Photographic lighting

CS 178, Spring 2009

Marc Levoy
Computer Science Department
Stanford University
Outline

- taxonomy of light sources
- lighting for portraiture
- studio lighting
- special lighting problems
- flash photography
## Taxonomy of light sources

[Langer and Zucker, CVPR 1997]

<table>
<thead>
<tr>
<th>Non-ideal example</th>
<th>Ideal model</th>
<th>$h_x$</th>
<th>$h_y$</th>
<th>$h_p$</th>
<th>$h_d$</th>
<th>dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>overcast sky</td>
<td>uniform source</td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>4</td>
</tr>
<tr>
<td>Cyberware™ scanner</td>
<td></td>
<td>∞</td>
<td>∞</td>
<td>∞</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>fluorescent tube</td>
<td>linear source</td>
<td>∞</td>
<td>0</td>
<td>∞</td>
<td>∞</td>
<td>3</td>
</tr>
<tr>
<td>sunlight</td>
<td>point source at infinity</td>
<td>∞</td>
<td>∞</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>louvered linear source (see text)</td>
<td>uniform distribution of rays in a plane</td>
<td>∞</td>
<td>0</td>
<td>∞</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>small panel light</td>
<td>point source</td>
<td>0</td>
<td>0</td>
<td>∞</td>
<td>∞</td>
<td>2</td>
</tr>
<tr>
<td>sunlight through crack in doorway</td>
<td>parallel rays in a plane</td>
<td>∞</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>rotating spotlight</td>
<td>fan of rays</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>∞</td>
<td>1</td>
</tr>
<tr>
<td>spotlight or laser</td>
<td>single ray</td>
<td>0</td>
<td>0</td>
<td>∞</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Geometry for table on previous slide

- $h_x$ and $h_y$ give spatial extent of light source (zero or infinity, i.e. point or area), and $h_p$ and $h_q$ give angular extent (zero or infinity, i.e. parallel beam or fan beam)
What’s different between these two?
Leonardo, study of umbra and penumbra
Lighting for portraiture

- conventional studio lighting
- unconventional lighting
- available light
- narrative light
As I discussed in class, last time we looked at this portrait, we focused on its triangle composition (head-hand-hand). This time, think about figure-ground. It is accents of light against a dark background. Compare this to the next portrait...
Unlike the previous portrait, here Karsh is using accents of dark against a mainly light-colored composition. Note also the strong lower-right to upper-left diagonal of the subject’s back and famously long neck. By tilting her head just so, Karsh balances this diagonal with smaller upper-right to lower-left diagonals formed by her nose, eyelashes, and gaze direction.
Yousuf Karsh,
Peter Lorre,
1946
Yousuf Karsh, Georgia O’Keeffe, 1956
Caravaggio, The Calling of St. Matthew, 1599
Rembrandt, Belshazzar’s Feast, 1599
Studio lighting

- spotlight with reflective umbrella
- floodlight
- zebra board
- lights with diffusers
- spotlight
- strobe

(Kodak)
Adjustments on studio spotlights

- barn doors
- zoom control
- filter holder

Goniometric diagram showing luminous intensity at each angle.
Lighting rigs can be large

- soft box
- film view camera with digital light meter
- polaroid preview pictures
- 1970’s haircut
Basic portrait lighting

- main/key
- fill
- accent/rim
- background
Basic portrait lighting

(London)
Alternative lighting arrangements

- main light on side towards camera - broadens narrow faces
- main light on side of face away from camera - most common
- main light directly in front of face - glamour lighting

broad  short  butterfly
key:fill light ratio

- 8:1 means 3 f/stops (3 doublings)
- think about the mood you want to convey
- the color of the key and fill lights can be different...
Maxfield Parrish, Daybreak, 1922
Pixar, Toy Story, 1995
Professional photographic lighting manuals

photographed by
D.W. Mellor

(Kodak)
Special problems:
architectural interiors

2-second exposure
to show dusk outdoors

note lighting
in 2nd room

(Kodak)
Special problems: food (without breaking FTC laws)

photographed by Richard Fukuhara

(Kodak)
Special problems: surface details

(Hunter)

overhead light

grazing light
How is this sculpture lit?
The bas-relief ambiguity
[Belhumeur CVPR 1997]

- changing the depth of an object is equivalent to changing the angle of lighting on it - they produce the same image
  - otherwise, bas-relief sculpture wouldn’t work
Special problems: shiny objects

photographed by Fil Hunter

(London)
Special problems: glassware

(Hunter)

brightfield
darkfield
When to use flash?

- freezing the action
- fill-flash
- flash-plus-ambient
- ways to avoid using flash
Lois Greenfield, dance photography, 1988-
Fill-flash (for brightly lit backdrops)

- shorten exposure, then add flash
- could instead use HDR, but that requires multiple shots
Flash-plus-ambient (in low light)

- use flash, and lengthen exposure
- avoids isolating the foreground from its background
Avoiding flash

(Peterson)

straight shot

with graduated neutral-density filter
Flash placement

direct flash, on camera
direct flash, off camera
bounce flash, from above
bounce flash, from the side
Flash technology

1880: flash powder
powdered magnesium + potassium chlorate + antimony sulfide

1927: flashbulbs
aluminum foil in oxygen, later tungsten or zirconium filament coated in explosive primer paste

1960s: flashcubes
Electronic flash

- battery charges up a capacitor (dangerous when disassembled!)
- high-voltage trigger ionizes the gas inside the tube, reducing its resistance to the flow of electricity and causing streamers of ionized gas to form (like “leaders” in lightning)
- the capacitor discharges through the ionized gas, heating it to a plasma state and causing an intense but brief discharge of light
Controlling exposure in flash photography

- the luminous intensity of a particular xenon flash tube is fixed
- flash is briefer than the shutter, so you can’t use shutter speed to control illuminance on sensor
  - you can still use it to control ambient light
- aperture and ISO affects recording of both flash and ambient light
- instead, adjust duration of the flash pulse
Guide numbers

- flash power is measured in **guide numbers**
  - proper aperture size = guide number / distance to subject
  - varies with focal length for zooming flashes
  - assumes ISO 100

- examples
  - Canon 580 EX hot-shoe flash: guide number 58
  - Nikon D40 pop-up flash: guide number 15
  - Canon SD800 point-and-shoot: guide number 4

  - for Canon 580EX and a subject 10’ away, use f/5.6
  - for Canon 580EX and f/1.4 lens, subject can be 41’ away!
The effect of distance to the subject

- if you treat flash as a point source, then illuminance (power per unit area) arriving on a subject from the flash falls as $d^2$
- with respect to a camera pixel, a subject is an area source, so the illuminance arriving on a pixel is independent of $d$
- hence, under ambient light subjects don’t dim with distance, but under flash illumination they dim quadratically!
- to double the distance a flash can reach (~guide number), you must increase its luminous intensity (power per sr) by $4 \times !!
Metering for flash photography
(Canon E-TTL or Nikon iTTL, including Nikon D40)

✦ on shutter half-press, focus under ambient light (or AF assist light) and meter for ambient light
✦ on shutter press, fire weak preflash and record on flash sensor
✦ compute some combination of aperture, flash duration, and ISO
  • decision uses multi-point metering of ambient light, multi-point autofocusing, shooting mode, etc.
✦ flip up mirror, open shutter, and fire flash

✦ drawbacks
  • fooled by specular objects, scenes that fool metering and focusing,...
  • delay between pre-flash and flash is long enough to cause some people to blink, especially if using 2nd curtain sync
Second-curtain sync

1\textsuperscript{st} curtain sync

shutter open

20 ms
Second-curtain sync

ambient light only

shutter open

20 ms

2nd curtain sync
Derrick Story, card flip using second-curtain flash
Color temperature of xenon flash

- broad spectrum, approximates daylight (6500°K, i.e. D65)
- if mixed with ambient tungsten light, flash will look blue if WB is Tungsten, or background will look orange if WB is Flash
  - can compensate with color correction filter on the flash
  - filters are enumerated in °K of correction
  - filters reduce effective flash power
Other flash features

- flash exposure lock (FEL)
- flash exposure compensation (FEC)
- flash exposure bracketing (FEB)
- strobe modes
- speciality flashes, like ring flash
- wireless master-slave
  - uses light pulses to pass messages, not radio!

- check out http://photonotes.org/articles/eos-flash/index2.html
Master-slave metering and firing

- three flash units
  - A. left side of ring flash
  - B. right side of right flash
  - C. disconnected flash

20 ms
Master-slave metering and firing

A and B fire (on-camera)
Master-slave metering and firing

C instructed to fire via light pulses (off-camera)
Master-slave metering and firing
Master-slave metering and firing

Thinking...
Master-slave metering and firing

C told how bright it should be
Master-slave metering and firing

Everyone fires
Problems with flash

- power falls as distance squared
  - subject is too bright
  - background is too dark
- in-camera flash is too close to lens
  - no shadows on subject
  - shadow of lens in wide-angle view
- red-eye
  - worse with in-camera flash
  - worse in low light (pupils are wide open)
  - pre-flash to shrink pupils, which looks better anyway
- shutter speed must be low enough that shutter is completely open
  - 1/90 - 1/250 sec on Canon EOS cameras ("flash synch speed")
  - limits the range of shutter speeds for fill-flash
- don’t shoot perpendicularly into glass
compute ambient + flash – features in sum that don’t appear in ambient alone (as determined from image gradients) (except where ambient image is nearly black)
Multi-flash photography
[Raskar SIGGRAPH 2004]

✦ flash photographs cast small shadows in one direction
✦ flash image minus no-flash image = shadow-only image
✦ repeat from several directions and add shadow-only images
Slide credits

✦ Andrew Adams