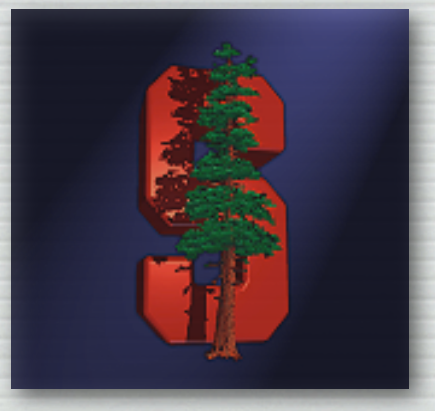
Image stabilization (IS)

CS 178, Spring 2009



Marc Levoy
Computer Science Department
Stanford University

Outline

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

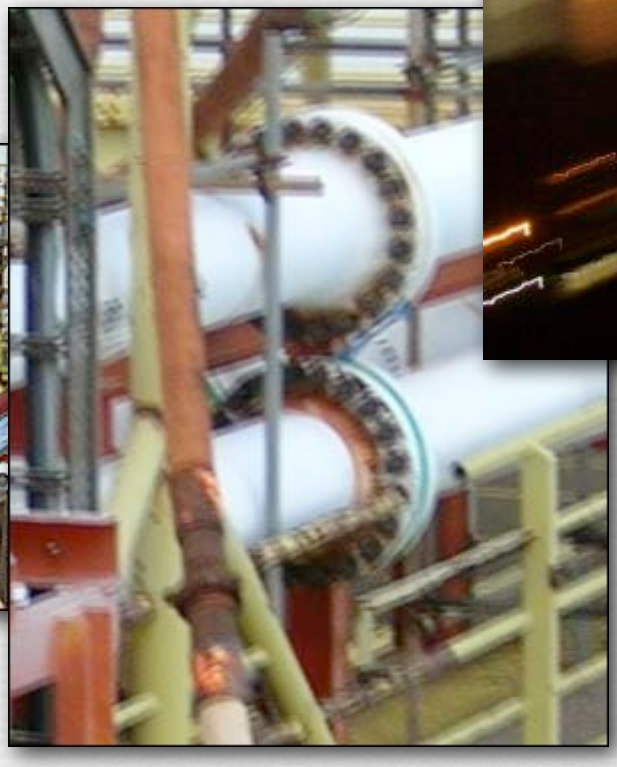
Camera shake

- 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

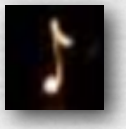
(samgraphicdesign.com)

(wildsight.co.uk)

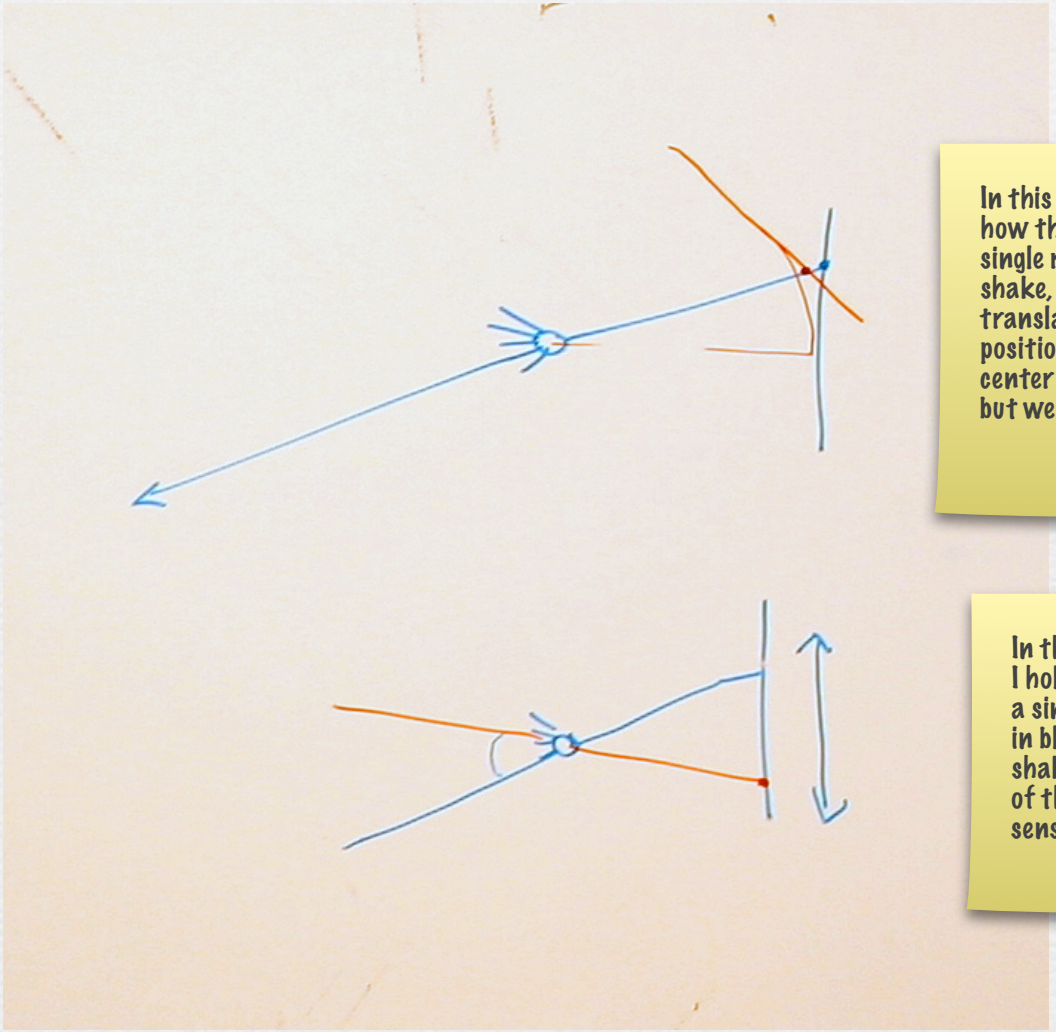


Camera shake as convolution

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

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



In this view of the situation, where I show how the effective sensor position for a single ray changes (red line) with camera shake, I should have showed it as translation parallel to the original sensor position (blue line), not rotation around the center of perspective. It is indeed rotation, but we approximate it as translation.

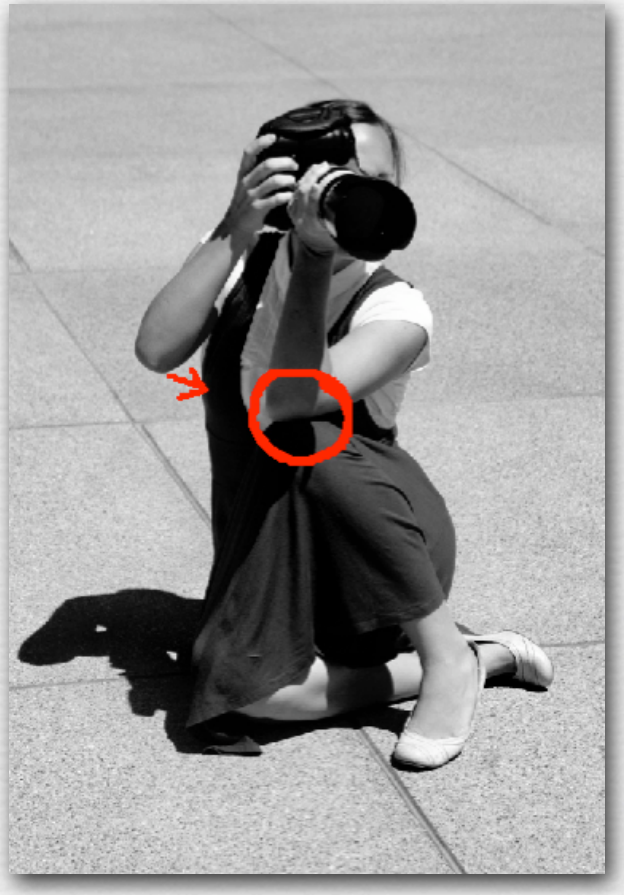
In this view of the same effect, where I hold the sensor stationary and draw a single line of sight in the world first in blue and then in red after camera shake, I correctly show the movement of the point of intersection with the sensor as pure translation.

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
- reduce exposure time
  - rule of thumb

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

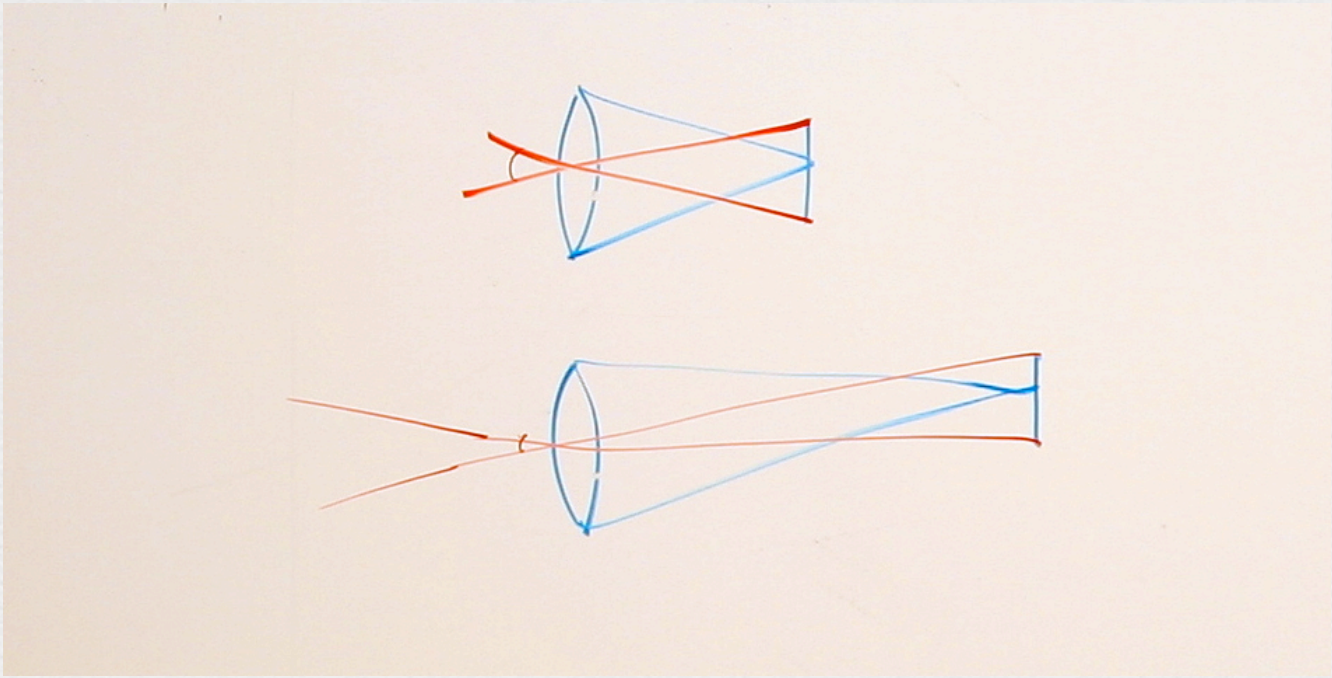
e.g. 1/500 second for a 500mm lens

  - open the aperture or raise the ISO to compensate
  - use flash
- use a shorter focal length and crop the image?
- no, use a shorter focal length and get closer to the subject

As mentioned in class, this rule of thumb is for 35mm format cameras. For smaller sensors, you need to convert the focal length to a 35mm equivalent length before applying this rule. For example, for an APS-C format sensor (like the Canon Digital Rebel), you should multiply the focal length written on the zoom lens by 1.6, then apply the rule. So a Digital Rebel set at 312mm needs a 1/500 sec exposure to avoid camera shake.

Angular FOV

- for a fixed sensor size, as you increase focal length (from top to bottom drawing below), angular field of view (red arc) decreases
- camera shake is rotation around center of perspective, so it too is an arc
- as you increase focal length, the camera shake arc becomes a larger fraction of the FOV arc, hence camera shake covers a larger fraction of the FOV, hence looks worse



Avoiding camera shake

- hold the camera carefully, trigger the shutter slowly
- 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
- use a shorter focal length and crop the image?
- no, use a shorter focal length and get closer to the subject
- lock up the mirror
- get a better tripod
- drink less coffee

For new Canon cameras, you can alternatively put them into Live View mode.

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)
    - we'll talk about this later in the course...

Optical image stabilization

- lens-shift

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

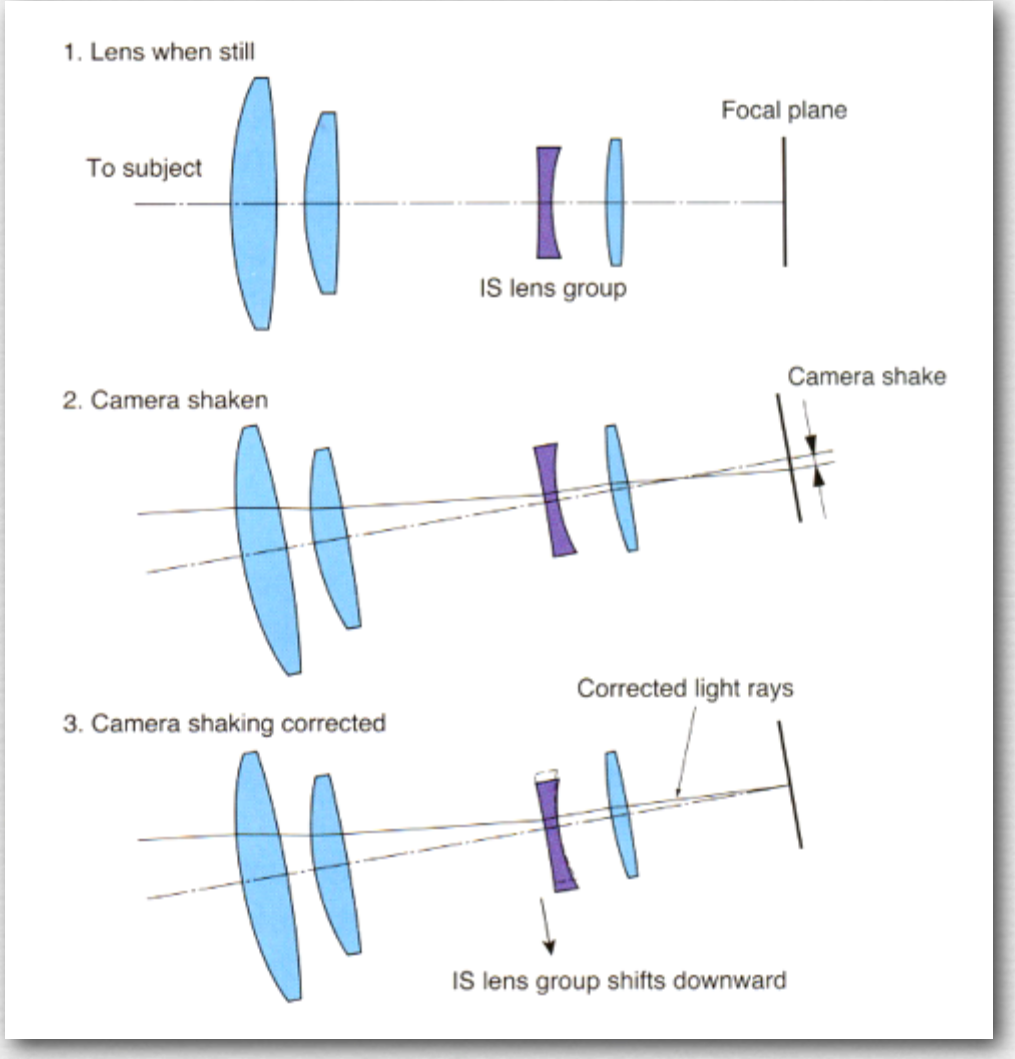
- sensor-shift

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

Lens-shift stabilization

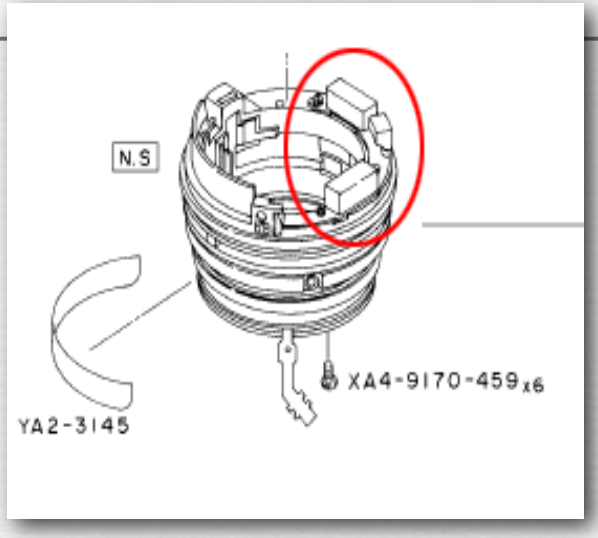
- camera shake is treated as rotation around the center of perspective
- effect is treated as translation of the image
- can be offset by translating a lens the other way
- must be done at the same instant in time!

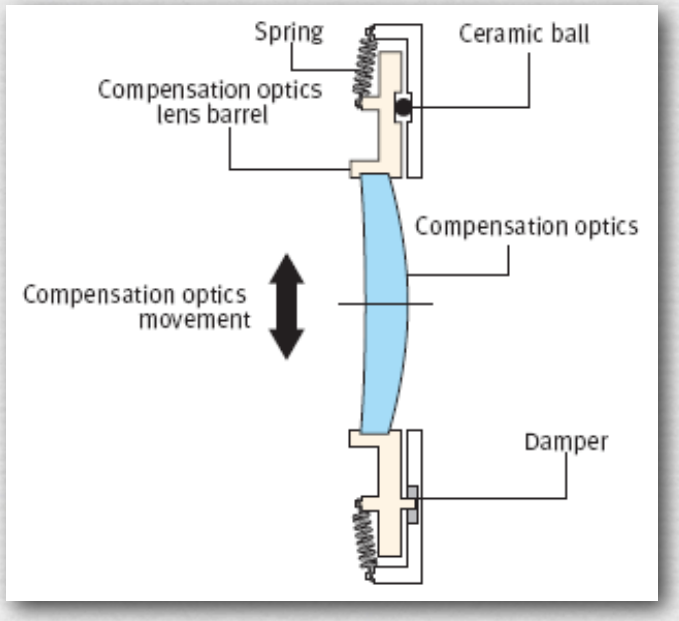
(Canon)

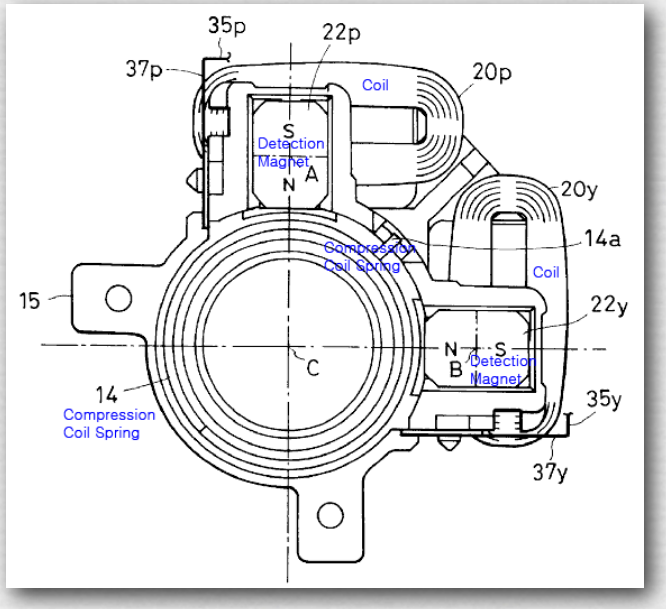


Lens-shift stabilization

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

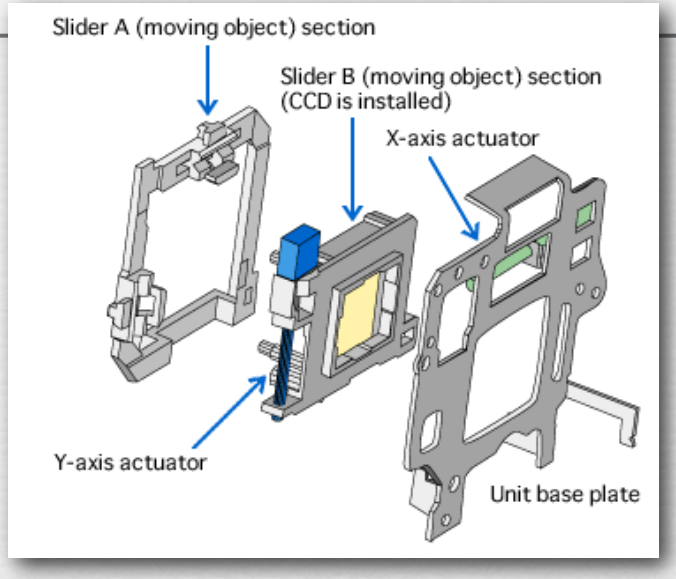


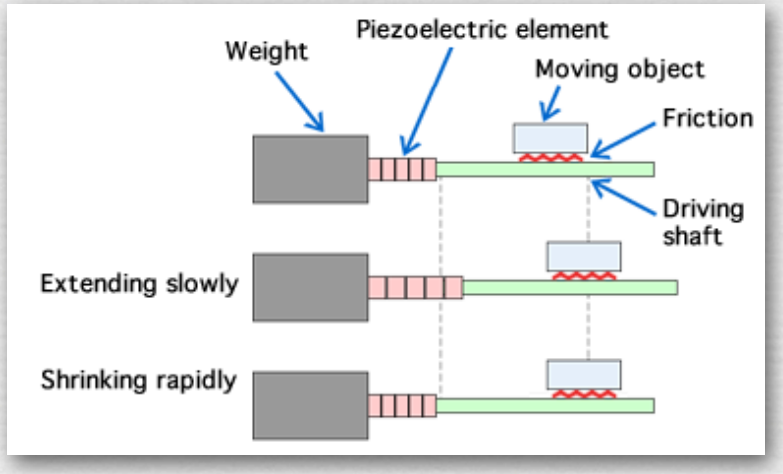




Sensor-shift stabilization

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





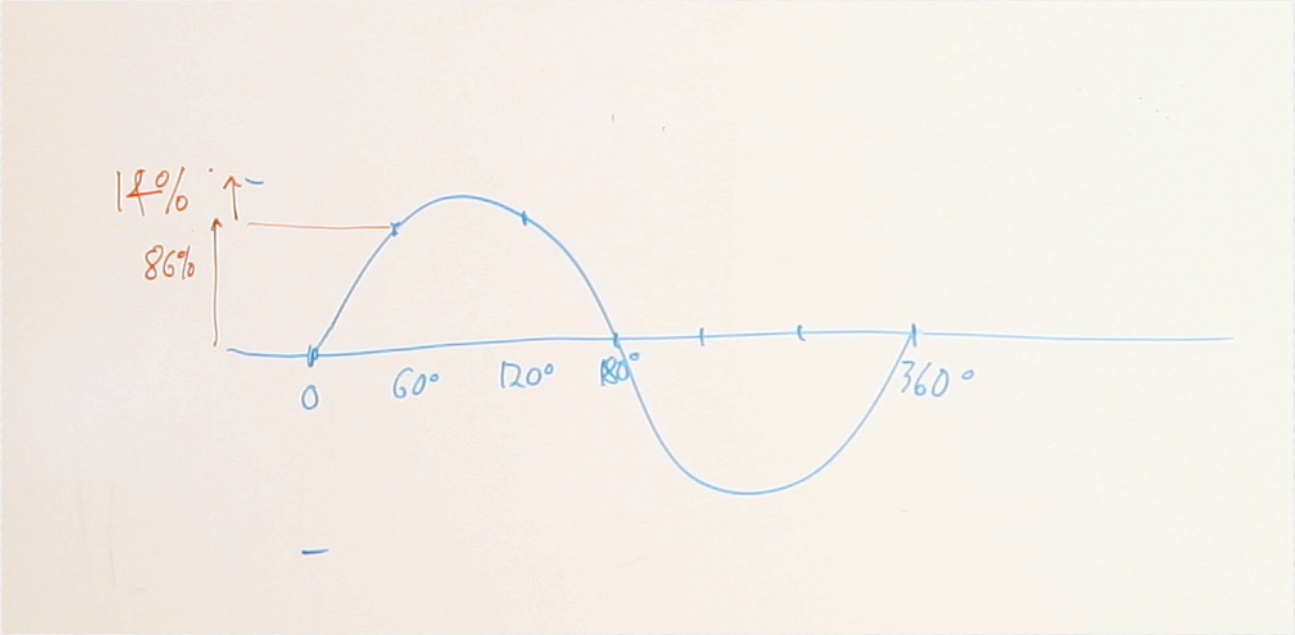
Additional features

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

I tried to skip this topic in class to save time, but students had experienced these problems in their own photography (e.g. IS messing up if the camera is on a tripod), so I ended up covering them after all!

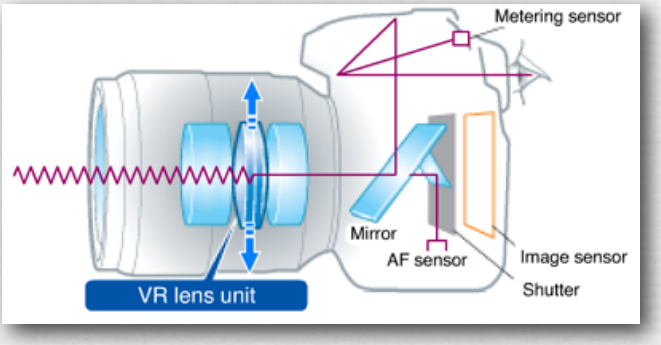
To avoid shake, take lots of shots

- if your shot falls in the first 1/6 of a hand tremor, you'll see 86% of the total excursion in that direction (cos θ);
- if your shot falls in the second 1/6, you'll see only 14%
- so take at least ~5 shots; the amount of shake will differ
- this strategy is worthwhile <u>even</u> if you have an IS system

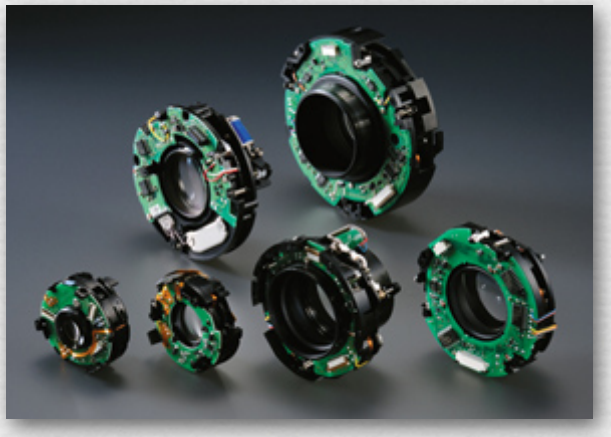


Which is better?

- 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!

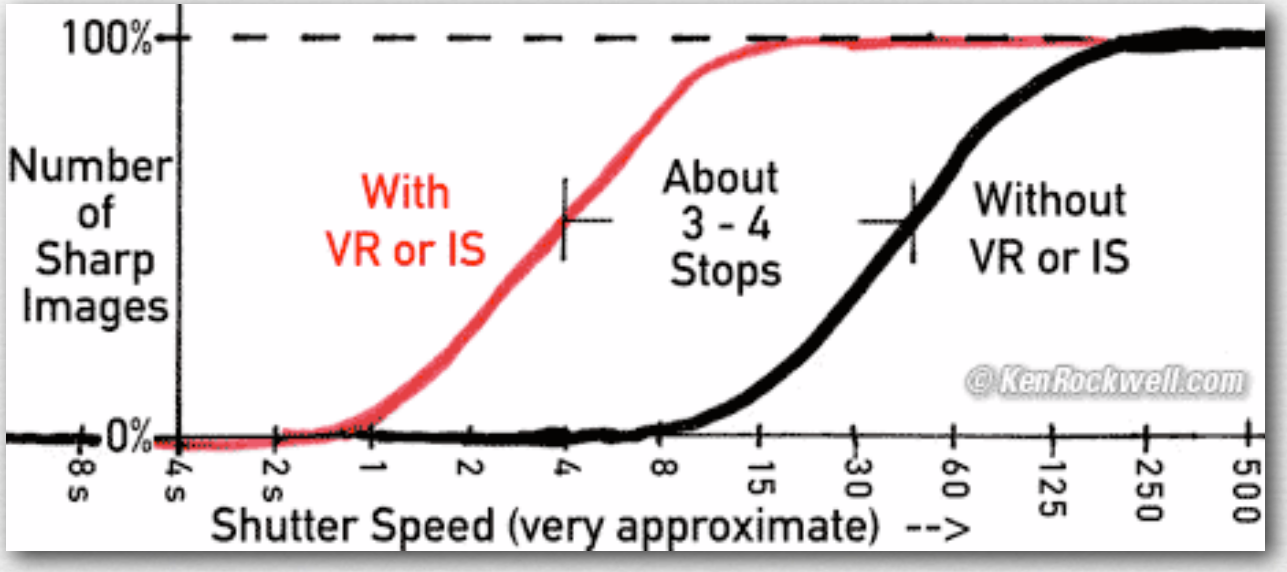
Examples of image stabilization

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
  - # of stops depends on focal length

Slide credits

- Sung Hee Park

- Canon, *EF Lens Work III: The Eyes of EOS*, Canon Inc., 2004.
- http://KenRockwell.com