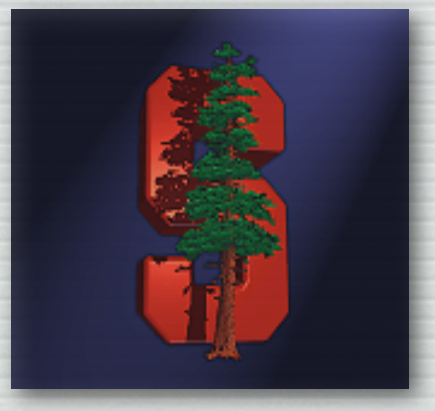
Autofocus (AF)

CS 178, Spring 2009



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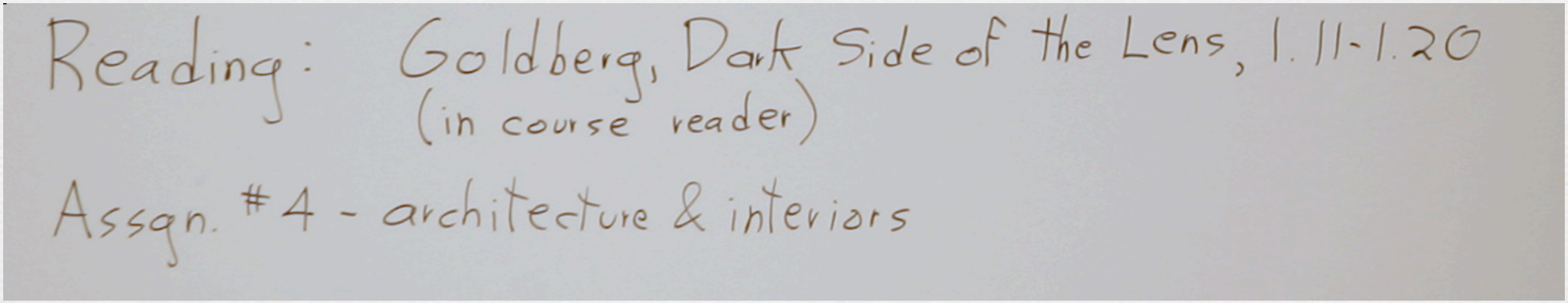
Stanford University

Announcements (from whiteboard)



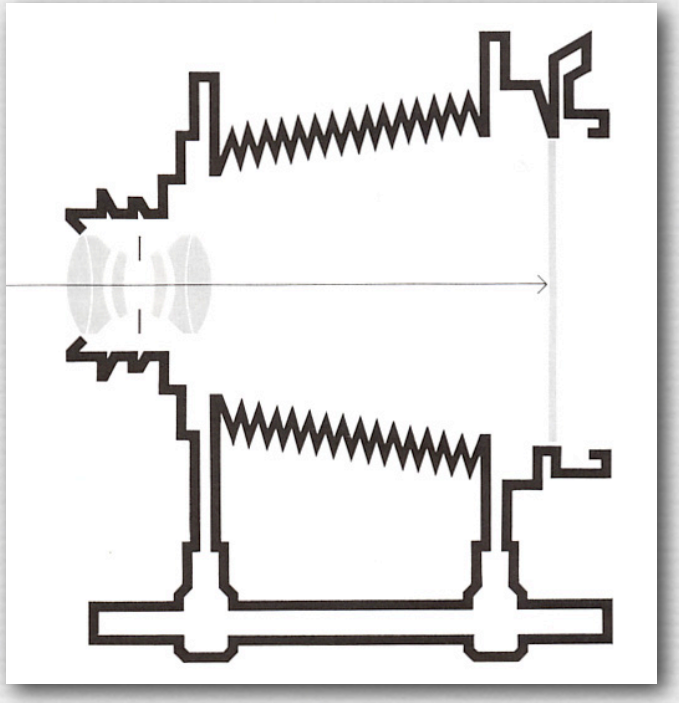
- bring cameras and student IDs to section this week!
  - so you can get into Green Library

Outline

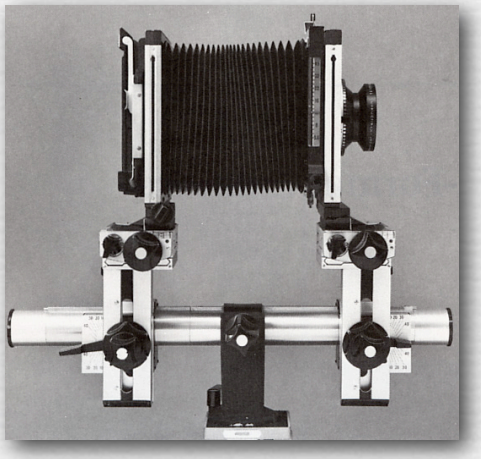
- viewfinders and manual focusing
- active autofocusing
  - time-of-flight
  - triangulation
- passive autofocusing
  - phase detection
  - contrast detection
- autofocus modes
- lens actuators

Large format camera with focusing screen

- 4×5” or 8×10” formats
  - film or scanned digital
- ground glass focusing screen
  - dim
  - hard to focus
  - inverted image



(Adams)

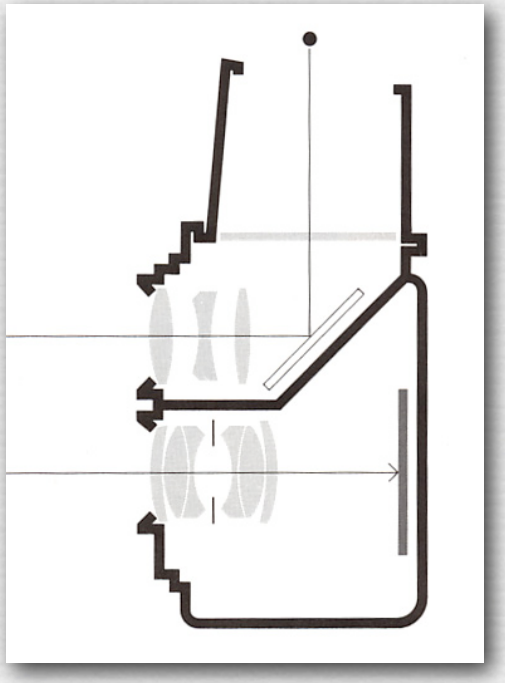


Sinar 4×5

Twin-lens reflex with focusing screen

- older medium format cameras
  - 2¼ × 2¼" film
- different perspective view than main lens sees

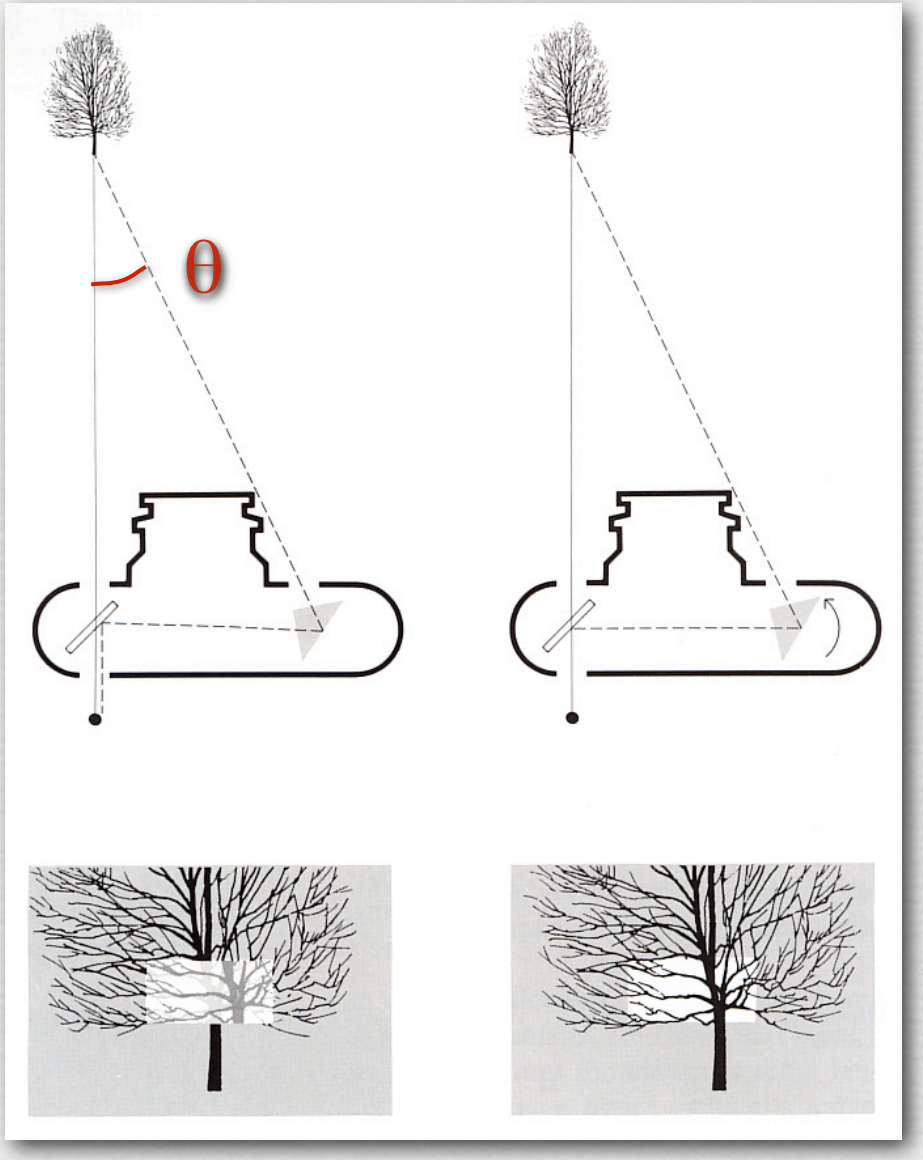
(Adams)



Manual rangefinder

- accurate
- painstaking
- different perspective view than main lens sees
- triangulation concept widely applicable

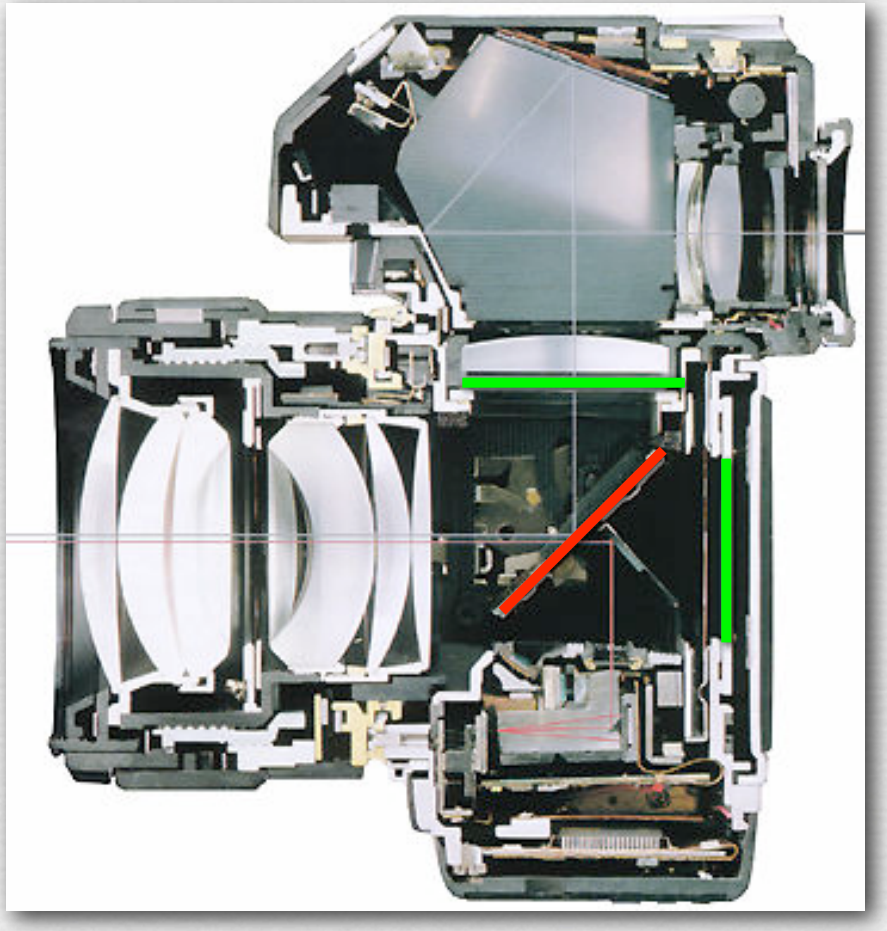
Leica



(Adams)

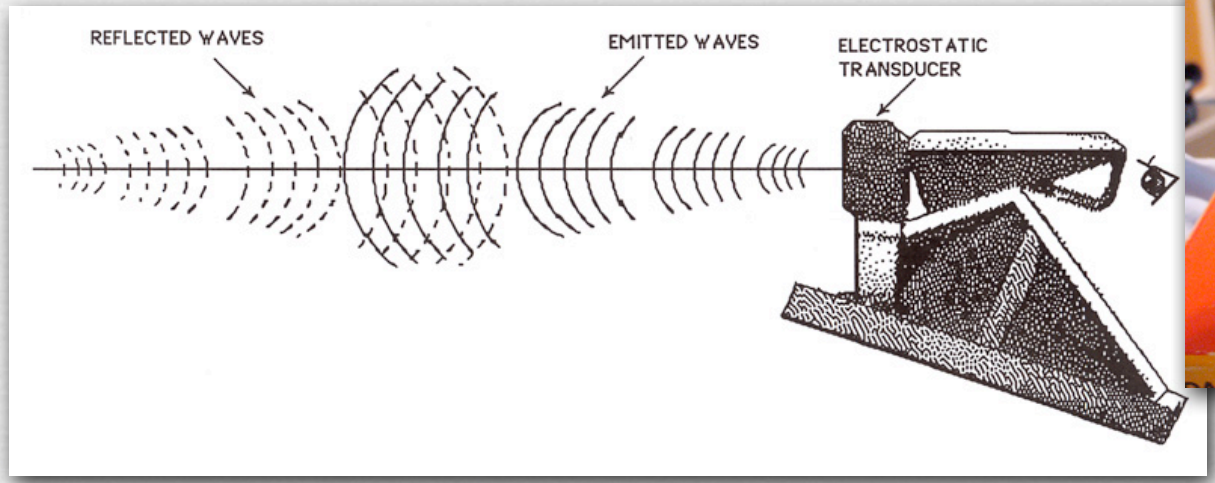
Single lens reflex with viewfinder

- image formed on focusing screen, seen (upright) through viewfinder
- same view as main lens
- mirror must be moved (quickly) to take picture
- manual or autofocus



Nikon F4

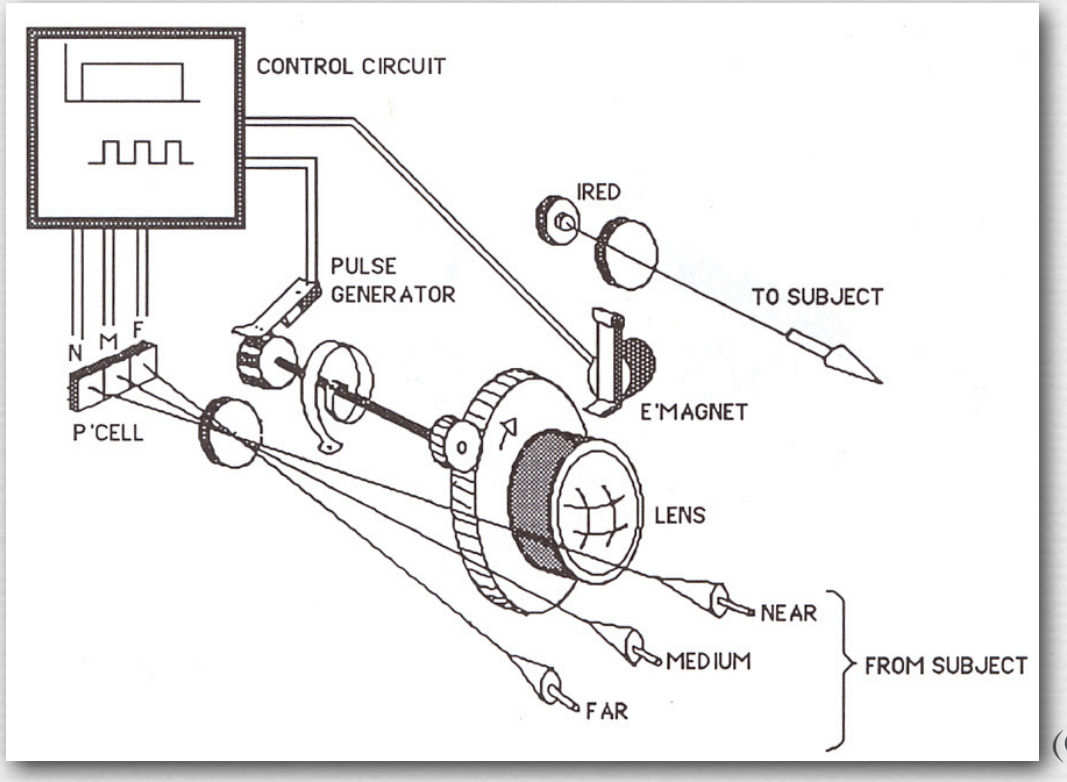
Active autofocus: time-of-flight



(Goldberg)

- SONAR = Sound Navigation and Ranging
- Polaroid system used ultrasound (50KHz)
  - well outside human hearing (20Hz - 20KHz)
- limited range, stopped by glass
- hardware salavaged and re-used in amateur robotics

Active autofocus: triangulation

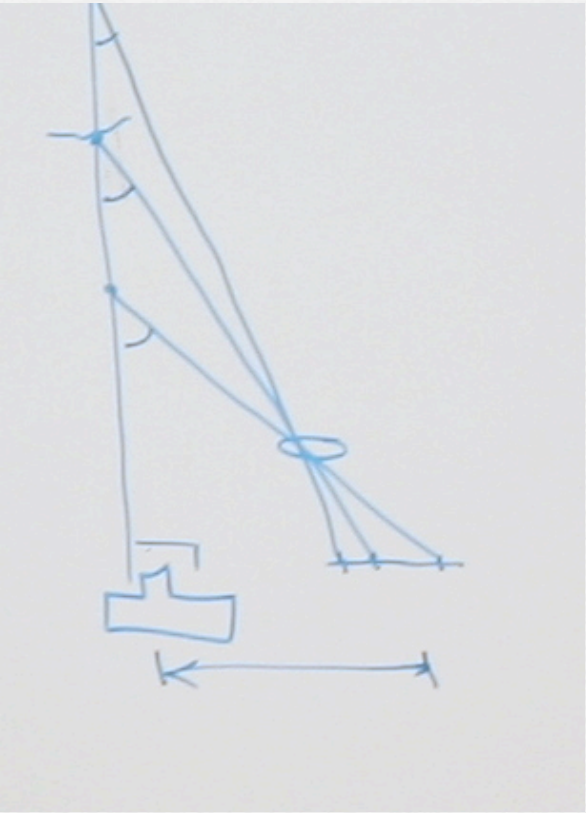


(Goldberg)

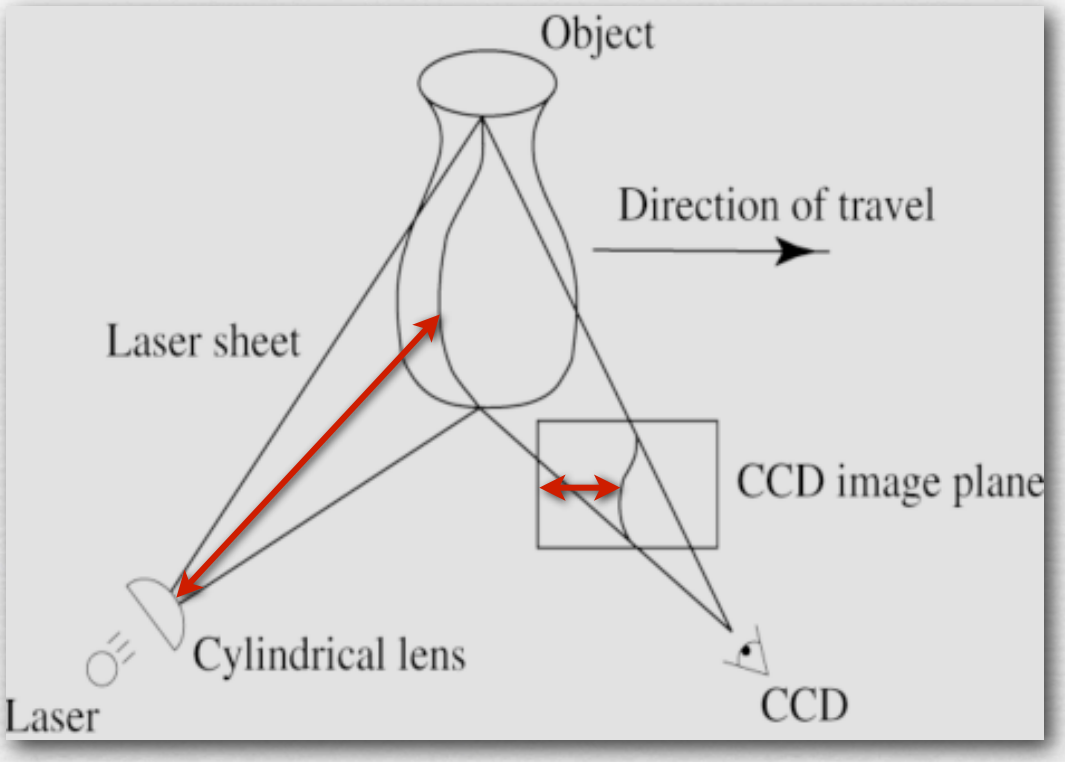
- infrared (IR) LED flash reflects from subject
- angle of returned reflection depends on distance
- fails on dark or shiny objects

Active autofocus: triangulation

- situation from previous slide, shown in plan view

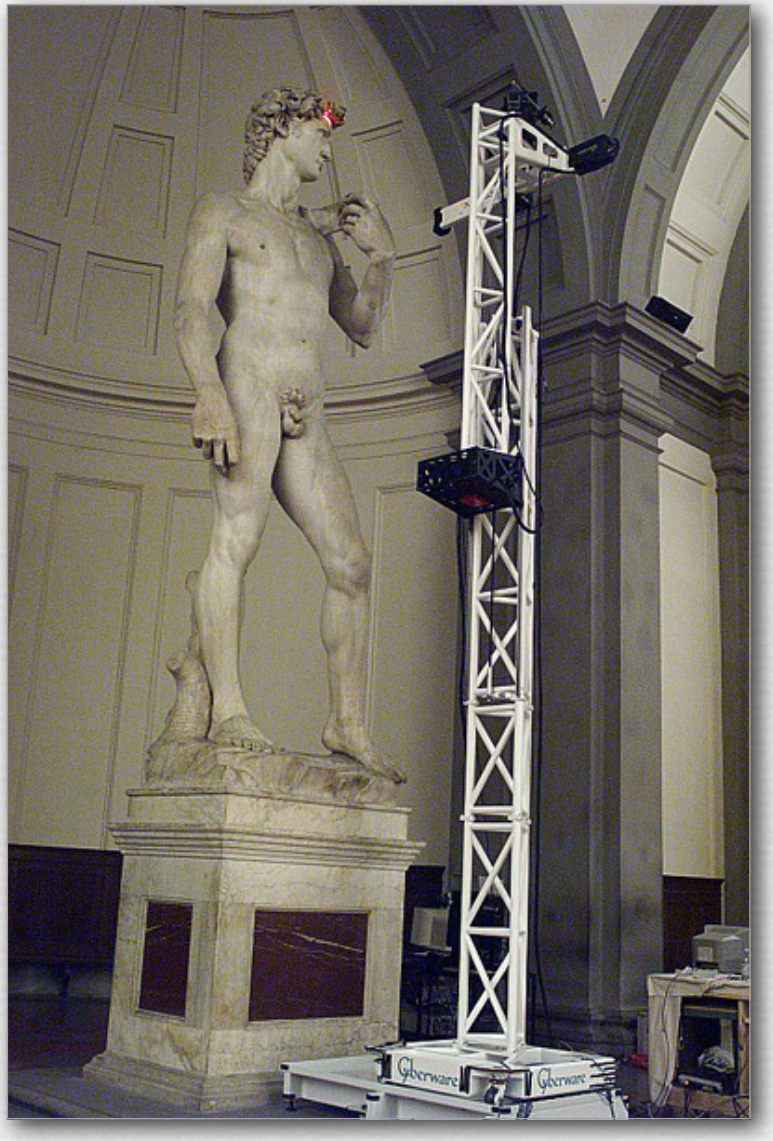


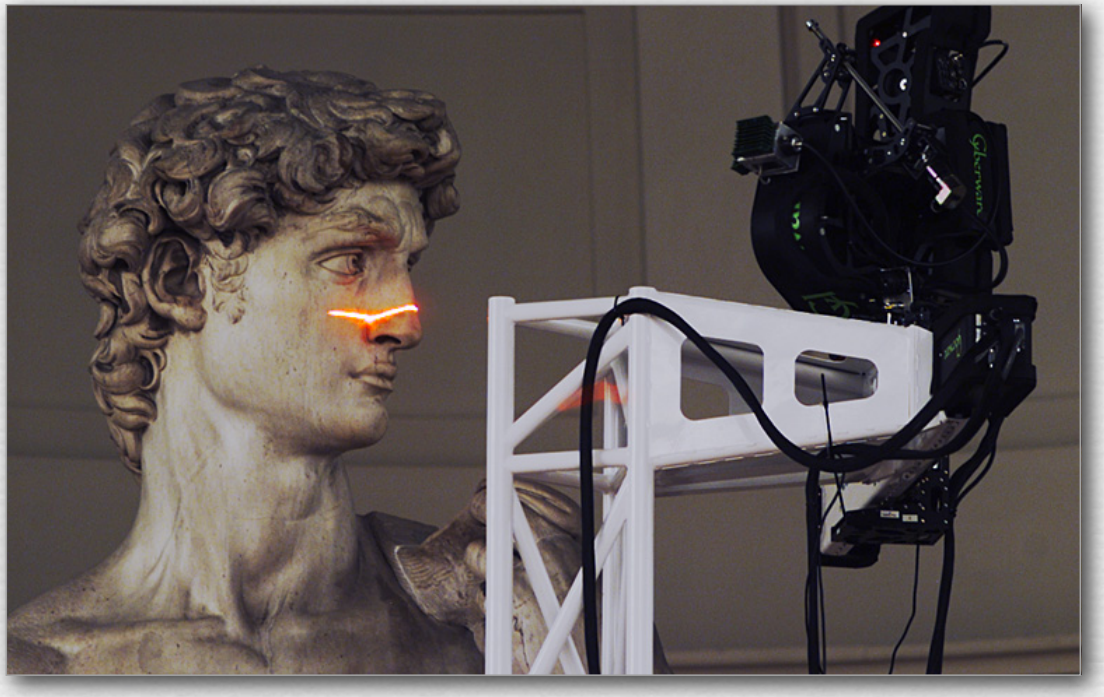
Sidebar:
laser triangulation rangefinding



- laser sheet illuminates a curve on the object
- distance from left edge of image gives distance from laser
- move object or sweep laser to create *range image* z(x,y)

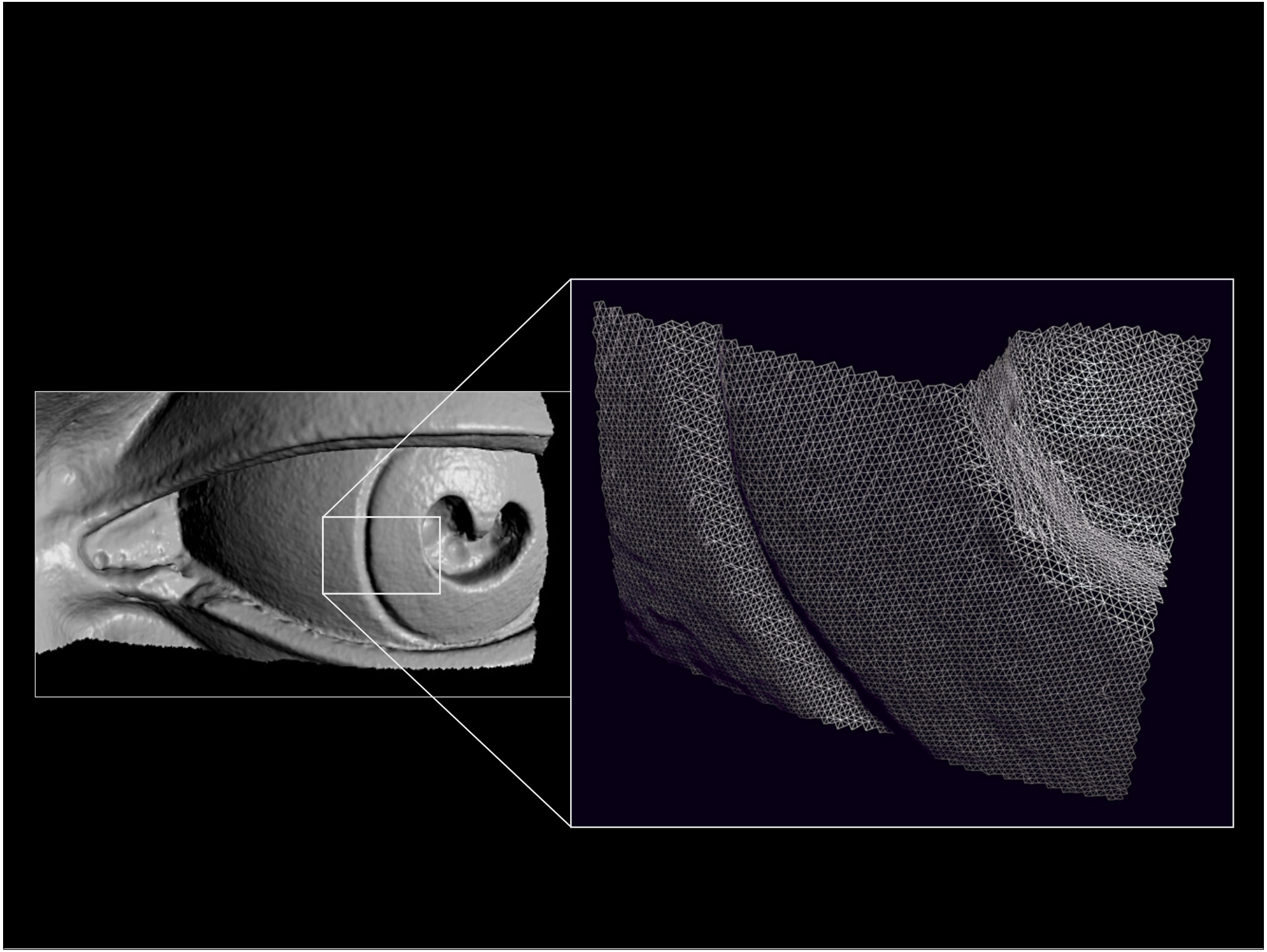
Scanning Michelangelo's David





- 480 range images
- 2 billion polygons
- 22 people × 30 nights

http://graphics.stanford.edu/projects/mich/

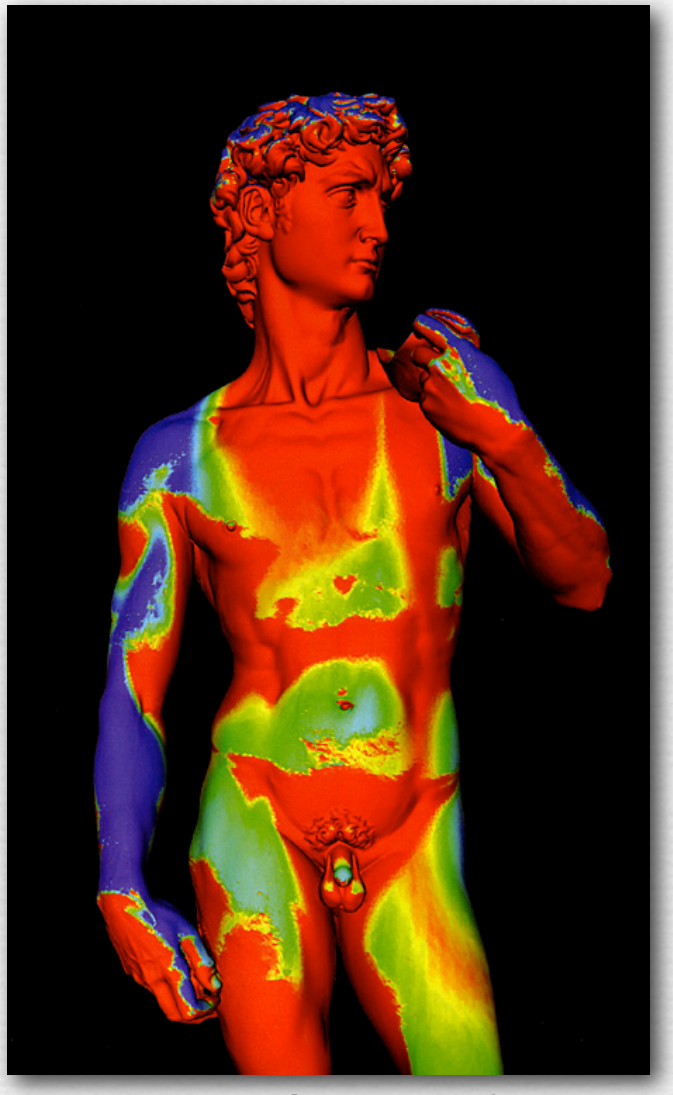


Uses of the 3D model

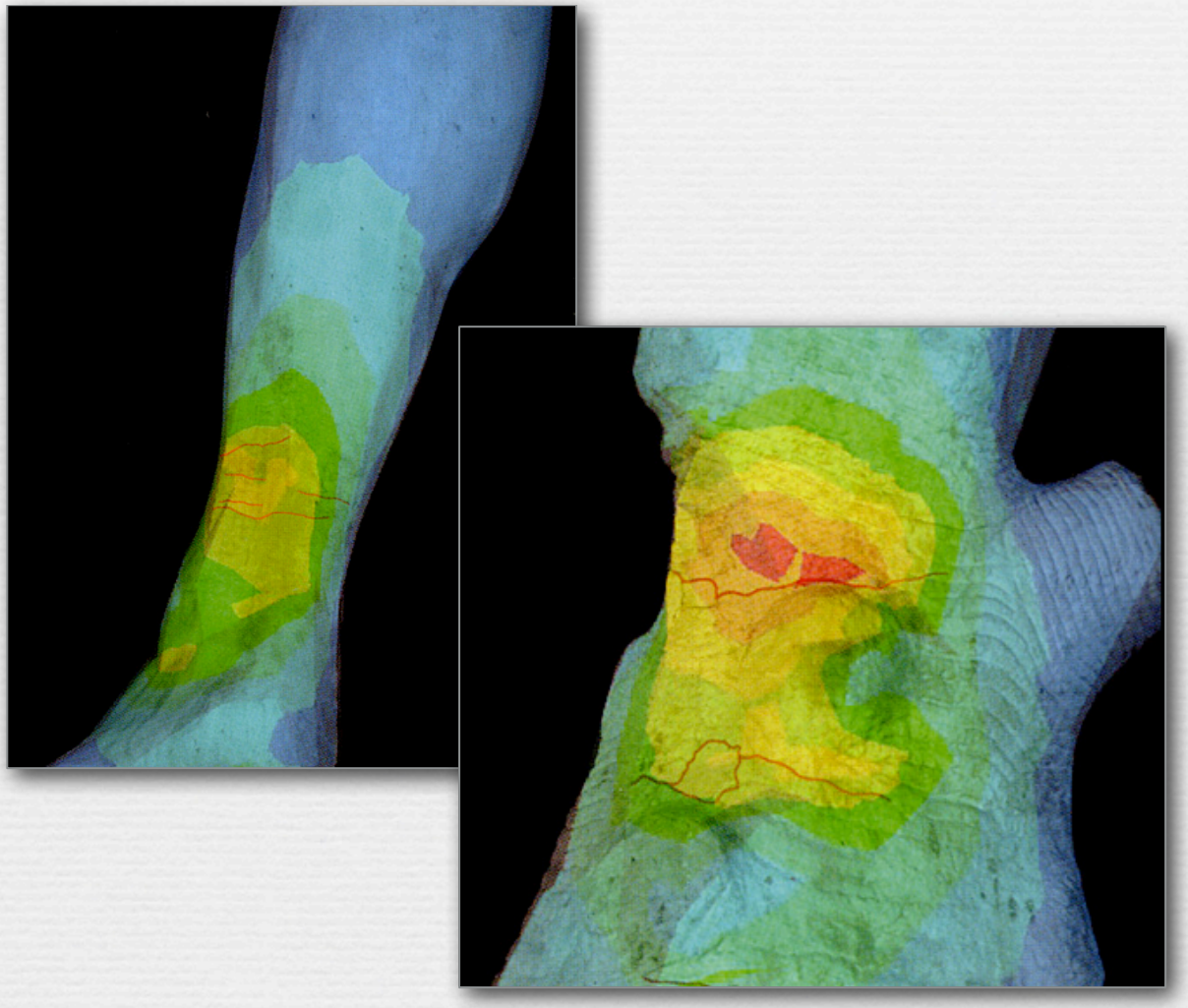
interactive kiosk

physical replica

Uses of the 3D model



scientific studies



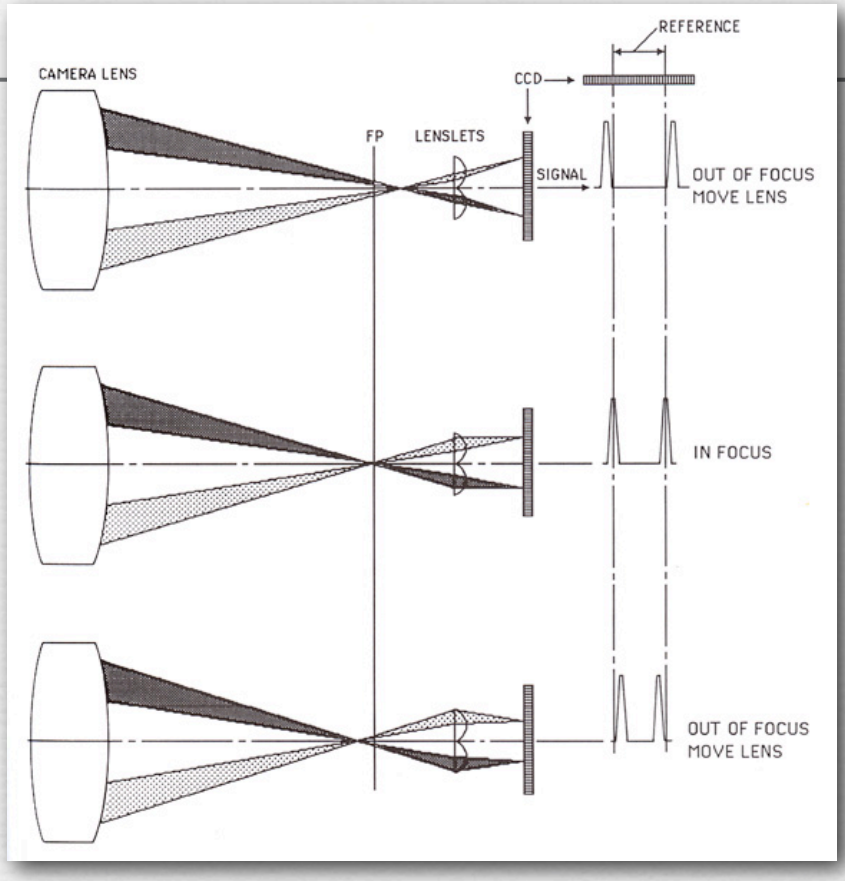
- commonly used to digitize physical maquettes to ease creation of 3D CG models

3D model

mocap

rendered

Passive autofocus: phase detection

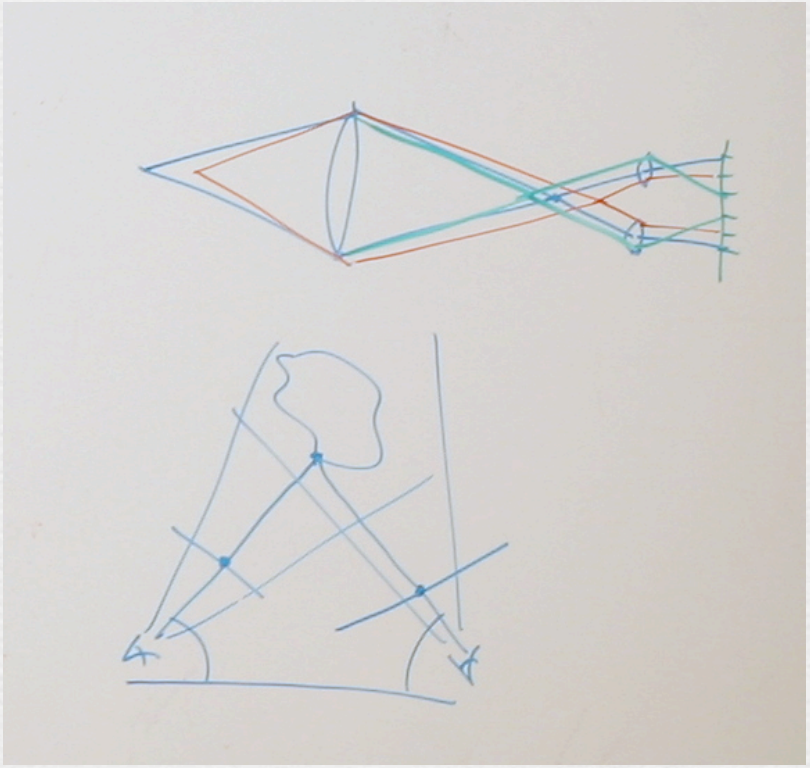


(Goldberg)

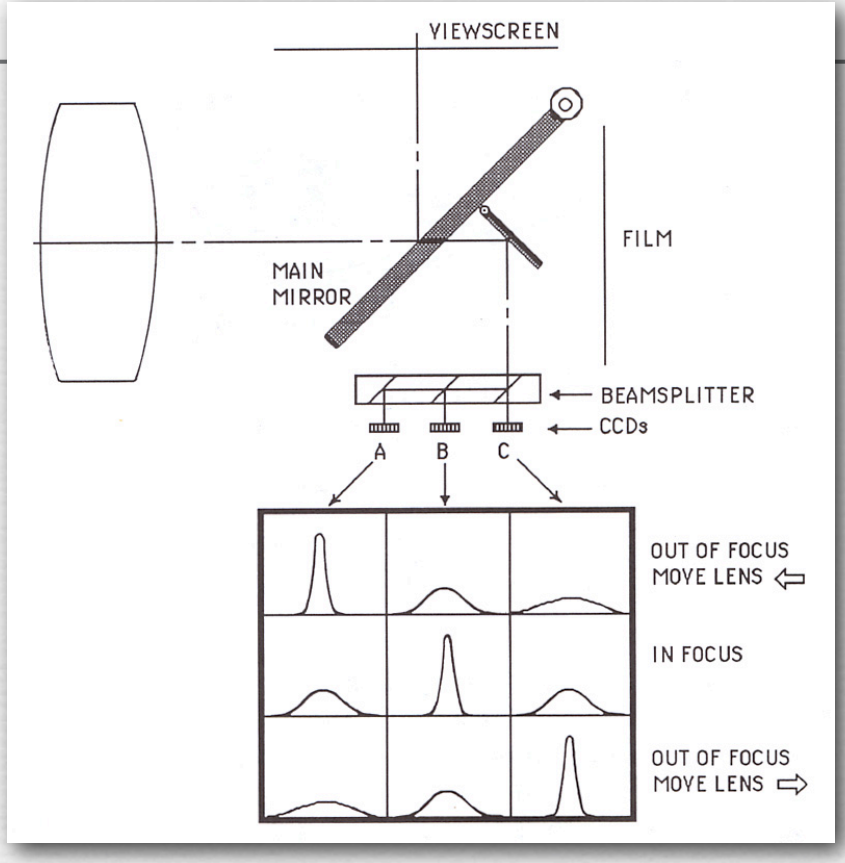
- as the lens moves, ray bundles from an object converge to a different point in the camera and change in angle
- this change in angle causes them to refocus through two lenslets to different positions on a separate AF sensor
- a certain spacing between these double images is "in focus"

Passive autofocus: phase detection

- situations at three focus settings from previous slide, drawn in different colors and shown in a single drawing
- at bottom is depth-from-stereo in computer vision, by finding corresponding object features in two views



Passive autofocus: contrast detection

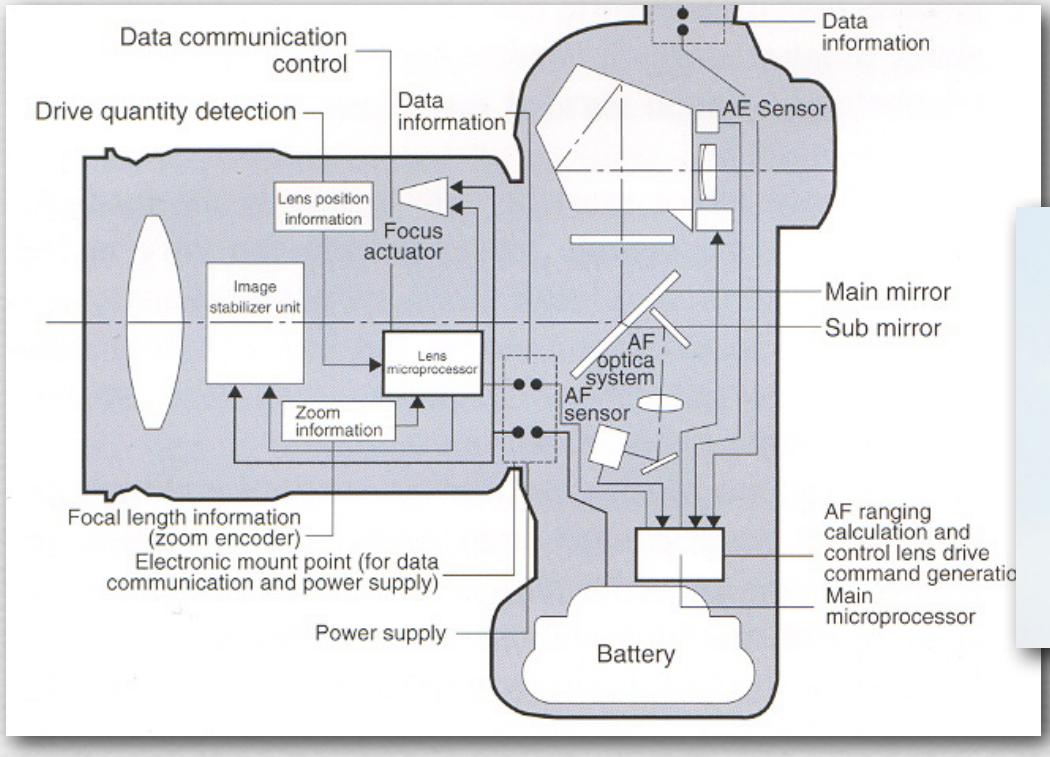


(Goldberg)

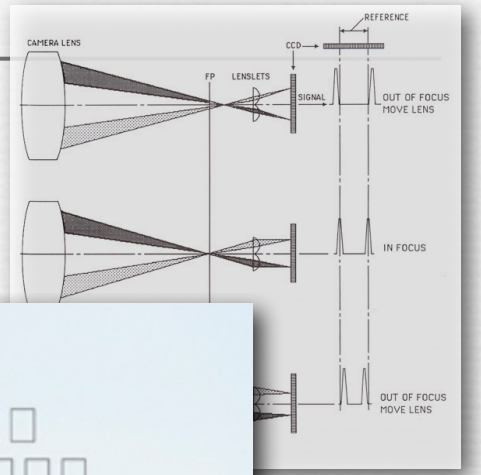
To reiterate something I said in class, modern point-and-shoot cameras use contrast detection, but they don't use 3 CCDs placed at different depths like this. They use only the main sensor, and they hunt around more (than would be required here) for the lens setting that produces the most contrasty image as recorded by that sensor.

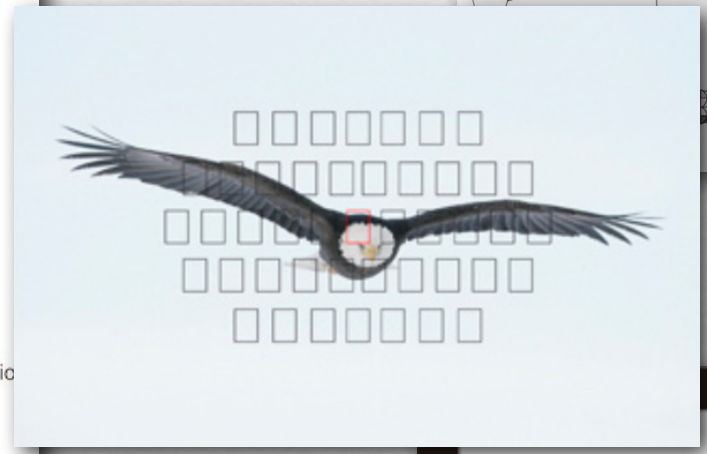
- sensors at different image distances will see the same object as contrasty if it's in focus, or of low contrast if it's not
- move the lens until the contrasty subimage falls on the middle sensor, which is conjugate to the camera's main sensor
- compute contrasty-ness using local differences of pixel values

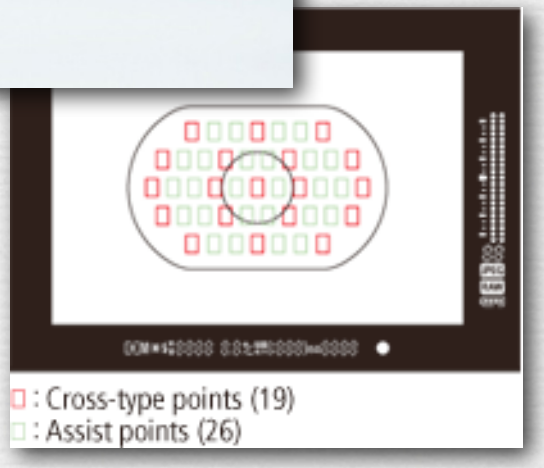
Most SLRs use phase detection



(Canon)



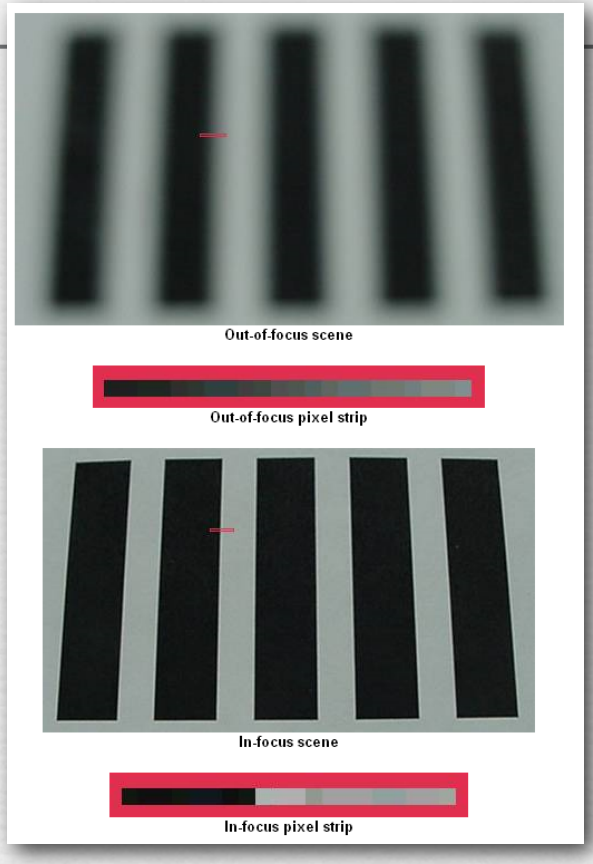


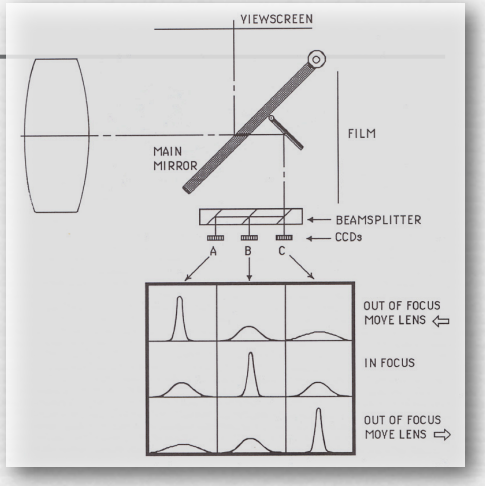


- distance between subimages allows lens to move directly into focus, without hunting
  - equivalent to depth-from-stereo in computer vision
- many AF points, complicated algorithms for choosing among them
  - generally use closest point, but also consider position in FOV

Most DSCs use contrast detection

(howstuffworks.com)





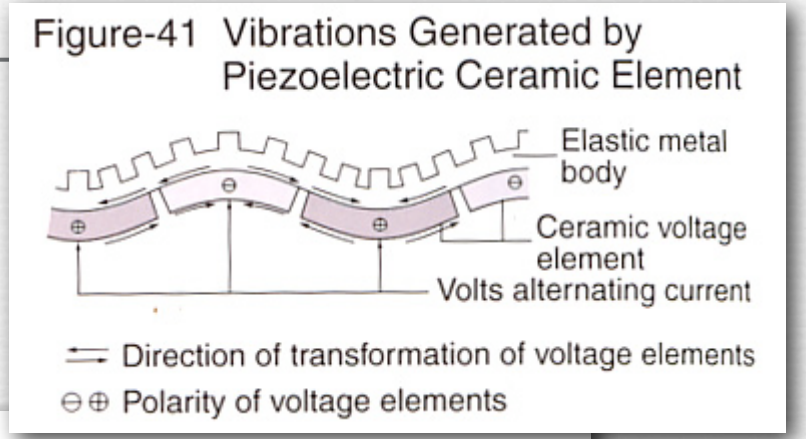
- uses main camera sensor
- requires repeated measurements as lens moves, which are captured using the main sensor
  - equivalent to depth-from-focus in computer vision
- slow, requires hunting, suffers from overshooting
  - it's ok if still cameras overshoot, but video cameras shouldn't

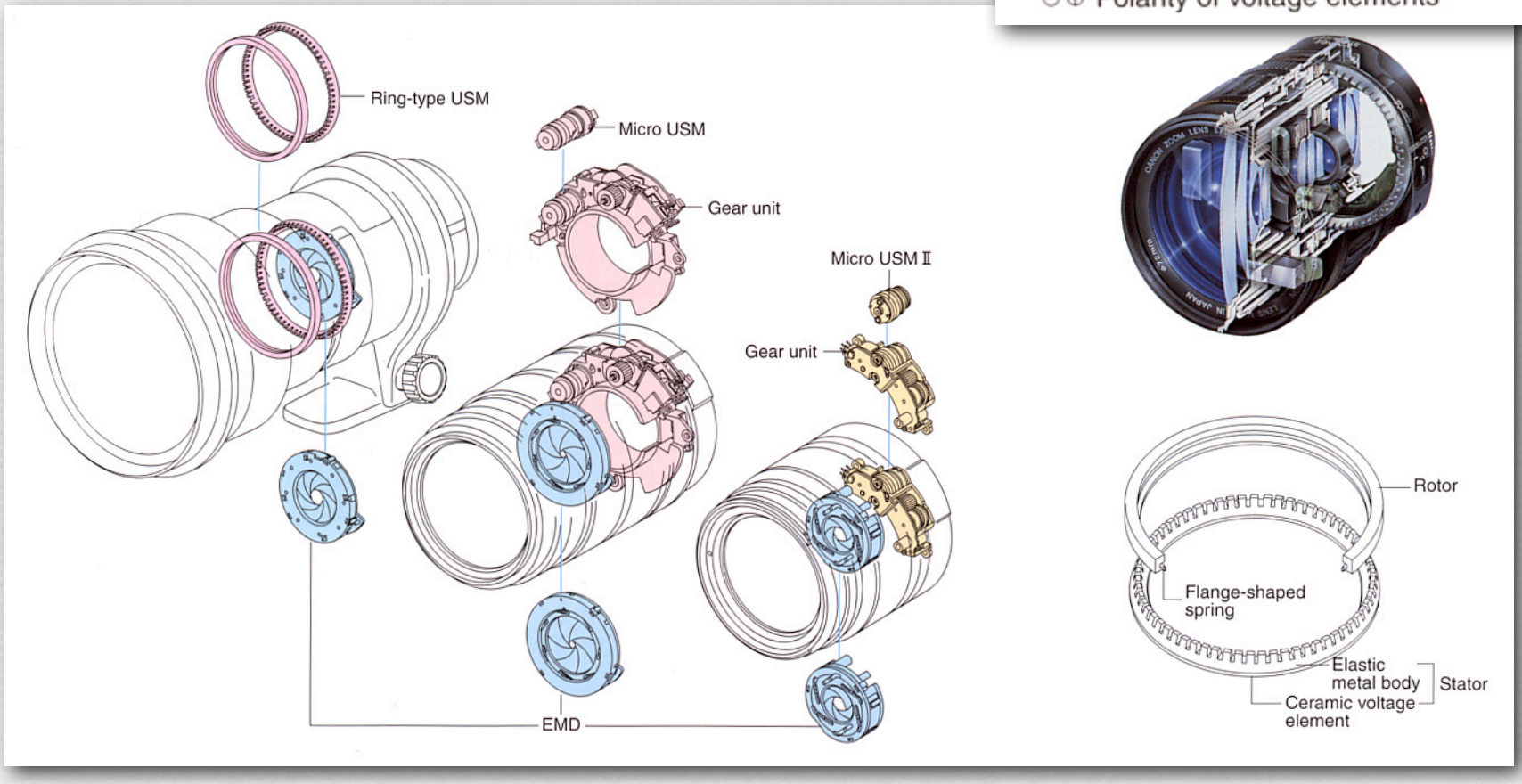
Autofocus modes

- AI servo (Canon) / Continuous servo (Nikon)
  - continues autofocusing as long as shutter is pressed halfway
  - predictive tracking so focus doesn't lag objects moving axially
- focusing versus metering
  - autofocus first, then meter on those points
- "trap focus"
  - trigger a shot if an object comes into focus (Nikon)
- depth of field focusing
  - find closest and furthest object; set focus and N accordingly
- overriding autofocus
  - manually triggered autofocus (AF-ON in Canon)

Lens actuators

- Canon ultrasonic motor (USM)





(Canon)

Slide credits

- Goldberg, N., *Camera Technology: The Dark Side of the Lens*, Academic Press, 1992.
- Canon, *EF Lens Work III: The Eyes of EOS*, Canon Inc., 2004.
- Adams, A., *The Camera*, Little, Brown and Co., 1980.
- Kerr, D.A., *Principle of the Split Image Focusing Aid and the Phase Comparison Autofocus Detector in Single Lens Reflect Cameras*.