Lighting: Types of Sources

1. Point (omni, radial)
   - Not typical of most real-world sources
     - Usually do not emit 360°
   - Can simulate real-world source by
     (a) Placing blockers around them
     (b) Add textures
     (c) Limit their volume and/or objects affected by

2. Spot
   - Softness of edge determined by hotspot and falloff angles
   - Greater the difference, increasing softness
   - Provides greatest control

3. Area
   - Computationally expensive
   - Usually used for stills or final renders
   - Not very standardized
   - Simulate with arrays of point sources
   - Can be 1D, 2D, or 3D

4. Directional
   - Distant light source
   - Parallel rays
   - Location immaterial
   - Only direction important

5. Ambient
   - Represents light reflected from other sources
   - CG implementation not realistic
     - CG is uniform, non-directional
     - CG produces flat shading
     - Real world ambient varies in intensity
     - Real world based on objects in vicinity
   - Recommend turn off ambient
   - Ambient effectively darkest color possible when turned on
Lighting: Source Attributes

1. On/off

2. Color
   (a) RGB
   (b) HSV
      • Easier for intensity control
         – Adjust V parameter
      • Multiplier multiplies intensity
      • Limit: $-1.0 \leq \text{multiplier} \leq 1.0$
      • Negative multiplier subtracts illumination

3. Volume that the source affects

4. Objects that the source affects

5. Attenuation

6. Shadows
Lighting: 3 Point Model Intro

- Light modeling uses light to enhance scene
- Sets mood, makes more realistic
- Simply placing light sources is usually not sufficient for realism in CG
  - Real life produces reflection from all surfaces (radiosity)
  - This tends to soften areas that would otherwise be in dark shadow
  - Radiosity often not part of CG package
- To mimic nature, use 3 Point Model
  1. Key light
     - Primary source of illumination
     - Brightest source of illumination
     - Creates darkest, most visible shadows
     - Often implemented using spot light
  2. Fill light
     - Softens and extends illumination of key light
     - Brightens areas in shadow, enhancing contour that would otherwise be hidden
     - Simulates reflected light and secondary lights
  3. Back light
     - Creates a defining edge for subject
     - Separates subject from background
     - Not a background light - does not illuminate background
- Purpose of 3 point model is to illuminate main subject, not necessarily entire scene
- No precise formula for positioning and intensities
Lighting: 3 Point Model - Key Lights

• Angle of key one of most important aspect
  
  – Affects mood:
    * Too far to side creates harsh, often unnatural image
    * Underneath creates eerie effect
    * Straight overhead creates sinister mood
    * Behind subject creates dramatic effect
      · Called *upstage* key

• General recommendation:
  
  – 15 to 45 degrees to the side
  – 15 to 45 degrees above
Lighting: 3 Point Model - Fill Lights

• Simulate reflected (and secondary) light in scene
• Placed on opposite side of camera from key light, at lower angle
• Best if angle is less than key, so effects overlap
• General recommendation:
  – 0 to 30 degrees above camera
  – 15 to 60 degrees opposite key
  – Motivation is that most key lighting originates overhead
    * Reflective light comes from floor and walls
  – Avoid symmetry - fill should be at different angle than key from camera
• To model specific radiosity effects:
  – Place fill of appropriate color opposite object being affected
  – Should have limited range
  – Turn off shadow-casting
• To model secondary lights
  – Place fill at source locations
Lighting: 3 Point Model - Fill Lights, Key-to-fill Ratio

• Ratio of brightnesses of key to fill light
• Measure of contrast
• Low ratio flattens scene
• High ratio creates dark areas of deep shadow
• Ratio is measured at the subject
  – Must take attenuation into account when measure
• Low key-to-fill ratio
  – Used for situation with lots of reflected light:
    * Scenes with lots of white or highly reflective surfaces
    * Cloudy, overcast, or snowy scenes
    * Cartoons, comedy, children’s programming to create cheerful mood
  – Generally 2:1 is lowest acceptable ratio
  – If have overlap of fill illumination, calculate ratio based on total illumination
• High key-to-fill ratio
  – Used for situation with high contrast, shadowy scene with little reflection:
    * Night scenes
    * Horror movies
    * Film noir
  – Scene can be brightly lit and still have deep shadows
  – Make sure main subject is adequately lit
  – Use 8:1 or more
Lighting: 3 Point Model - Back Lights

- Separates subject from background
- Most useful with black and white
- Not always necessary - use only when needed
- May require multiple lights to rim subject
- Can be brighter than key, as will not interfere with key
- In CG, do not place directly behind camera

Recommendations:
1. Use diffuse, not specular light (precludes single hotspot)
2. Reduce specular component of object material
3. Use Blinn, not Phong
• Shadows play a major role in animation:
  1. Indicate location of light source(s)
  2. Provide cues re depth, size, position of objects
  3. Provide contrast
  4. Emphasize contour of objects
  5. Hint at what lies beyond camera
  6. Highlight aspects of scene
  7. De-emphasize aspects of scene
  8. Anchor scene in reality

• Expensive process
Lighting: Shadows - Types

1. Shadow (depth) mapped
   - Distance from source to shadow-casting objects mapped prior to rendering
   - Values of closest objects stored in bitmap
   - Light calculations not performed for objects beyond the map
   - Soft shadows created by blurring edges
   - Cannot deal with colored shadows and translucent objects
   - Resolution of bitmap controls grain of shadow edge
   - Faster than ray traced
   - Many parameters - requires lots of tweaking

2. Ray traced
   - Natural result of ray traced rendering
   - More computationally expensive than shadow mapped
   - Can deal with colored shadows and translucent objects
   - Soft shadows problematic
     (a) Can create by casting multiple times from offset source
     (b) Increase size of source
Lighting: Shadows - Alternatives

- Due to cost, want viable alternatives to full-out shadow casting

1. Use several small sources instead of one large source

2. Use source with negative brightness to fake shadows
   - Use spot
   - Turn off shadow casting ability
   - Aim where want shadow to appear

3. Replace omnis with multiple spots for contained sources (e.g., in lamp-shades)

4. Use shadow-only lights
   - Provide greater control without affecting lighting of scene
   - Can be simulated using
     (a) Shadow casting source
     (b) Clone of source with shadow casting turned off
     (c) Clone has negative intensity of source
     (d) Together, they create only shadows
Lighting: Shadows - Saturation

- Shadows normally brightened by reflected light in scene
- Saturation can be increased by
  1. Changing shadow color
     - Simulates reflected light
     - Does NOT add color to shadow caster
  2. Use global ambience
  3. Use additional sources (e.g., fill lights)
• Color balance associated with film
• Color-balanced film is film that associates white with a given color temperature
• Two general color-balanced films:
  1. 3200°K for indoor use
  2. 5500°K for outdoor use
• A light source will appear tinted depending on whether it has a higher or lower color temperature than film
• Not a factor in CG, so must be simulated for realism
• Dominant source is responsible for white
• Color-balance lights wrt dominant source (p 15)
  – Source at lower temperature tinted Y, then R
  – Source at higher temperature tinted B
• Greater the difference, greater the tint
• No set formula
• Fluorescents usually tinted G
Lighting: Practical Aspects - Light Qualities

1. Intensity
   - Dominant source is one with greatest intensity
   - Film and CG adjust for intensity differently
     - Film: f-stop, shutter speed, film speed
     - CG: manually

2. Attenuation
   - Real world is inverse square law
   - In CG, may want to limit to minimize computation
     (a) Specify start and end limits
        - Controls objects illuminated
     (b) Use linear attenuation
     (c) Use no attenuation
        - Virtually none in small enclosed spaces

3. Color
   - Indicates nature of source
     - Indoor tends to Y
     - Outdoor tends to B
   - Sets mood

4. Softness
   - Most light is soft in real world
     - Light filtered by atmospherics
   - CG light hard

5. Throw
   - Shape or pattern of projected light
   - Simulate in CG by
     (a) Model shadow-casting objects to block light
        - Assign textures to source
        - Simulates cookies/gobos of stage
6. Animation
   - Much light in real world not steady
     - Atmospherics
     - Sources flicker (candle, neon)
     - Sources move
   - Set mood

7. Shadows
   - Used to highlight aspects
   - Used to hide other aspects
   - Can be hard or soft

8. Motivation
   (a) Logical
      - Provides illumination
      - May be physically present or out-of-scene (sun)
   (b) Pictorial
      - Presence is aesthetic
      - Sets mood