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

(wildsight.co.uk)

(samgraphicdesign.com)
**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:

As translation:

Sensor rotates down, features move up.

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
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

- 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?
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
- 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**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canon</td>
<td>IS (Image Stabilization)</td>
</tr>
<tr>
<td>Nikon</td>
<td>VR (Vibration Reduction)</td>
</tr>
<tr>
<td>Panasonic, Leica</td>
<td>MegaOIS</td>
</tr>
<tr>
<td>Sigma</td>
<td>OS (Optical Stabilization)</td>
</tr>
<tr>
<td>Tamron</td>
<td>VC (Vibration Compensation)</td>
</tr>
</tbody>
</table>

**sensor-shift**

<table>
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<tr>
<th>Manufacturer</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Konica Minolta</td>
<td>AS (Anti Shake)</td>
</tr>
<tr>
<td>Sony</td>
<td>SSS (Super Steady Shot)</td>
</tr>
<tr>
<td>Pentax</td>
<td>SR (Shake Reduction)</td>
</tr>
<tr>
<td>Olympus</td>
<td>IS (Image Stabilization)</td>
</tr>
</tbody>
</table>
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!
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

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

Nikon D200, 18-200mm at 28mm at 1/4s (77% crop)
Nikon D70, 18-200mm at 28mm at 1/4s (100% crop)
Examples of image stabilization

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

Nikon D200, 18-200mm at 28mm at 1/4s (77% crop)
Canon SD700 IS at 1/4s (100% crop)
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

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

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

- [http://KenRockwell.com](http://KenRockwell.com)