Optical image stabilization (IS)

CS 448A, Winter 2010

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Outline

- what are the causes of camera shake?
  - how can you avoid it (without having an IS system)
  - treating camera shake as a 2D convolution of the image
- image stabilization systems
  - mechanical
  - optical
  - electronic (i.e. digital)
- optical image stabilization
  - lens shift
  - sensor shift
  - how much does stabilization help?

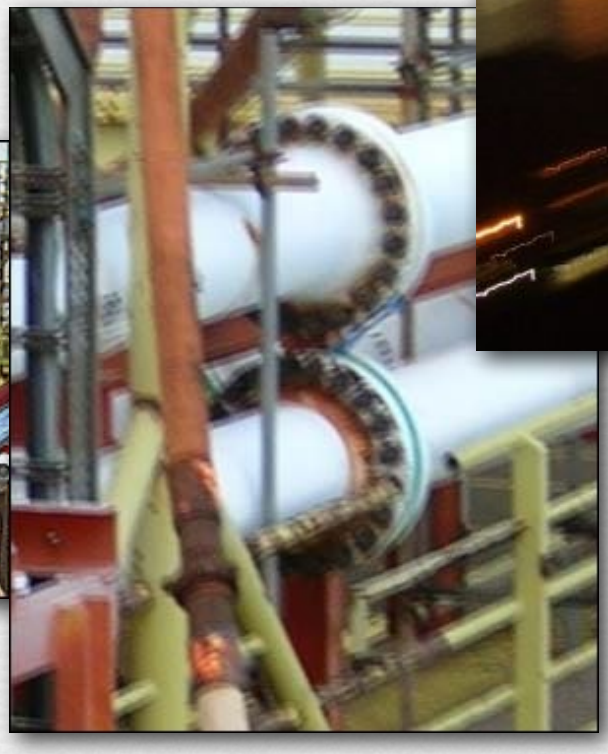
Camera shake

- primary cause is neuro-muscular tremor
  - period = 8-12 cycles per second
  - amplitude increases with muscular contraction, fatigue, emotional state, cold temperatures, stimulants, time of day
- secondary causes
  - SLR mirror and shutter
  - lightweight tripod
  - wind and other sources of vibration
- exacerbating factors
  - long focal length lenses
  - long exposure time
  - heavy camera, light camera, poor grip, poking at the shutter

Examples

(samgraphicdesign.com)

(wildsight.co.uk)



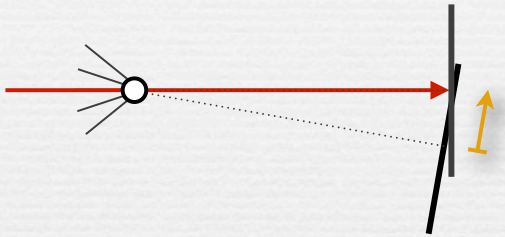
Camera shake as convolution

- camera shake is camera translation (3 d.o.f.) + rotation (3 d.o.f.)
- for sufficiently distant objects, camera translation can be ignored
- camera rolling (around optical axis) is seldom a problem*
- assume pitching & yawing are around center of perspective
- these motions can be approximated as 2D translation of the scene

*recent research suggests otherwise [Levin 2009]

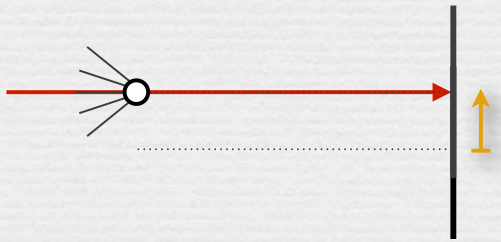
Rotation around center of perspective can be approximated as 2D translation of the image

as rotation



sensor rotates down, features move up

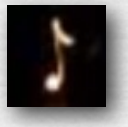
as translation



effect is nearly the same

Camera shake as convolution

- camera shake is camera translation (3 d.o.f.) + rotation (3 d.o.f.)
- for sufficiently distant objects, camera translation can be ignored
- camera rolling (around optical axis) is seldom a problem
- assume pitching & yawing are around center of perspective
- these motions can be approximated as 2D translation of the scene
- their effect over time is a 2D convolution of the scene $f(x,y)$ by a filter function $g(x,y)$ equal to the translation path

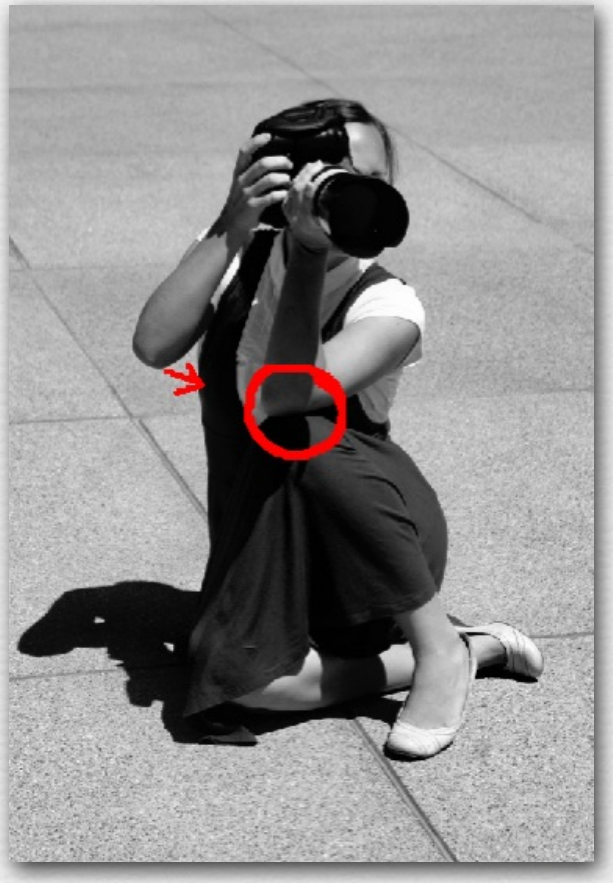
scene $f(x,y)$ $\otimes$  =

Avoiding camera shake

- hold the camera carefully, trigger the shutter slowly

- elbows in
- exhale first

- cradle the camera



- create a tripod

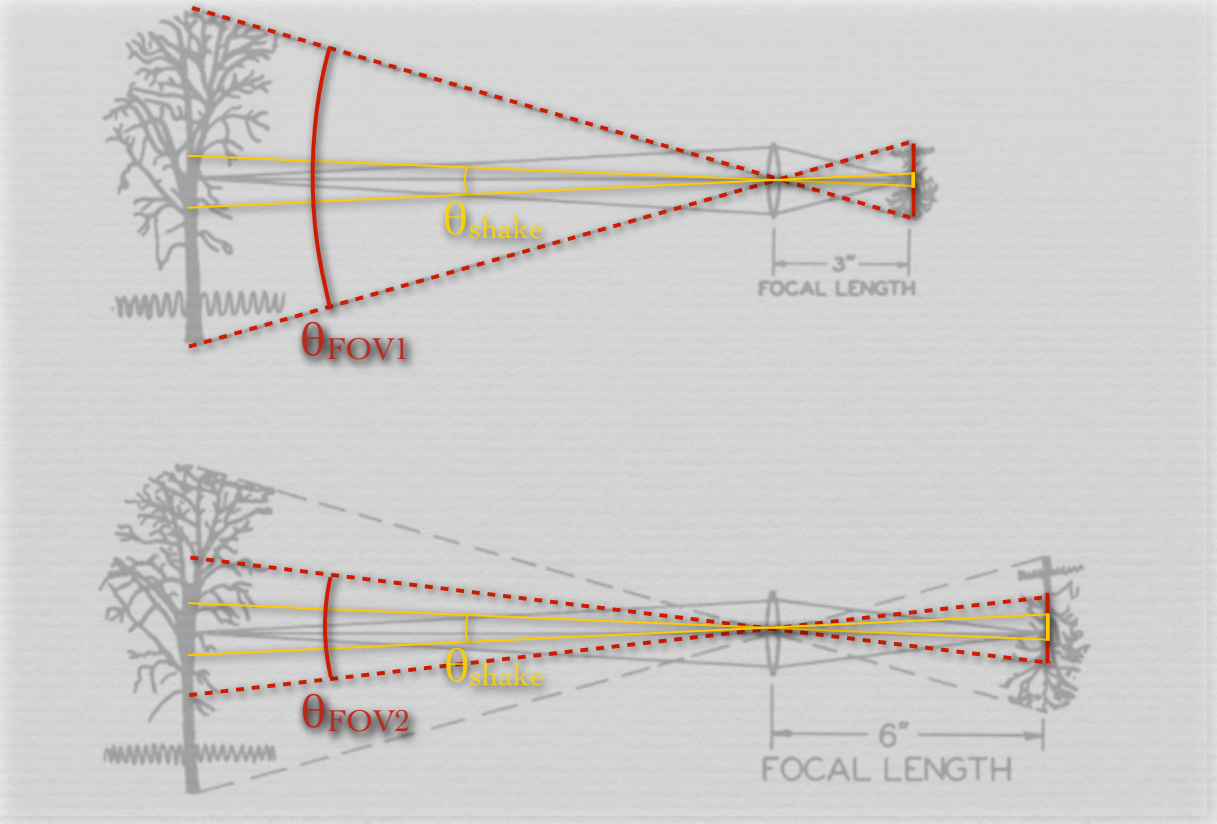
http://digital-photography-school.com/how-to-avoid-camera-shake

Avoiding camera shake

- hold the camera carefully, trigger the shutter slowly
- as you increase focal length, reduce exposure time

Effect of focal length on handshake

(Kingslake)



- as you increase focal length (for a fixed sensor size), handshake becomes a larger fraction of the FOV

Avoiding camera shake

- hold the camera carefully, trigger the shutter slowly
- as you increase focal length, reduce exposure time
  - rule of thumb

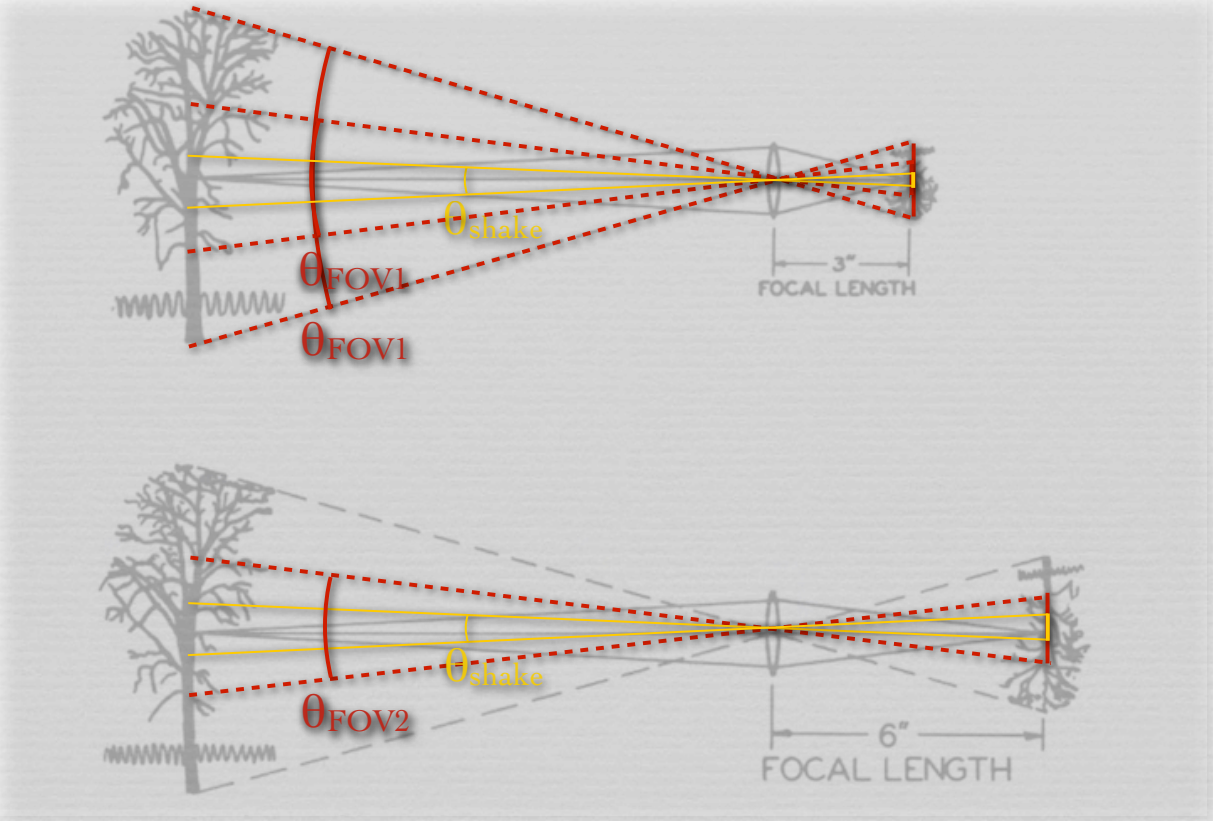
$$T = \frac{1}{f}$$

e.g. 1/500 second for a 500mm lens

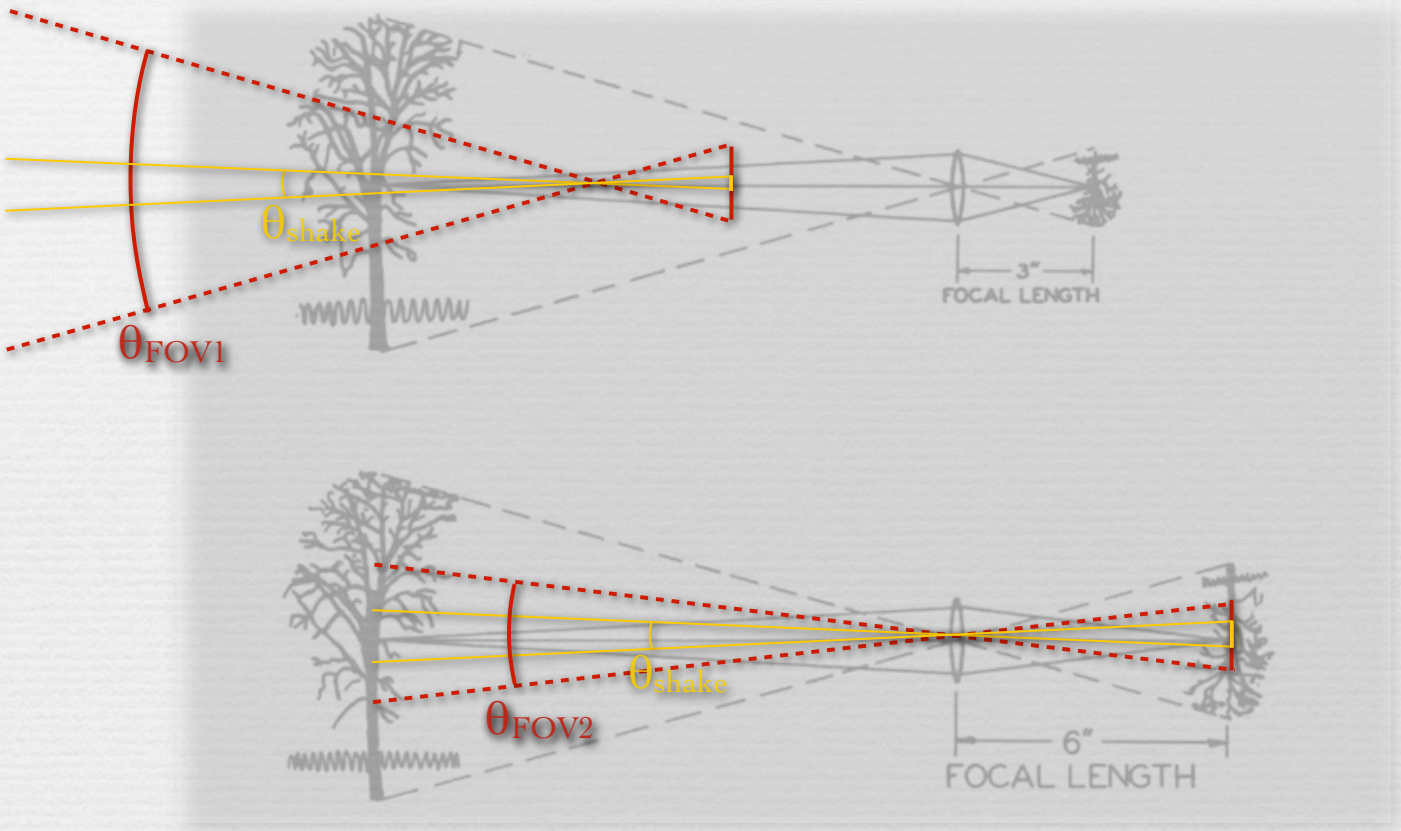
  - open the aperture or raise the ISO to compensate
  - use flash

Q. Keep the shorter focal length and crop the image?

(Kingslake)



- no, cropping the image is like increasing the focal length; handshake becomes a larger fraction of the FOV
- for small sensors, use 35mm equivalent focal length in formula



(Kingslake)

- keep the focal length constant and move towards the object

Avoiding camera shake

- hold the camera carefully, trigger the shutter slowly
- as you increase focal length, reduce exposure time
  - rule of thumb

$$T = \frac{1}{f}$$

e.g. 1/500 second for a 500mm lens;
for small sensors, use 35mm equivalent

  - open the aperture or raise the ISO to compensate
  - use flash
- keep the focal length constant and move towards the object
- lock up the mirror
- get a better tripod
- drink less coffee

Image stabilization systems

- mechanical image stabilization
  - Steadicam

Image stabilization systems

- mechanical image stabilization
  - Steadicam
- optical image stabilization
  - shift the lens, or
  - shift the sensor
- electronic image stabilization
  - shorten the exposure (raise the ISO to compensate)
  - shift the image after capture (video or bursts of still frames)
    - Fredo will talk about this next week...

Optical image stabilization

- lens-shift

Canon	IS (Image Stabilization)
Nikon	VR (Vibration Reduction)
Panasonic, Leica	MegaOIS
Sigma	OS (Optical Stabilization)
Tamron	VC (Vibration Compensation)

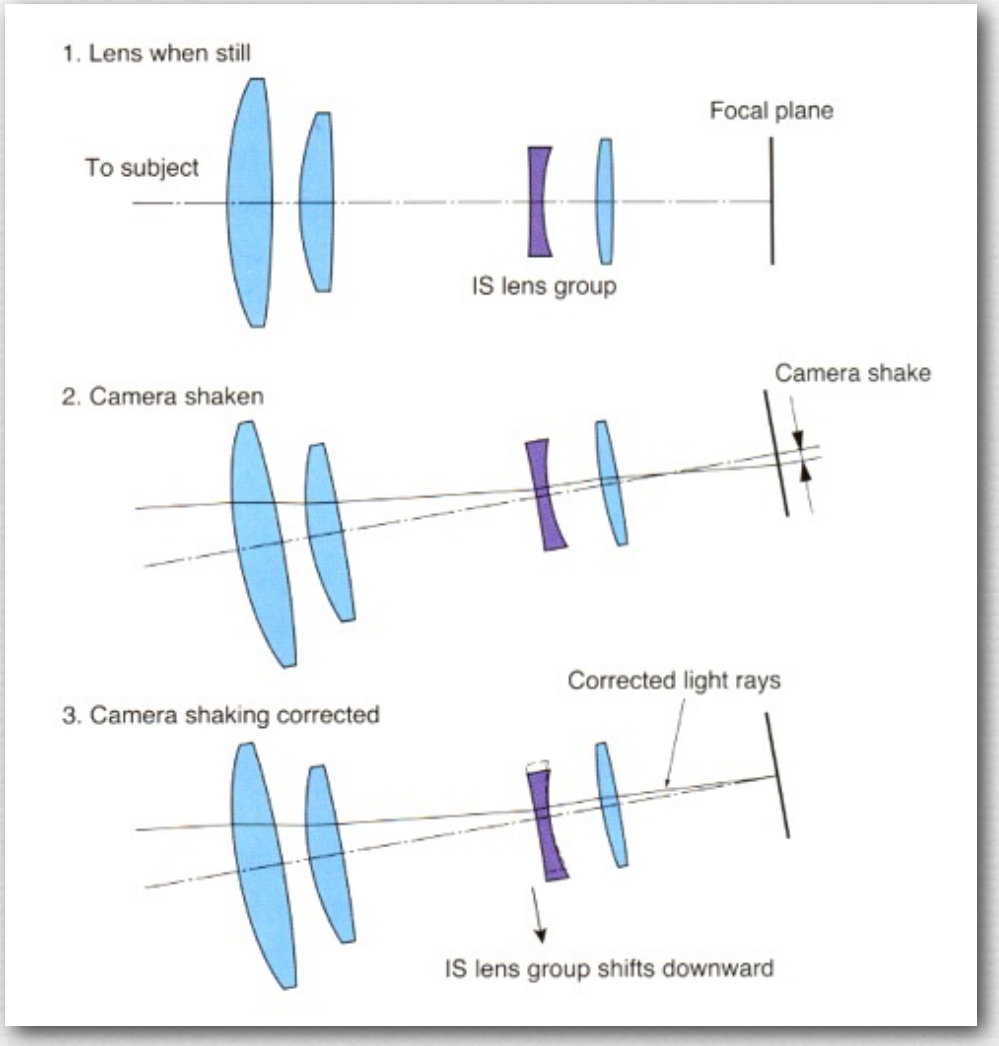
- sensor-shift

Konica Minolta	AS (Anti Shake)
Sony	SSS (Super Steady Shot)
Pentax	SR (Shake Reduction)
Olympus	IS (Image Stabilization)

Lens-shift stabilization

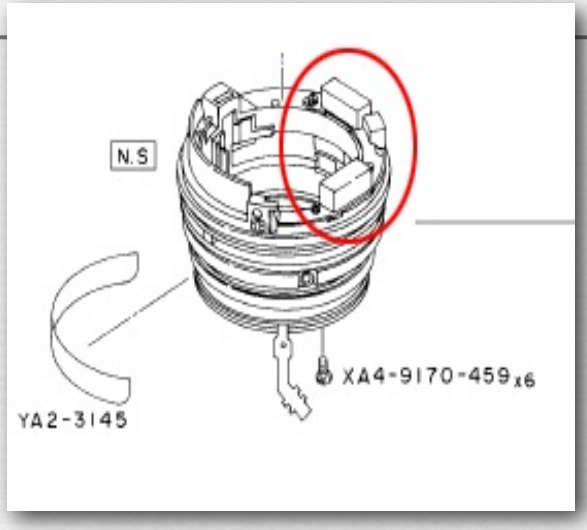
- camera shake is treated as rotation around the center of perspective
- effect is treated as translation of the image
- can be offset by translating a lens the other way
- must be done at the same instant in time!

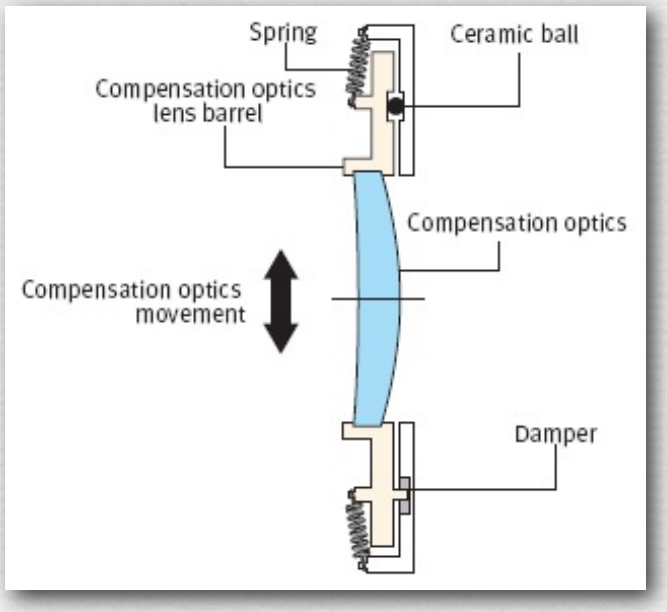
(Canon)

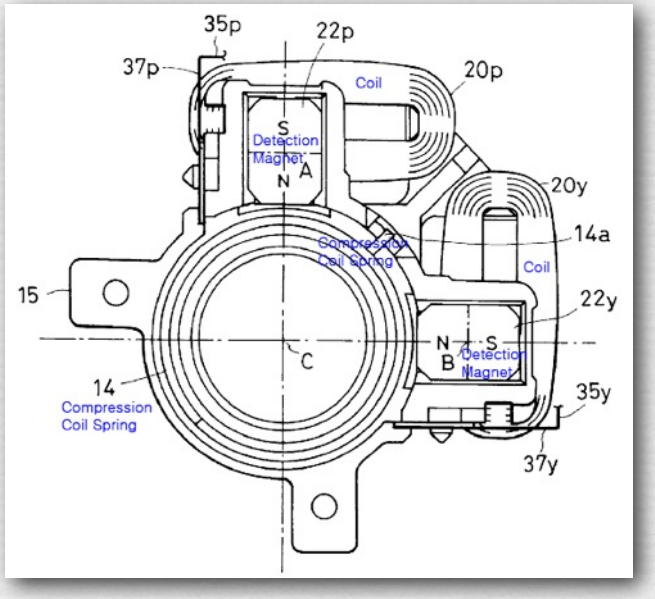


Lens-shift stabilization

- detect pitching and yawing using two gyroscopes at 90°
- move spring-mounted lens laterally using two electromagnets at 90°

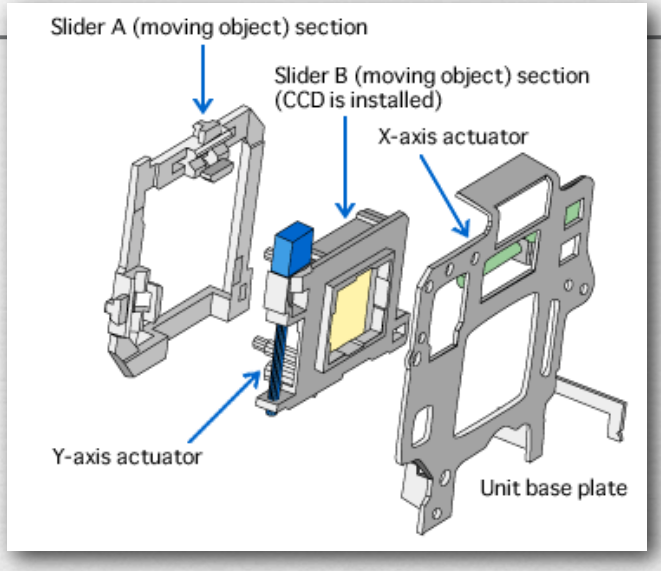


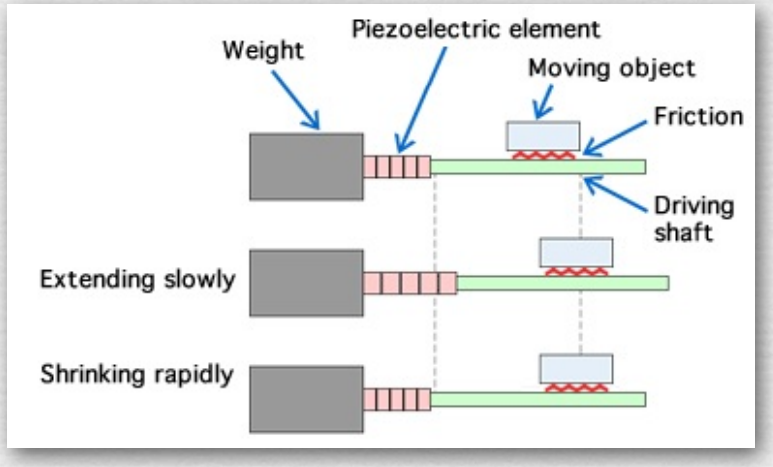




Sensor-shift stabilization

- detect pitching and yawing using two gyroscopes, as before
- move sensor laterally on sliders using two piezo actuators at 90°



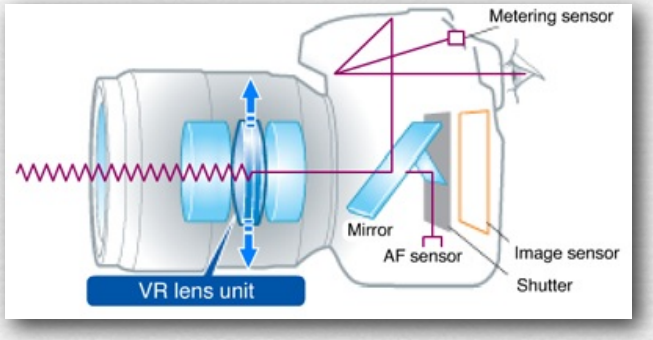


Additional features

- panning detection
- tripod detection
- centering prior to exposure (Nikon)

Which is better?

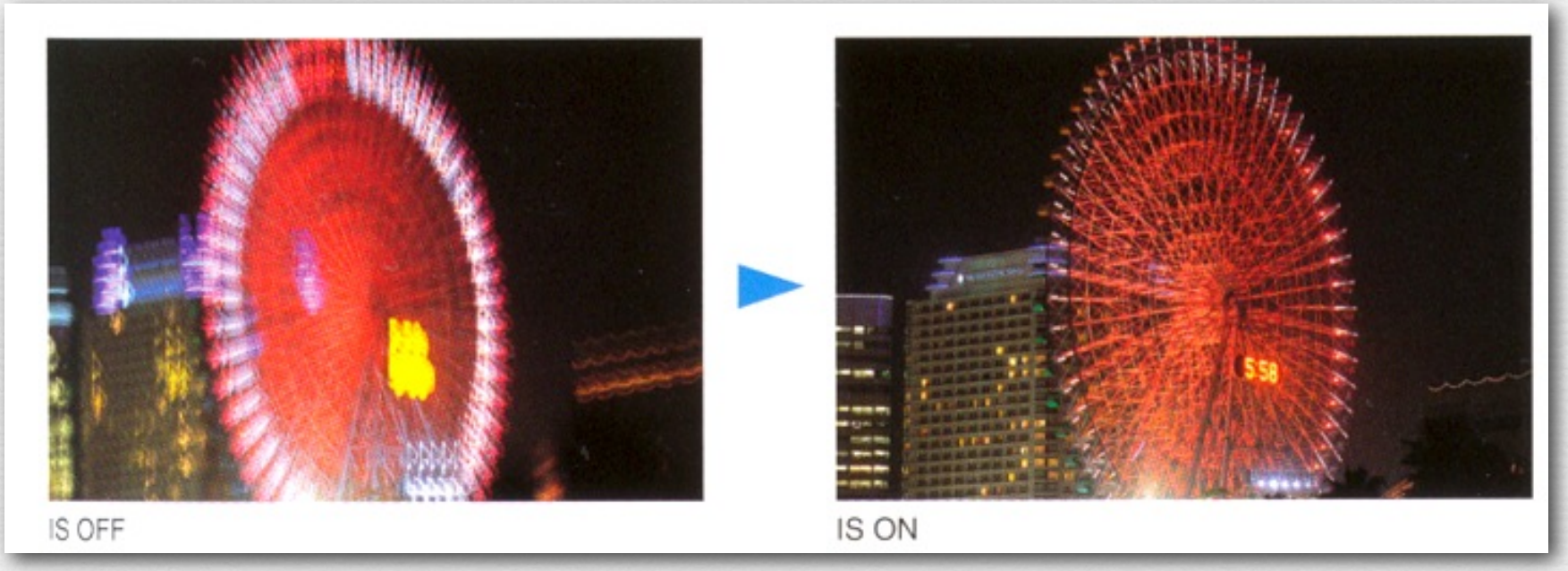
- lens-shift
  - stable viewfinder
  - better autofocus and metering
  - optimized for each lens



- sensor-shift
  - works for every lens, so cost effective
  - reduces size and weight of lenses
  - better optical performance

Examples of image stabilization

(Canon)



Examples of image stabilization

Nikon D200, 18-200mm at 28mm at 1/4s (77% crop)

Nikon D70, 18-200mm at 28mm at 1/4s (100% crop)

- lesson: fancy camera body and lots of megapixels don't matter much if you can't hold it still!

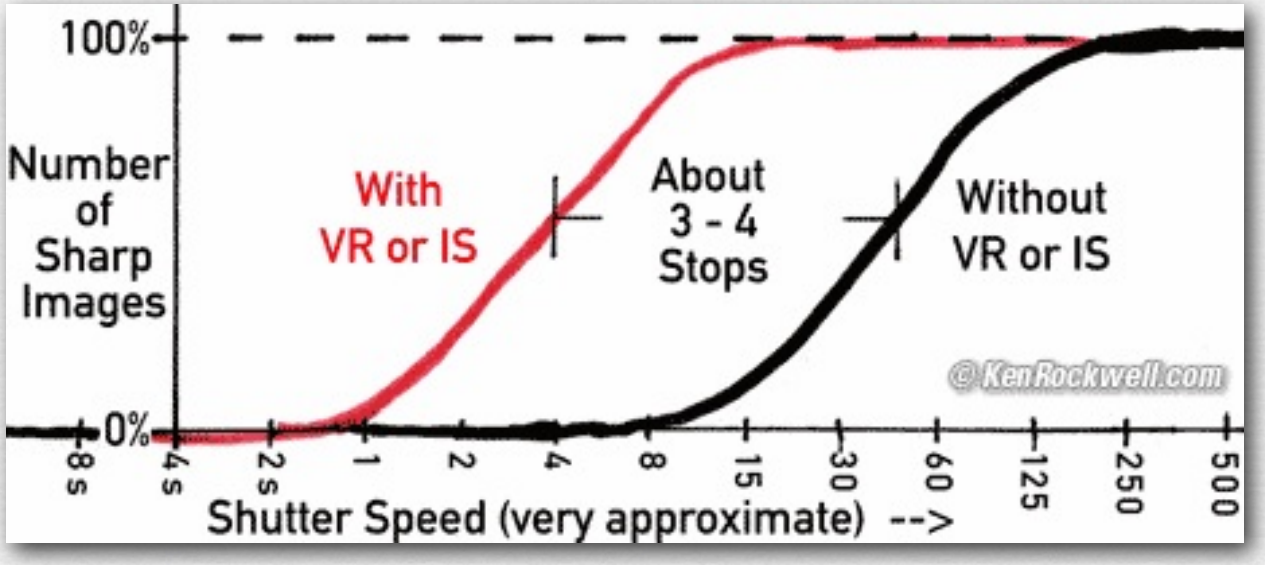
Examples of image stabilization

Nikon D200, 18-200mm at 28mm at 1/4s (77% crop)

Canon SD700 IS at 1/4s (100% crop)

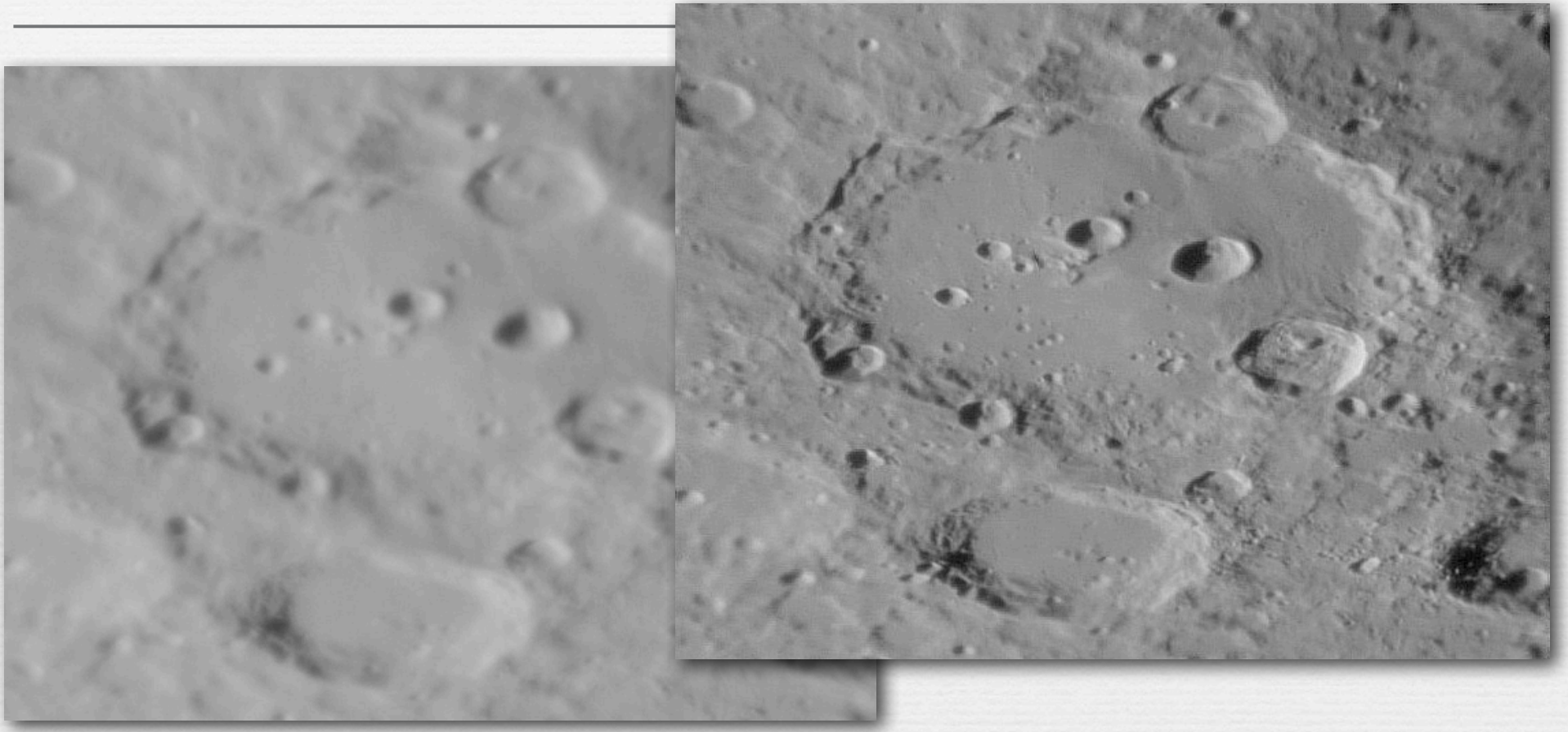
- lesson: fancy SLR doesn't matter if you can't hold it still!

How much does stabilization help?



- if you don't have stabilization, take lots of shots
  - some of them will be sharp, due to sinusoidal nature of camera shake
  - faster than 1/60 second, most shots are sharp
  - slower than 1/2 second, almost none of them are sharp
- between these exposure times, stabilization helps a lot
  - 3-4 stops assumes the best lenses; your mileage may vary

Lucky imaging in astronomy

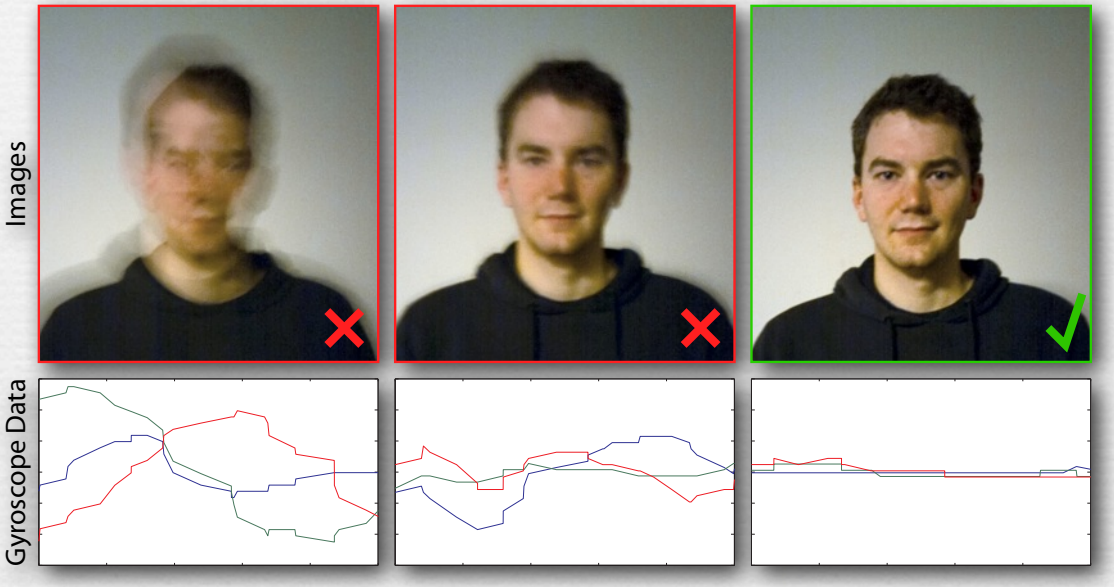


(http://www.ast.cam.ac.uk/~optics/Lucky_Web_Site/LI_Amateur.htm)

- quality of "seeing" varies with atmospheric turbulence
- select sharpest parts of sharpest frames, align and average

Lucky imaging using the N900 "F"

- 3-axis gyroscope on N900
- burst of 1/2-sec exposures
- save image if little motion



- could alternatively combine multiple lucky 1/8-sec exposures
- future: deconvolve using IMU trace as initial guess of kernel
- also: deconvolve from multiple lucky images

Slide credits

- Sung Hee Park

- Canon, *EF Lens Work III: The Eyes of EOS*, Canon Inc., 2004.
- http://KenRockwell.com
- Levin, A., et al., "Understanding and evaluating blind deconvolution algorithms," *Proc. CVPR 2009.*