CSE 167: Introduction to Computer Graphics Lecture #6: Lights

Jürgen P. Schulze, Ph.D.
University of California, San Diego
Spring Quarter 2016

Announcements

- Project 2 due next Friday at 2pm
- This Friday at 2pm: late grading project 1
- Midterm #1 on Tuesday, April 26

Lecture Overview

- OpenGL Light Sources
  - Directional Lights
  - Point Lights
  - Spot Lights

Light Sources

- Real light sources can have complex properties
  - Geometric area over which light is produced
  - Anisotropy (directionally dependent)
  - Reflective surfaces act as light sources (indirect light)







- In OpenGL we have to use a drastically simplified model to allow real-time rendering

Types of Light Sources

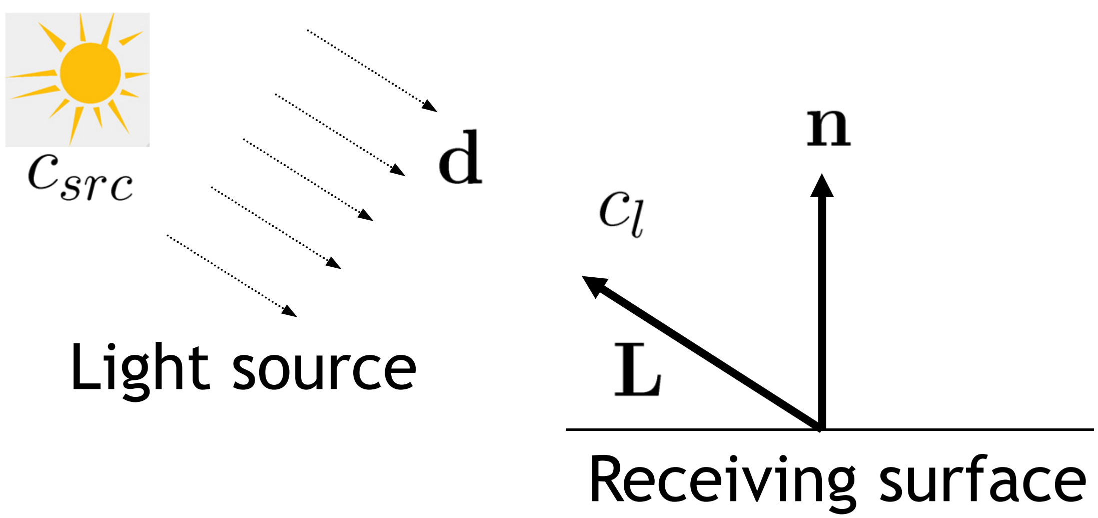
- At each point on surfaces we need to know
  - Direction of incoming light (the $\mathbf{L}$ vector)
  - Intensity of incoming light (the c_l values)
- Three light types:
  - Directional: from a specific direction
  - Point light source: from a specific point
  - Spotlight: from a specific point with intensity that depends on direction

Lecture Overview

- Light Sources
  - Directional Lights
  - Point Lights
  - Spot Lights

Directional Light

- Light from a distant source
  - Light rays are parallel
  - Direction and intensity are the same everywhere
  - As if the source were infinitely far away
  - Good approximation of sunlight
- Specified by a unit length direction vector, and a color



$$\mathbf{L} = -\mathbf{d}$$

$$c_l = c_{src}$$

Lecture Overview

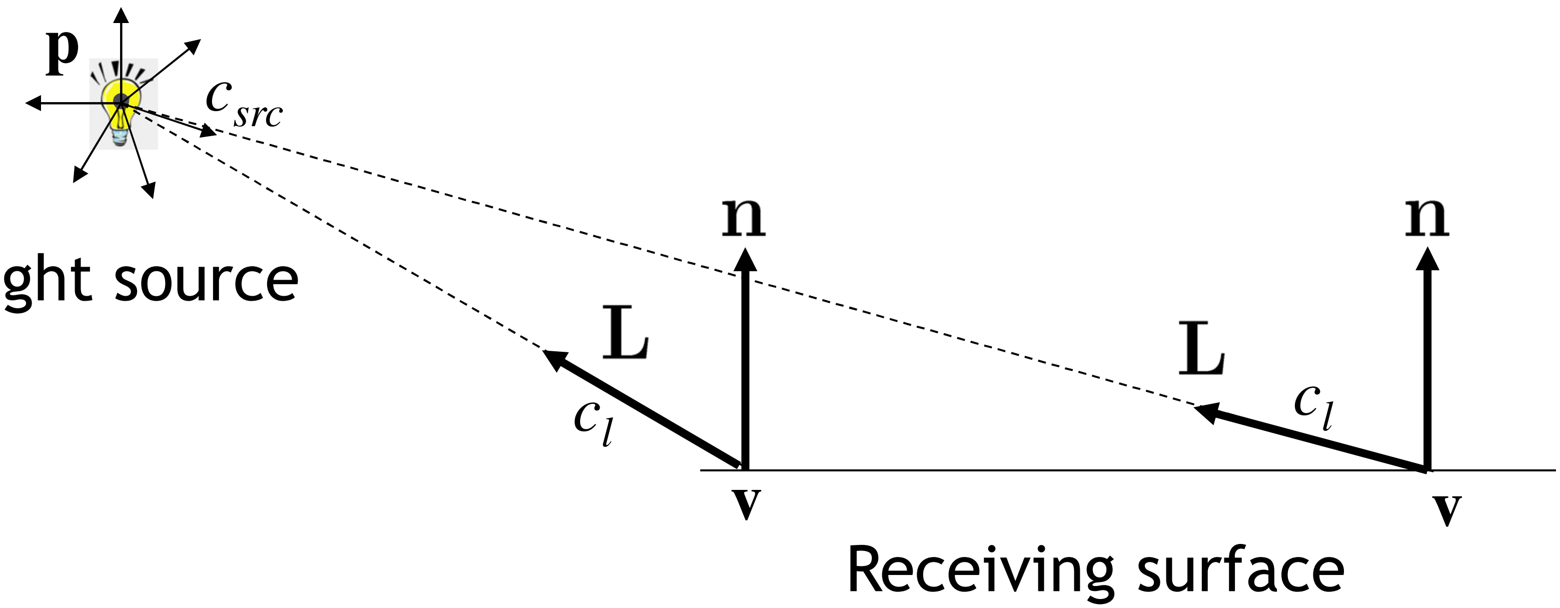
- Light Sources
  - Directional Lights
  - Point Lights
  - Spot Lights

Point Lights

- Similar to light bulbs
- Infinitely small point radiates light equally in all directions
  - Light vector varies across receiving surface
  - What is light intensity over distance proportional to?
  - Intensity drops off proportionally to the inverse square of the distance from the light
    - Reason for inverse square falloff:
      Surface area A of sphere:
      $A = 4 \pi r^2$

UCSD

Point Light Math



At any point v on the surface:

$$\mathbf{L} = \frac{\mathbf{p} - \mathbf{v}}{\|\mathbf{p} - \mathbf{v}\|}$$

Attenuation:
$$c_l = \frac{c_{src}}{\|\mathbf{p} - \mathbf{v}\|^2}$$

Light Attenuation

- Adding constant factor k to denominator for better control
- Quadratic attenuation: $k*(p-v)^2$
  - Most computationally expensive, most physically correct
- Linear attenuation: $k*(p-v)$
  - Less expensive, less accurate
- Constant attenuation: k
  - Fastest computation, least accurate

Lecture Overview

- Light Sources
  - Directional Lights
  - Point Lights
  - Spot Lights

Spotlights

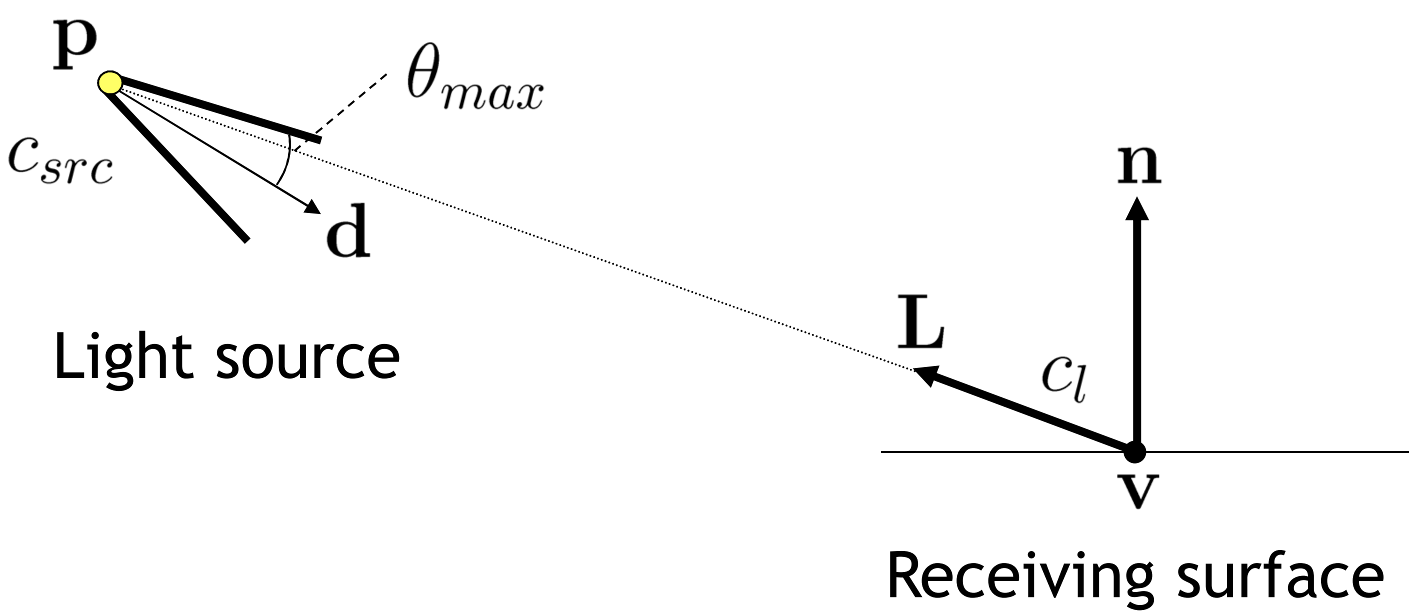
- Like point light, but intensity depends on direction

Parameters

- Position: location of light source
- Spot direction: center axis of light source
- Intensity falloff:
  - Beam width (cone angle)
  - The way the light tapers off at the edges of the beam (cosine exponent)

UCSD

Spotlights



$$\mathbf{L} = \frac{\mathbf{p} - \mathbf{v}}{\|\mathbf{p} - \mathbf{v}\|}$$

$$c_l = \begin{cases} 0 & \text{if} \quad -\mathbf{L} \cdot \mathbf{d} \leq \cos(\theta_{max}) \\ c_{src} \, (-\mathbf{L} \cdot \mathbf{d})^f & \text{otherwise} \end{cases}$$