring.