Photographic lighting

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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>$h_q$</th>
<th>dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>overcast sky</td>
<td>uniform source</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>4</td>
</tr>
<tr>
<td>Cyberware™ scanner</td>
<td></td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>fluorescent tube</td>
<td>linear source</td>
<td>$\infty$</td>
<td>0</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>3</td>
</tr>
<tr>
<td>sunlight</td>
<td>point source at infinity</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>uniform distribution of rays in a plane</td>
<td>$\infty$</td>
<td>0</td>
<td>$\infty$</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>louvered linear source (see text)</td>
<td>fan of rays perpendicular to a linear source</td>
<td>$\infty$</td>
<td>0</td>
<td>0</td>
<td>$\infty$</td>
<td>2</td>
</tr>
<tr>
<td>small panel light</td>
<td>point source</td>
<td>0</td>
<td>0</td>
<td>$\infty$</td>
<td>$\infty$</td>
<td>2</td>
</tr>
<tr>
<td>sunlight through crack in doorway</td>
<td>parallel rays in a plane</td>
<td>$\infty$</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>$\infty$</td>
<td>1</td>
</tr>
<tr>
<td>spotlight or laser</td>
<td>single ray</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Geometry for table on previous slide (contents of whiteboard)

- $h_x$ 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
Yousuf Karsh, Winston Churchill, 1941
Yousuf Karsh, Audrey Hepburn 1956
Yousuf Karsh, Peter Lorre, 1946
Photography in available light

- challenging
- worthwhile
- requires patience and luck
- always carry your camera
Yousuf Karsh,
Georgia O’Keeffe, 1956
Richard Avedon, Oil Field Worker, 1980
Richard Avedon, Sandra Bennett, 1980
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

(Kodak) © Marc Levoy
Basic portrait lighting

main/key

fill

accent/rim

background
Basic portrait lighting
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
Alternative names for arrangements

- broad lighting is sometimes called Rembrandt lighting
  - note triangular light on her left cheek (right side of image)
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)
Professional photographic lighting manuals

- darkfield lighting
- took all day to set up
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
Stanford Cuneiform Visualization Project

- in a photograph, it’s hard to see marks along tablet edges
- also, raking illumination favors strokes of one orientation

original tablet  scanned 3D model  unwrapped surface relief  non-photorealistic shading

(Nissen)
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)
Recap

- lighting can be classified by its *spatial spread* (point vrs. line vrs. area) and by its *angular spread* (parallel rays vrs. diffuse)

- point lights (like flash) or parallel rays (like sunlight) create hard shadows, while diffuse area lights create soft shadows (containing both *umbra* and *penumbra*)

- to change its character, lighting can be focused by lenses, diffused by cloth or by reflection from *boards* or *umbrellas*, colored by *gels*, etc.

- portrait lighting is typically divided into *key* and *fill* lights, with varying positions, ratios, & colors, plus *rim* or *background* lights

- special subjects require special treatment, such as *darkfield* lighting, diffuse reflectors, cards, flags, grazing light, etc.

Questions?
When to use flash?

- freezing the action
- fill-flash
- flash-plus-ambient
- flash as a fill light
- ways to avoid using flash
Lois Greenfield,
dance photography,
1983-1988
Lois Greenfield,
dance photography,
1983-1988
Fill-flash (for brightly lit backdrops)

- shorten exposure, then add flash
- could instead use HDR, but that requires multiple shots

exposed for foreground

exposed for background

exposed for background, with fill flash

(London)
Flash-plus-ambient (in low light)

- use flash, and lengthen exposure
- avoids isolating the foreground from its background
Flash as a fill light

- golden hour sun + off-camera fill flash
  (Canon 5D Mark II, Speedlite 580EX, orange gel)

as cameras get more sensitive, flash is less frequently needed when the scene is dark, but it’s still useful for changing the light balance or color.
How was this shot lit?

- key flash (on right side of scene) with orange gel & umbrella
- fill flash (extreme left side of scene) with no gel or diffuser
- background flash (pointed at back wall) with blue gel

(Linda Cicero)
How was this shot lit?

- flash with orange gel bounced off wall behind camera + rim light from nearby desk lamp
- flash behind camera controlled from camera by radio (e.g. Pocket Wizard)
Avoiding flash

straight shot with graduated neutral-density filter

(Peterson)
Flash placement

- Direct flash, on camera
- Direct flash, off camera
- Bounce flash, from above
- Bounce flash, from the side

(London)
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

Canon 430EX at low power

1 ms

Canon 430EX at high power
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 (contents of whiteboard)

- if you treat flash as a point source, then illuminance (power per unit area) arriving on a subject from the flash falls as \(d^2\) (left drawing above)

- for extended diffuse area sources (larger than a pixel in the photograph):
  - the solid angle captured from each point falls as \(d^2\) (center drawing)
  - but the number of points seen by the pixel rises as \(d^2\) (right drawing)
  - these effects cancel, so the illuminance at a pixel is independent of \(d\)

- hence, under ambient light subjects don’t dim with distance from the camera, but if illuminated by on-camera flash they dim quadratically; to double the distance a flash can reach, increase its power per sr by 4×
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 2\textsuperscript{nd} curtain sync
Derrick Story, card flip using second-curtain flash
Stanford programmable Frankencamera with 2 flash heads attached

- Canon 430EX (smaller flash) strobed continuously
- Canon 580EX (larger flash) fired once at end of exposure
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
  - radio controls are also available (e.g. Pocket Wizard)

- check out http://photonotes.org/articles/eos-flash/index2.html
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
Recap

- Flash can be used to freeze the action, as *fill-flash* for bright scenes, as *flash+ambient* for dark scenes, or as a fill light to change the balance or color of the lighting.

- To avoid the deer-in-the-headlights look of on-camera flash (and its lack of shadows, and red eye), use *off-camera flash*, via a cord or remote control, or *bounce flash* off a wall or umbrella.

- To adjust flash intensity, change its pulse duration; to adjust the amount of ambient light in the mix, adjust the shutter speed.

- Flash intensity is specified by a *guide number*:
  - F-number = guide number / distance to subject
  - $2 \times$ distance to subject $\rightarrow 2 \times$ F-number $\rightarrow 4 \times$ illuminance
  - But under ambient light, large subjects don’t dim with distance.

Questions?
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

- For a great tutorial on off-camera flash lighting, see http://strobist.blogspot.com