9. Illumination Model & Surface Rendering Methods

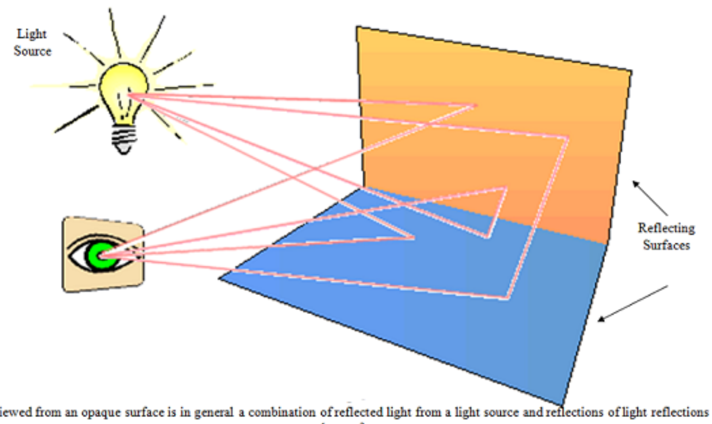
Contents

Introduction

- Illumination: the transport of energy (luminous flux of visible light) from light sources to surfaces, indirect and direct.
- Often a confusion between lighting and shading
- Lighting
  – The process of computing the luminous intensity (outgoing light) at a particular 3D point.
  – Illumination model (shading model!) (Hearn Baker)
- Shading
  – The process of assigning colors to pixels
  – Surface-rendering method (Hearn Baker)

9.1 Different light sources used in 3D modelling

- When we view an opaque no luminous object, we see reflected light from the surfaces of the object.
- The total reflected light is the sum of the contributions from *light sources* and other reflecting surfaces in the scene.



Light viewed from an opaque surface is in general a combination of reflected light from a light source and reflections of light reflections from other surfaces.

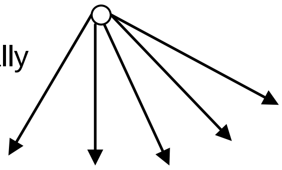
- Light sources = *light-emitting sources.*
- Reflecting surfaces = *light-reflecting sources.*
- Light source: object that radiates energy.

Sun, lamp, globe, sky…

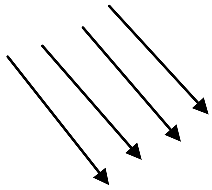
Intensity $I = (I_{red}, I_{green}, I_{blue})$,If $I_{red} = I_{green} = I_{blue}$: white light

Light Source Models

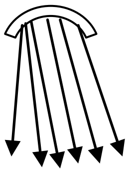
- Point Source: All light rays originate at a point and radially diverging. A reasonable approximation for sources whose dimensions are small compared to the object size.



- Parallel source: Light rays are all parallel. May be modelled as a point source at infinity (the sun).

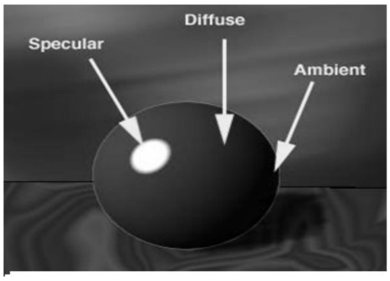


- Distributed source : All light rays originate at a finite area in space. – A nearby sources such as fluorescent light.



9.2 Basic Illumination model

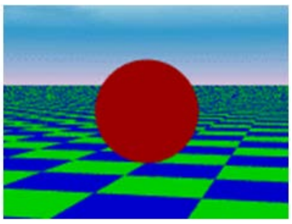
- Simplified and fast methods for calculating surfaces intensities.
- Calculations are based on optical properties of surfaces and the lighting conditions (no reflected sources nor shadows).
- Light sources are considered to be point sources.
- A reasonably good approximation for most scenes.



Phong Shading Model

1. ambient
2. diffuse
3. specular

9.3 Ambient Light



Ambient light shading.

- Even though an object in a scene is not directly lit it will still be visible. This is because light is reflected from nearby objects.
- Ambient light has no spatial or directional characteristics.
- The amount of ambient light incident on each object is a constant for all surfaces and over all directions.
- The amount of ambient light that is reflected by an object is independent of the objects position or orientation and depends only on the optical properties of the surface.
- The level of ambient light in a scene is a parameter I_a , and each surface illuminated with this constant value.

- Illumination equation for ambient light is

$$I = k_a I_a$$

where

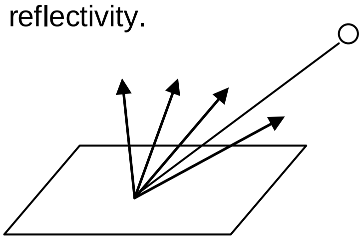
I is the resulting intensity

I_a is the incident ambient light intensity

k_a is the object's basic intensity, *ambient-reflection coefficient*.

9.4 Diffuse Reflection

- Diffuse reflections are constant over each surface in a scene, independent of the viewing direction.
- The amount of the incident light that is diffusely reflected can be set for each surface with parameter k_d, the diffuse-reflection coefficient, or diffuse reflectivity.



$0 \le k_d \le 1$;

k_d near 1 – highly reflective surface;

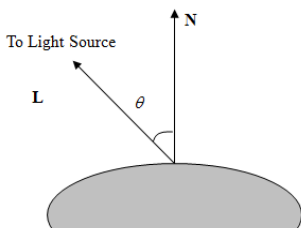
k_d near 0 – surface that absorbs most of the incident light;

k_d is a function of surface color;

- Diffuse (Lambertian) surfaces are rough or grainy (like clay, soil,fabric).
- The surface appears equally bright from all viewing directions.
- The brightness at each point is proportional to cos(θ)

This is because a surface (A) perpendicular to the light direction is more illuminated than a surface (B) at an oblique angle.

- As the angle between the surface normal and the incoming light direction increases, les of the incident light falls on the surface.
- We denote the angle of incidence between the incoming light direction and the surface normal as θ. Thus, the amount of illumination depends on cosθ. If the incoming light from the source is perpendicular to the surface at a particular point, that point is fully illuminated.



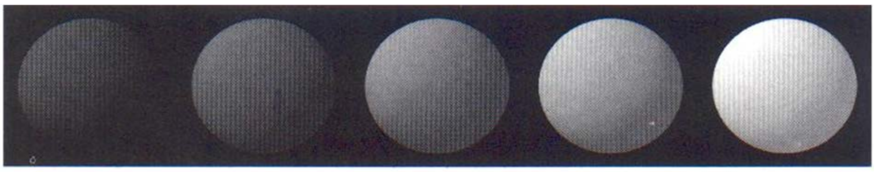
- If I_l is the intensity of the point Light source, then the diffuse reflection equation for a point on the surface can be written as

$I_{l,diff} = k_d I_l \cos\theta$ or $I_{l,diff} = k_d I_l (N \cdot L)$

where N is the unit normal vector to a surface and L is the unit direction vector to the point light source from a position on the surface. Angle of incidence θ between the unit light-source direction vector L and the unit surface normal N

- We can combine the ambient and point-source intensity calculations to obtain an expression for the total diffuse reflection.

  $I_{diff} = k_a I_a + k_d I_l (N \cdot L)$ where both k_a and k_d depend on surface material properties and are assigned values in the range from 0 to 1.

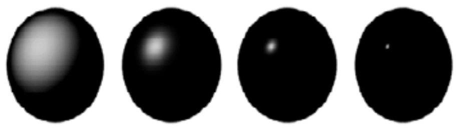


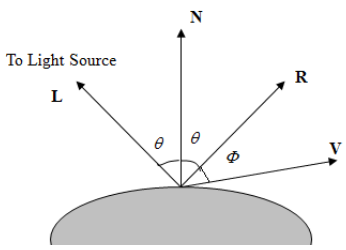
Series of pictures of sphere illuminated by ambient and diffuse reflection model.
$I_a = I_l = 1.0$, $k_d = 0.4$ and k_a values (0.0, 0.15, 0.30, 0.45, 0.60).

9.5 <u>Specular Reflection</u>

- *Specular reflection* is the result of total, or near total, reflection of the incident light in a concentrated region around the *specular-reflection angle.*
- Shiny surfaces have a narrow specular-reflection range.

  Dull surfaces have a wider reflection range.





Modeling specular reflection.

The above Figure shows the specular reflection direction at a point on the illuminated surface. In this figure,

- R represents the unit vector in the direction of specular reflection;
- L – unit vector directed toward the point light source;
- V – unit vector pointing to the viewer from the surface position;
- Angle Φ is the viewing angle relative to the specular-reflection direction R.