



6.A44 Computational Photography

Frédo Durand

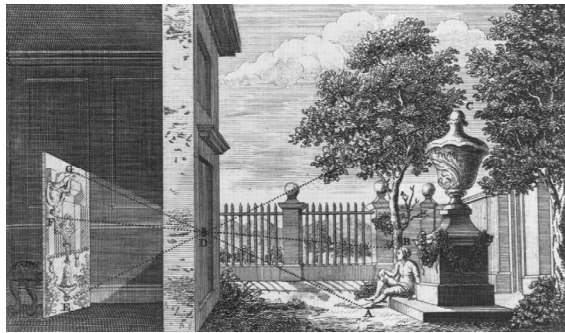


- Focal length
- Shutter
- Aperture
- Reciprocity
- DoF
 - Focal
- Motion
- Viewfinder
- ISO
- Metering
- AF

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Pinhole imaging

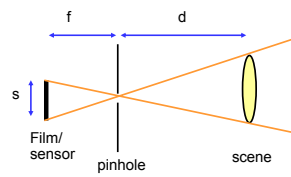


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Focal length: pinhole optics

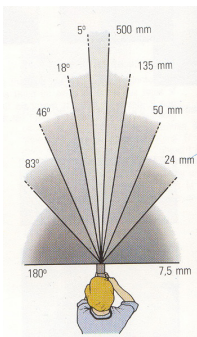
- Verify focal length equivalence of pinhole and lens
- What is the view angle for a given focal length & 24x36mm film



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Lenses



24mm



50mm



135mm

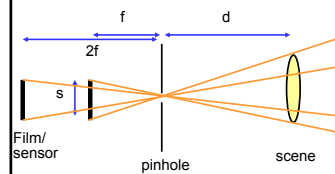


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Focal length: pinhole optics

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



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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?

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Perspective vs. viewpoint

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

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Perspective vs. viewpoint

- Telephoto makes it easier to select background (a small change in viewpoint is a big change in background).

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Perspective vs. viewpoint

- Martin Scorsese, Good Fellas
- Moves camera as you zoom in
- Better known as the Hitchcock Vertigo effect

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Perspective vs. viewpoint

- Portrait: distortion with wide angle
- Why?

Wide angle Standard Telephoto

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Focal length: pinhole optics

- 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?

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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

Blade (closing) Blade (open) Focal plane (closed) Focal plane (open)

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Shutter

Figure 6-6. Jacques Henri Lartigue, *Grand Prix of the Automobile Club of France, 1912*. This classic photograph provides an exaggerated example of the distortion that can be caused by a focal-plane shutter. The oval shape of the automobile tire is caused by the motion of the car between the time the bottom of the tire was exposed and the top. [Remember—the image is upside-down on the negative!] The same principle caused the leaning appearance of the spectators. Lartigue turned the camera to follow the automobile (panning), and thus the image of the spectators moved at the film plane during the exposure. [Courtesy International Museum of Photography at George Eastman House.]

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Effect of shutter speed

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

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Effect of shutter speed

- Freezing motion

Walking people	Running people	Car	Fast train
1/125	1/250	1/500	1/1000

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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
 - E.g., 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)

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Your best friend

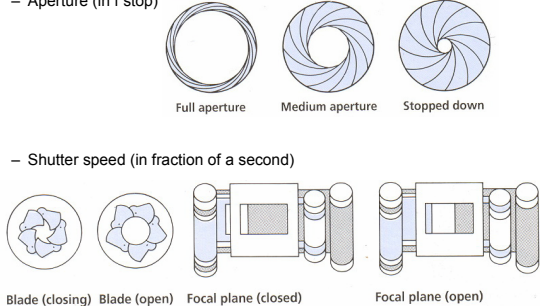
- Use a tripod! It will always enhance sharpness



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Exposure


- Two main parameters:
 - Aperture (in f stop)
 - Full aperture
 - Medium aperture
 - Stopped down
 - Shutter speed (in fraction of a second)
 - Blade (closing)
 - Blade (open)
 - Focal plane (closed)
 - Focal plane (open)



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Aperture

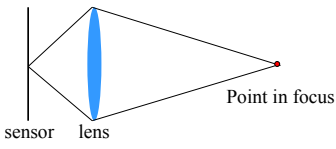
- Diameter of the lens opening (controlled by diaphragm)
- Expressed as a fraction of focal length, in f-number
 - f/2.0 on a 50mm means that the aperture is 25mm
 - f/2.0 on a 100mm means that the aperture is 50mm
- Disconcerting: small f number = big aperture
- What happens to the area of the aperture 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?



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Lens

- Gather more light!



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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




Figure 2-1 When a diaphragm is located in front of a lens, the effective aperture is the same as the aperture or diaphragm opening.

Figure 2-2 A diaphragm will transmit more light when located behind the lens than in front.

- Zoom lenses usually have a variable maximal aperture
 - Why?

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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

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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)**

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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

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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)

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SLR view finder

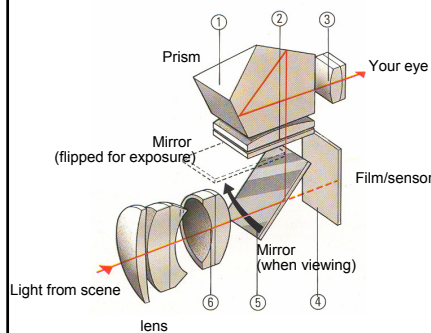
- **Reflex (R in SLR) means that we see through the same lens used to take the image.**
- **Not the case for compact cameras**
- **Pros and cons?**



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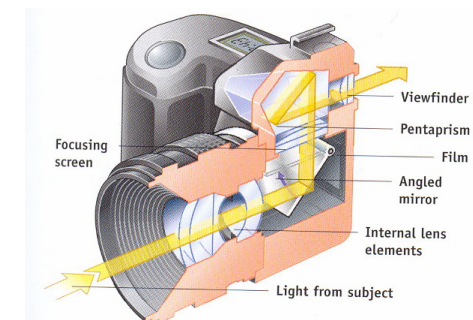
SLR view finder



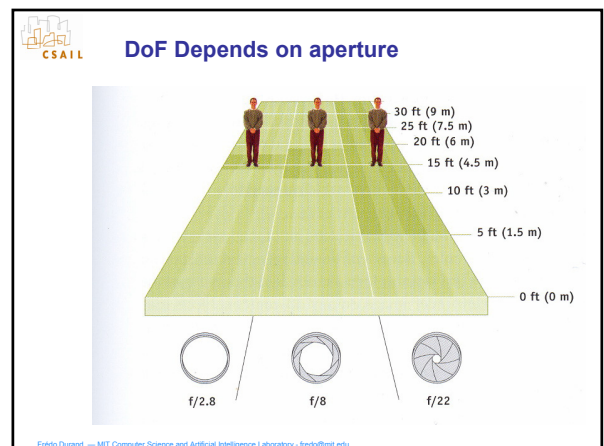
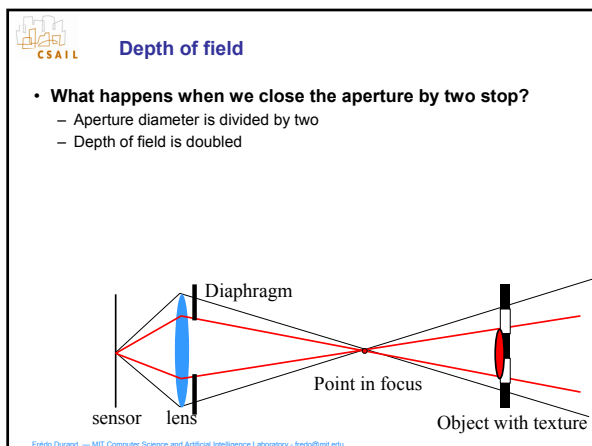
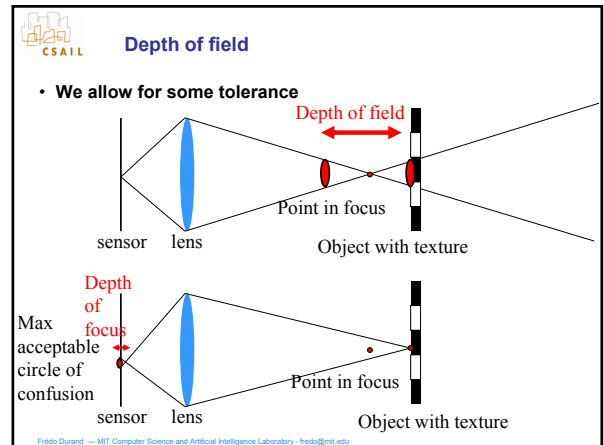
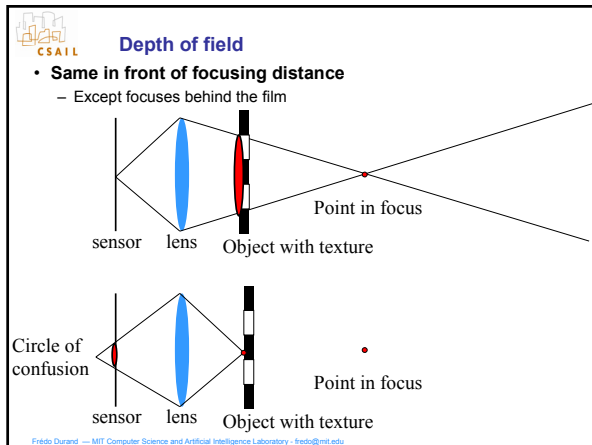
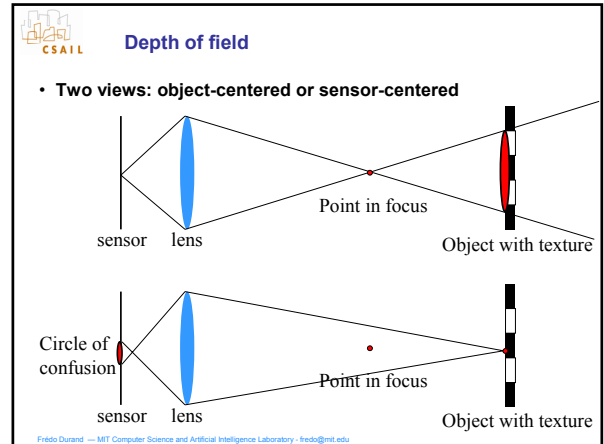
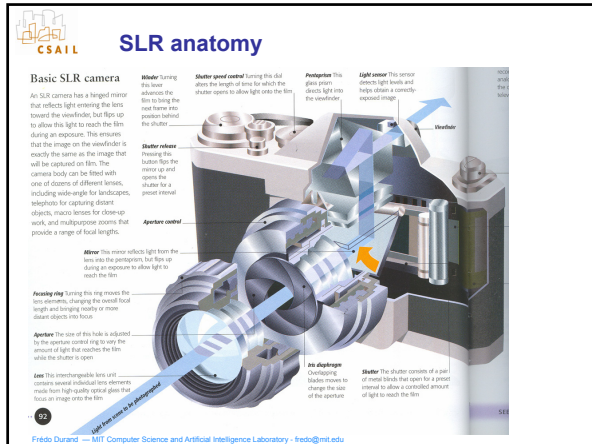
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SLR view finder

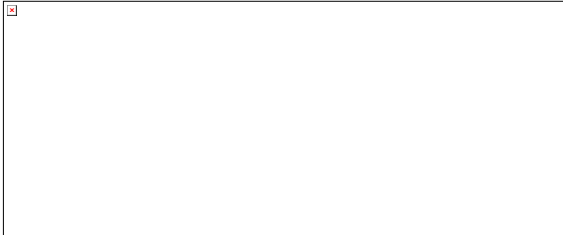


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CSAIL **Depth of field**

- Depends on aperture and lens
- Selective focus



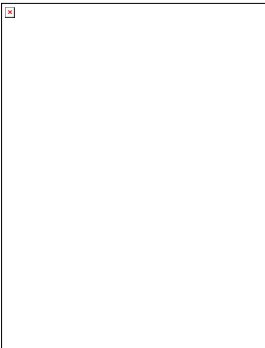
Snapshot-Perspective-Speed, aperture-Filter-Lighting-Processing & Print-Make up-Retouching

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CSAIL **Depth of field**

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

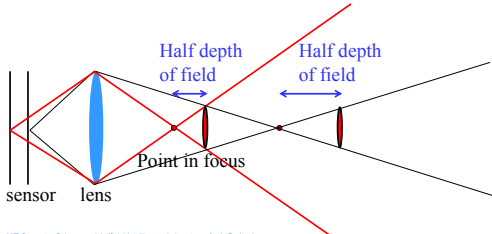


Snapshot-Perspective-Speed, aperture-Filter-Lighting-Processing & Print-Make up-Retouching

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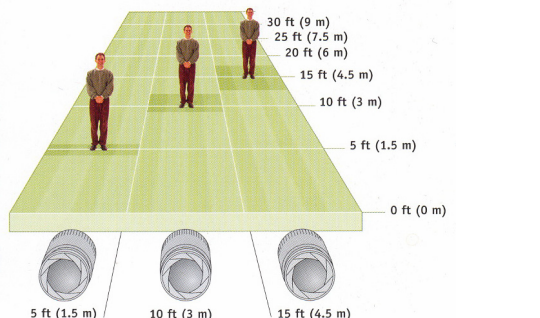
CSAIL **Depth of field depends on focusing distance**

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



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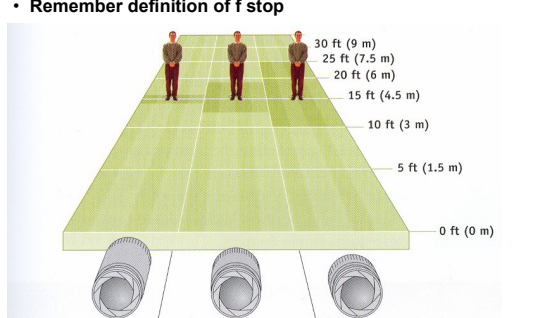
CSAIL **Depends on focusing distance**




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CSAIL **Depends on focal length**

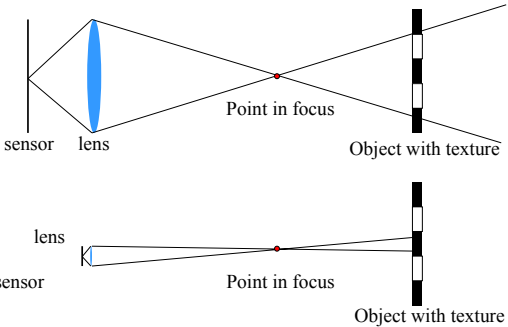
- Remember definition of f stop




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 **Depth of field**

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




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 **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

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 **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.**

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