Characterization of camera shake

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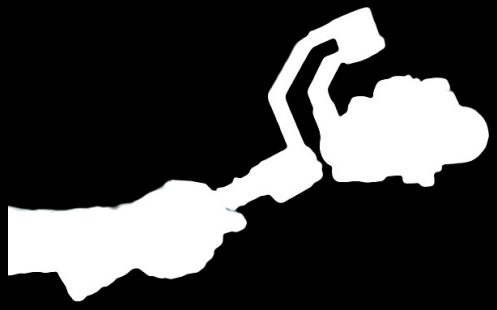
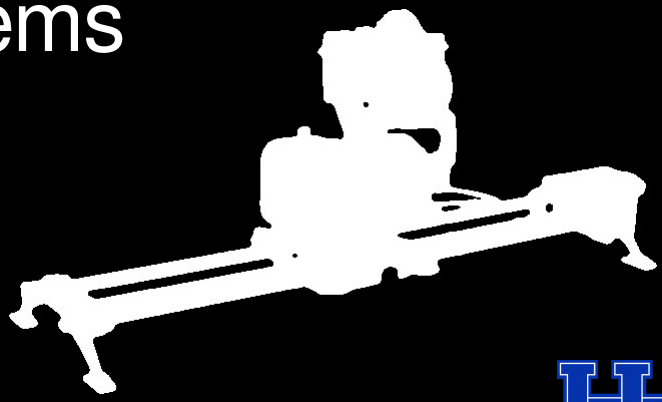
Camera Shake

- **Unintended vibration or movement of the Camera system during an exposure**
- Causes:
  - Unsteady mount, e.g., human hands
  - Moving parts within the camera system, e.g., mirror, shutter curtain, lens aperture
  - Uneven motion, e.g., while panning
- Effects:
  - **Motion blur**
  - **Reduced resolution**

Methods to reduce shake

- Rigid mounts, especially **tripods**
- Large, heavy, **dollies** for smooth motion
- ***Brown Stabilizer***, aka, ***Steadicam*** (using high intertial mass to resist shake)
- Intelligently-controlled **gimbals** and **motion control** systems





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Methods to correct shake

- **During exposure**:
  - **OIS**: Optical Image Stabilization (lens elements move to compensate)
  - **IBIS**: In-Body Image Stabilization (image sensor moves to compensate)
- As **computational postprocessing**:
  - Nikon's **BSS**: Best Shot Selector
  - Sony et al multi-shot anti-blur mode
  - Computational deconvolution

Why characterize shake?

- Gimbals, motion control, OIS, and IBIS must respond to shake sensed in real time
  - Understand performance of systems
  - Develop better (predictive?) tracking
- Multi-shot anti-blur and deconvolution can use shake model to improve results
- To establish "**best practices**"

... knowledge is good, right? ;-)

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Hasn't CIPA done this?

- **CIPA**: Camera & Imaging Products Assoc.
  - International industry association
  - 1st charge is create & promote standards
- Created standard for testing camera image stabilization systems: **DC-X011-2014**
  - Specifies a camera test procedure
  - Reference 500Hz vibration pattern

... *experiments informed their test procedure, but that seems to have been the only goal*

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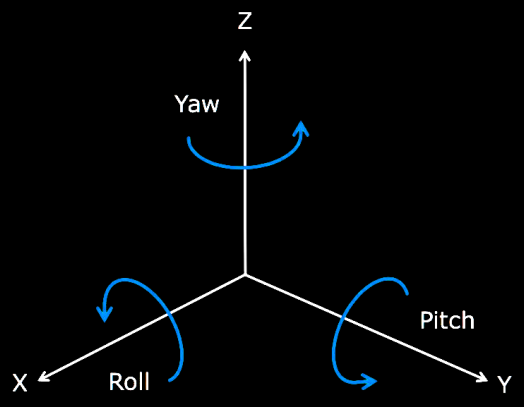
ShAKY



- **ShAKY**: SHift Angle KentuckY
  - Open source device, build for under $20
  - 9-axis sensor, 6-axis up to ~1000Hz
  - Provision for shutter synchronization
  - Driverless USB interface
- Originally made different device for each type of camera, now have a “generic” ShAKY

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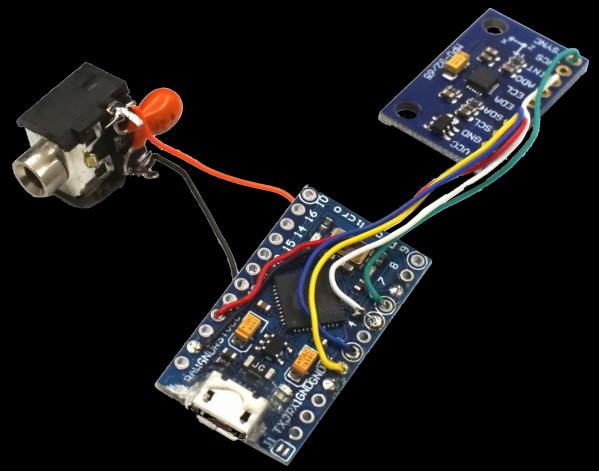
ShAKY Electronics

Pro Micro Vcc	———	MPU-9250 Vcc
Pro Micro Gnd	———	MPU-9250 Gnd
Pro Micro 2	———	MPU-9250 SDA
Pro Micro 3	———	MPU-9250 SCL
Pro Micro 5	———	MPU-9250 INT
Pro Micro 6	———	MPU-9250 FSYNC
Pro Micro 7	———	3.5mm Plug Outer
Pro Micro Gnd	———	3.5mm Plug Tip



- $8 **MPU-9250** multi-chip module
  - Gyroscope roll, pitch, & yaw @ 8000Hz
  - Accelerometer X, Y, & Z @ 4000Hz
  - Magnetometer X, Y, & Z @ 8Hz
- $5.60 **Atmega328 Arduino Pro Mini**
- 3.5mm jack + capacitor to debounce

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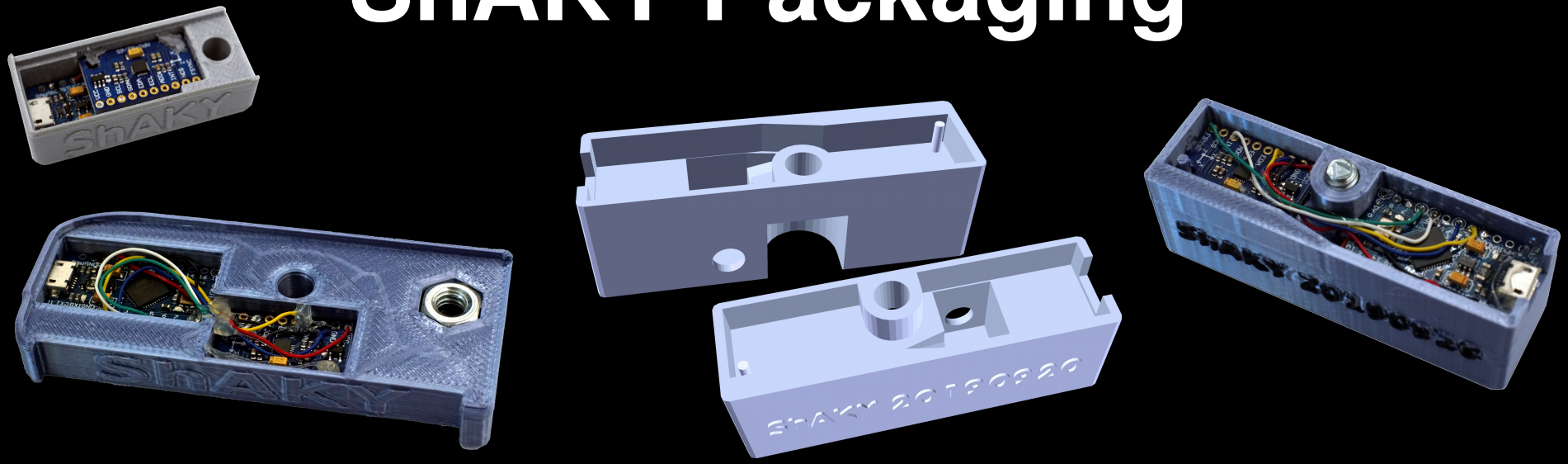
ShAKY Packaging



- 3D-printed housing, originally different for each camera model, but now generic
- Goal is to get 9-axis sensor rigidly aligned with the lens... alignment error convolves the axis measurements, but can be negligible

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ShAKY Software

- Calibration & sync were hard, but now work
- Software inside ShAKY (~1K lines):
  - Performs magnetometer calibration
  - Streams records to USB @ ~1000Hz with X, Y, Z, roll, pitch, yaw, sync
- Software in ShAKY's USB host (~600 lines):
  - Implements high-quality tracking
  - Given sync curtain delay & shutter speed, plots each exposure using **`gnuplot`**

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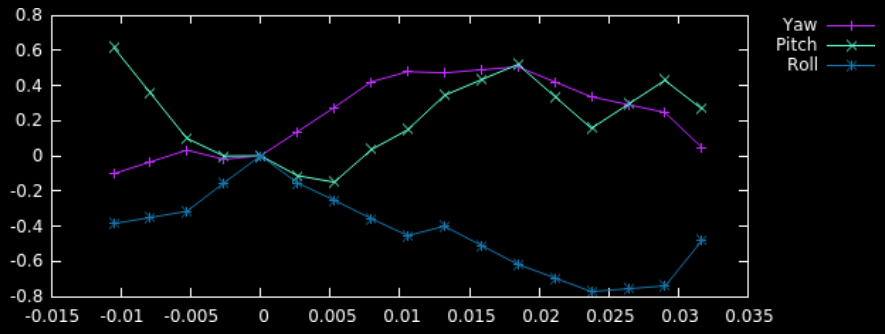
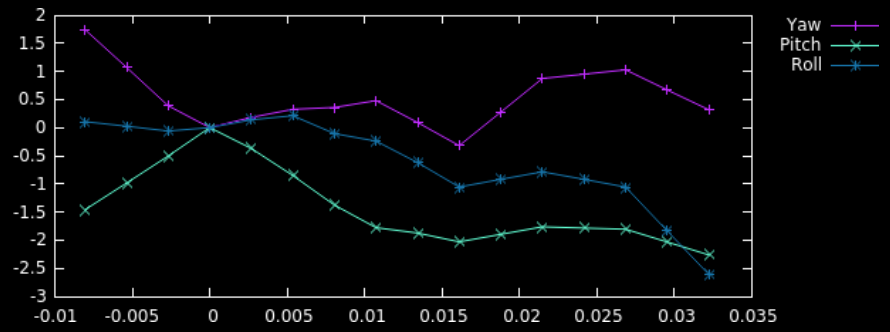
ShAKY Gnuplot Output





Typical ShAKY output for Sony A6500 (IBIS and EFC disabled)

Left: sitting still on a tabletop
Right: hand-held

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ShAKY Operation

- Mounts on camera via ¼-20 tripod thread
- Flash sync signal can be used to precisely sync with shutter
- Data streams out USB around 1000 records/s
- Powered by USB

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ShAKY Measurement Procedure

- Scene is a 4K display
  - Resolution target (used to detect shake)
  - QR code created by A CGI form
- Image EXIF contains:
  - Shutter speed, etc.
  - Resolution & QR data can be added

Data encoded is: f55;nMamiya/Sekor;d6;c1;h3;v240;g2

Shake Testing Protocol

The basic protocol that we are currently using involves holding a camera about 6 feet from a display showing the QR code generated by this WWW form.

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55 is the marked focal length of your lens in mm.

Mamiya/Sekor is the name of your lens.

The camera is approximately 6 feet from the target.

What are you using to compose the image?

- ○ Optical viewfinder (OVF)
- ◉ Electronic viewfinder (EVF)
- ○ Rear Liquid Crystal Display (LCD)
- ○ Rear LCD tilted up or down
- ○ Estimated aim without view

How are you holding the camera?

- ○ Mounted on a steadycam device
- ○ Mounted on a tripod or similar
- ○ Mounted on a monopod
- ◉ Two hands, with your body braced against something
- ○ Two hands, body not braced
- ○ One hand

It has been about 240 hours since I last used a hand-held vibrating power tool (e.g., a weed-whacker).

Generally, how steady do you think your grip is?

- ○ Very steady with lots of practice holding cameras
- ○ More steady than average
- ◉ About average
- ○ Less steady than average

Submit Reset

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Preliminary Results

- Variation in shake between consecutive shots by the same person and camera (which explains why Nikon's BSS works)
- Using Canon 5D IV, OVF (optical viewfinder) was ~2X better than rear LCD
- Using Sony A7, EVF (electronic viewfinder) was ~2X better than rear LCD
- EFC (electronic first curtain) very significantly reduced shake on Sony A7

Preliminary Results

CIPA DC-X011-2014 states yaw & pitch were measured for "*many people*" and the "*characteristic frequency and amplitude were extracted and synthesized to generate the vibration waveforms*" – claim is roll, X, Y, and Z are "practically negligible"

- We didn't see very consistent characteristics
- X, Y, and Z generally didn't matter much; **roll** can matter a lot – **off axis**
- Camera itself causes shake

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Preliminary Results

Does a two-handed grip on a camera give consistently less shake than one-handed shooting?

- Surprisingly, **NO!**
  - Two-handed is often worse or comparable
  - Differences in which axis moves most

Conclusions and Future Work

- ShAKY is a viable low-cost, open-source, device for studying camera shake
- Some preliminary results are surprising – it is worthwhile making more measurements

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