6.A44 Computational Photography

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- Focal length
- Shutter
- Aperture
- Reciprocity
- DoF
  - Focal
  - Motion
  - Viewfinder
  - ISO
  - Metering
  - AF

Pinhole imaging

Focal length: pinhole optics

- Verify focal length equivalence of pinhole and lens
- What is the view angle for a given focal length & 24x36mm film

Lenses

Focal length: pinhole optics

- What happens when the focal length is doubled?
  - Projected object size
  - Amount of light gathered
Focal length: pinhole optics

- What happens when the focal length is doubled?
- What happens when the scene is twice as far?
- How do we get the same relative object size when the focal length is doubled?
  - What is the difference then?
  - Is it equivalent to get closer and to zoom in?

Perspective vs. viewpoint

- Focal lens does NOT ONLY change subject size
- Same size by moving the viewpoint
- Different perspective (e.g. background)

- Telephoto makes it easier to select background (a small change in viewpoint is a big change in background).
- Martin Scorsese, Good Fellas
- Moves camera as you zoom in
- Better known as the Hitchcock Vertigo effect

Perspective vs. viewpoint

- Portrait: distortion with wide angle
- Why?

- What happens when the film is half the size?
- Application:
  - Real film is 36x24mm
  - On the 20D, the sensor is 22.5 x 15.0 mm
  - Conversion factor on the 20D?
  - On the SD500, it is 1/1.8 " (7.18 x 5.32 mm)
  - What is the 7.7-23.1mm zoom on the SD500?
Shutter

- Most of the time, the film/sensor is protected from light
- When we take a picture, the shutter opens and closes, thereby exposing the film.
- Exposure is proportional to the time the shutter is open
- Expressed in fraction of a second (1/60s, 1/125s, 1/250s, 1/500s, etc.)

Two types of shutter
The two-blind system (right) is most common

Effect of shutter speed

- Longer shutter speed ⇒ more light, but more motion blur
- Faster shutter speed freezes motion

Shutter speed and focal length

- Because telephoto "magnify", they also magnify your hand shaking
- Telephotos therefore require faster shutter speed
- Rule of thumb:
  - The slowest shutter speed where normal human can hand-hold and get a sharp picture is 1/f. For example, a 500mm requires 1/500 s or higher.
  - Solution: Image stabilization
    - mechanically compensates for vibration
    - Can gain 2 or 3 shutter speeds (1/125 or 1/60 for a 500mm)
Your best friend

• Use a tripod! It will always enhance sharpness

Exposure

• Two main parameters:
  – Aperture (in f stop)
  – Shutter speed (in fraction of a second)

Aperture

• Diameter of the lens opening (controlled by diaphragm)
• Expressed as a fraction of focal length, in f-number
  – f/2.0 on a 50mm means that the aperture is 25mm
  – f/2.0 on a 100mm means that the aperture is 50mm
• Disconcerting: small f number = big aperture
• What happens to the area of the aperture when going from f/2.0 to f/4.0?
  – Typical f numbers are f/2.0, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22, f/32
    – See the pattern?

Lens

• Gather more light!

Aperture & physical lens size

• On telephoto, the lens size is directly dictated by the max (that is min) f number
• Other lenses, not always clear
• The aperture can be internal or not

• Zoom lenses usually have a variable maximal aperture
  – Why?

Exposure

• Two main parameters:
  – Aperture (in f stop)
  – Shutter speed (in fraction of a second)

• Reciprocity
  – The same exposure is obtained with an exposure twice as long and an aperture area half as big
    – Hence square root of two progression of f stops vs. power of two progression of shutter speed
  – Reciprocity can fail for very long exposures
Exposure & metering

- The camera metering system measures how bright the scene is
  - We’ll see how it’s done

- In Aperture priority mode, the photographer sets the aperture, the camera sets the shutter speed

- In Shutter-speed priority mode, the photographers sets the shutter speed and the camera deduces the aperture
  - In both cases, reciprocity is exploited

- In Program mode, the camera decides both exposure and shutter speed (middle value more or less)

- In Manual, the user decides everything (but can get feedback)

Pros and cons of various modes

- Aperture priority (My favorite, I use it 90% of the time)
  - Direct depth of field control
  - Cons: can require impossible shutter speed (e.g. with f/1.4 for a bright scene)

- Shutter speed priority
  - Direct motion blur control
  - Cons: can require impossible aperture (e.g. when requesting a 1/1000 speed for a dark scene)
  - Note that aperture is somewhat more restricted

- Program
  - Almost no control, but no need for neurons

- Manual
  - Full control, but takes more time and thinking

Metering

- Photosensitive sensors measure scene luminance

- Most cameras then use a center-weighted average
  - Can fail if scenes are very white or very black
  - Nikon has a more advanced system (3D matrix)

SLR view finder

- Reflex (R in SLR) means that we see through the same lens used to take the image
- Not the case for compact cameras
- Pros and cons?
SLR anatomy

Depth of field
- Two views: object-centered or sensor-centered

- Same in front of focusing distance
  - Except focuses behind the film

- We allow for some tolerance
  - Depth of field

- What happens when we close the aperture by two stop?
  - Aperture diameter is divided by two
  - Depth of field is doubled

DoF Depends on aperture
Depth of field

- Depends on aperture and lens
- Selective focus

In reality, we would be able to shift focus
This is refused to us
The photographer rules

Depth of field depends on focusing distance

- What happens when we divide focusing distance by two?
  - Similar triangles => divided by two as well

Depth of field depends on focal length

- Remember definition of f stop

<table>
<thead>
<tr>
<th>Focal Length</th>
<th>Depth of Field</th>
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<tbody>
<tr>
<td>150mm</td>
<td>5 ft (1.5 m)</td>
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<tr>
<td>50mm</td>
<td>10 ft (3 m)</td>
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<tr>
<td>28mm</td>
<td>20 ft (6 m)</td>
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<table>
<thead>
<tr>
<th>Focusing Distance</th>
<th>Depth of Field</th>
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<tbody>
<tr>
<td>30 ft (9 m)</td>
<td>5 ft (1.5 m)</td>
</tr>
<tr>
<td>20 ft (6 m)</td>
<td>10 ft (3 m)</td>
</tr>
<tr>
<td>15 ft (4.5 m)</td>
<td>15 ft (4.5 m)</td>
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Depth of Field

- It's all about the size of the lens aperture

Assignment 1: Aperture/Speed

- Four pictures
  - Shallow depth of field to isolate the subject
  - Long depth of field to relate elements at different depths
  - Fast shutter speed to freeze motion
  - Slow shutter speed for motion blur

Assignment 2:

- Take one picture with the D1 of a subject of your choice and explain your choice of aperture and shutter speed.
  - Advice: go for extremes to better experiment
  - This is an exercise in collaboration and organization! Do schedule and synchronize!
- I want your photo by email by Monday at noon.