National Aeronautics and Space Administration

HRP Investigators Workshop - 2016

UTILIZING COMMERCIAL HARDWARE AND OPEN SOURCE COMPUTER VISION SOFTWARE TO PERFORM MOTION CAPTURE FOR REDUCED GRAVITY FLIGHT

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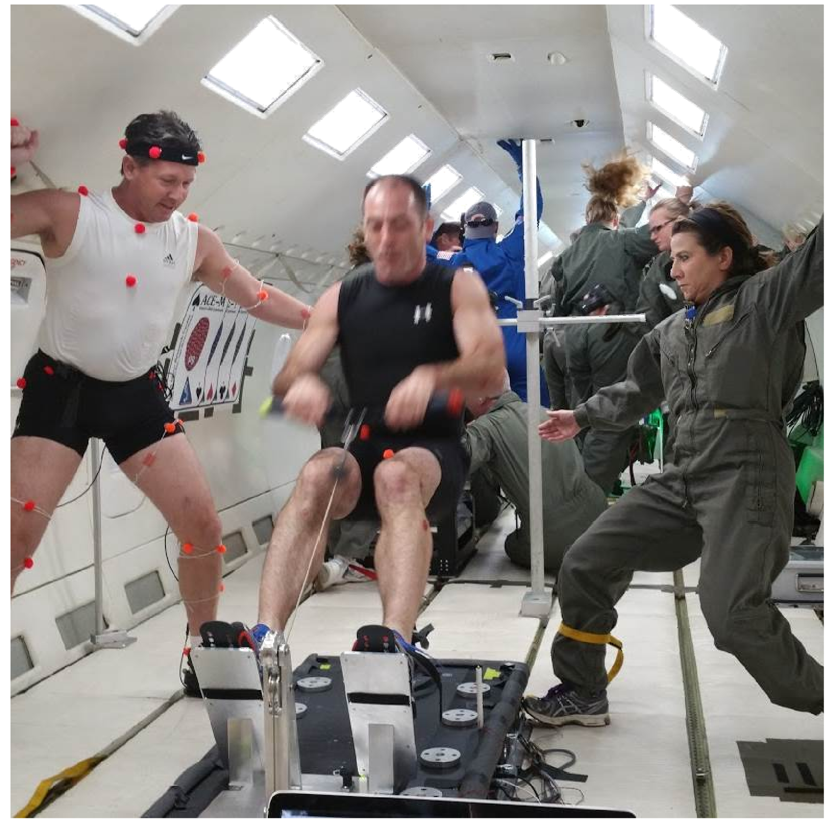
LoCapPy

- **Zero Gravity Flights have Unique Constraints**
  - Small Working Volume
  - Potential for damage to hardware
  - Laboratory motion capture best practices (obscured views and bumped cameras) often can not be followed
- **Goals**
  - Develop "Low Resolution" small foot print motion capture system that is capable of being used in Zero-Gravity Flights
    - Low to medium fidelity
    - Low Hardware Cost
    - Easy Setup
    - Small physical footprint
    - Minimal operational footprint
    - Reusable
    - Develop automated process (No need for manual digitization of points)

5 Cameras (Sony HDR-CX440)

- 1920x1080p at 60 fps (Interlaced)

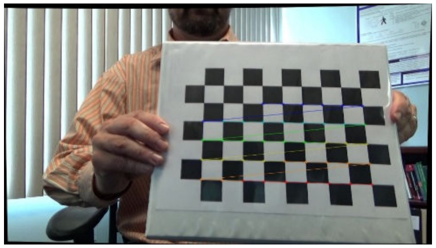


Markers

- ¾ in Yarn Pom Pom Balls (see Pintrest)
- Meets cabin safety requirements in case of release
- High Contrast Red and orange

Does this work?

Process

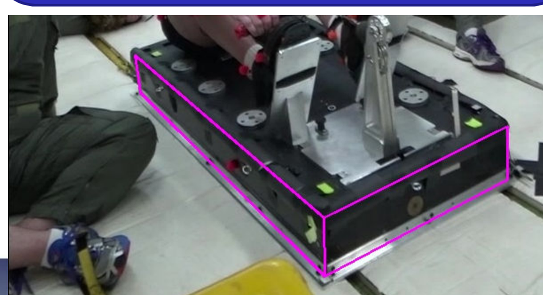


Pre-"Pre-Flight"
- Intrinsic Calibration
  Determine Individual Camera Distortion Parameters

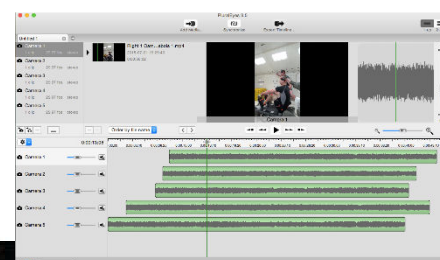
Flight
- Take Data
- Manually Start/stop cameras

Post Flight Analysis
- Marker Isolation
- Apply Intrinsic/Extrinsic Cal
- 3d Reconstruction & Volume

Pre-Flight
- Extrinsic Calibration
  - Perform Wand Wave
  - Determine Cameras Rotation & Location (aka Homogenous Transformation matrix)



Post Flight Editing
- Rotate Videos
- Collate video with activities
- Synch and Trim

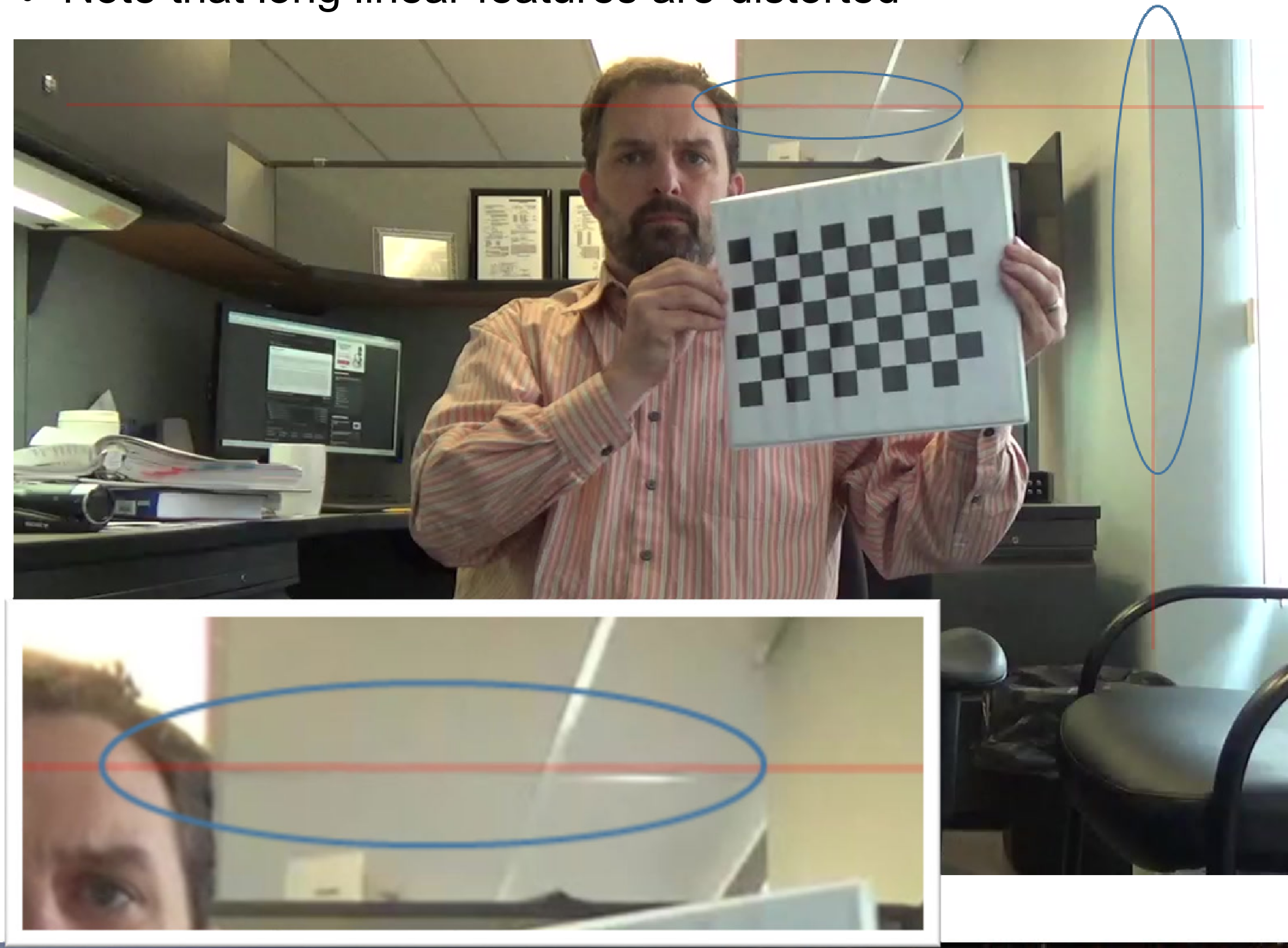


Software Tools

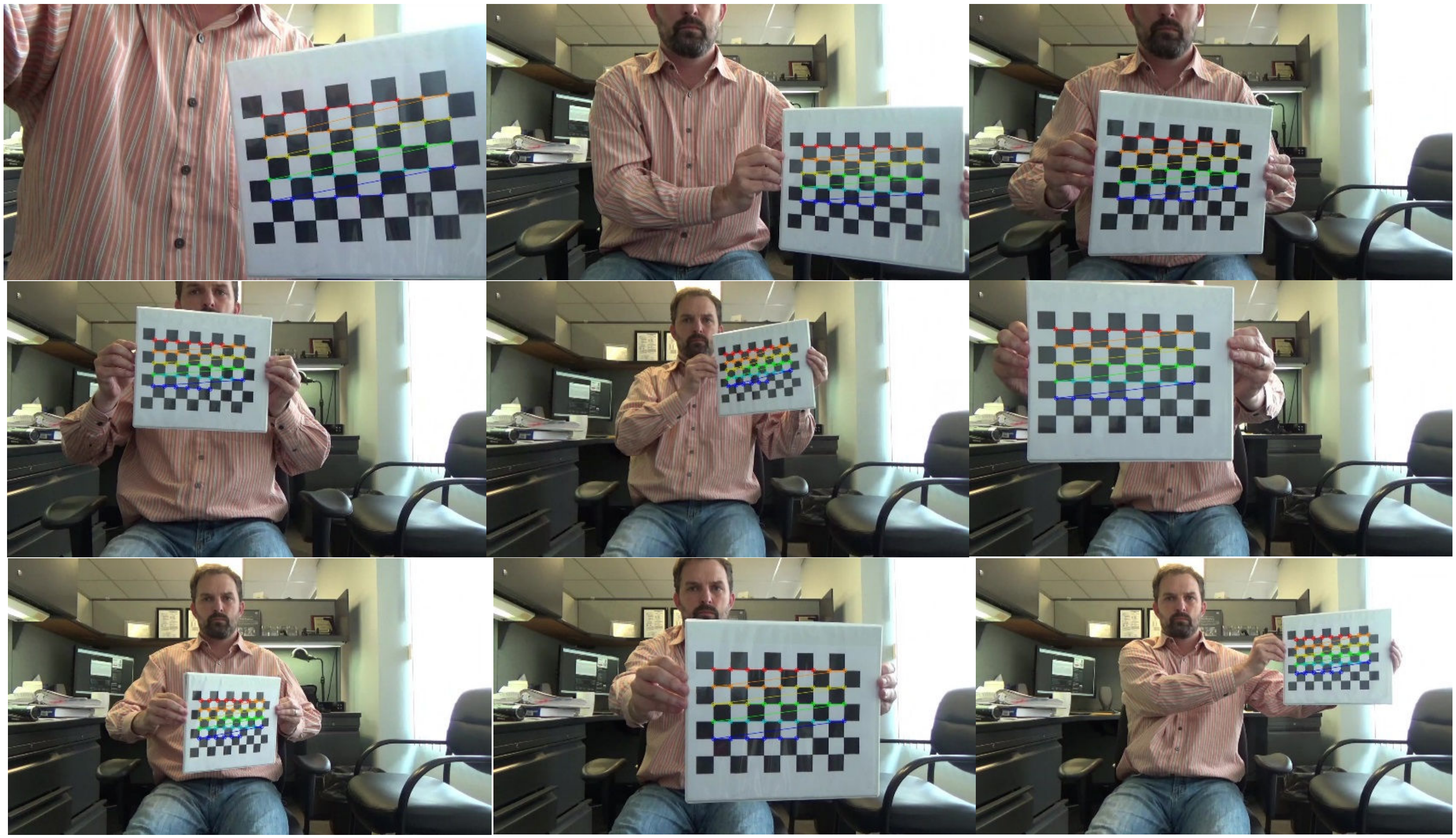
- Post Flight Editing
  - Utilized Red Giant's PluralEyes
  - Closed Source Video Editor
  - Synch and Trimming

- Pre-Processing, Post-Processing/Analysis
  - Python
    - Open Source
    - Developed custom code
    - OpenCV (Open Computer Vision) Python Library
  - FFMPEG
    - Open Source
    - Swiss Army Knife of video manipulation

- Calibration of camera distortion (e.g barrel distortion)
  - Note that long linear features are distorted

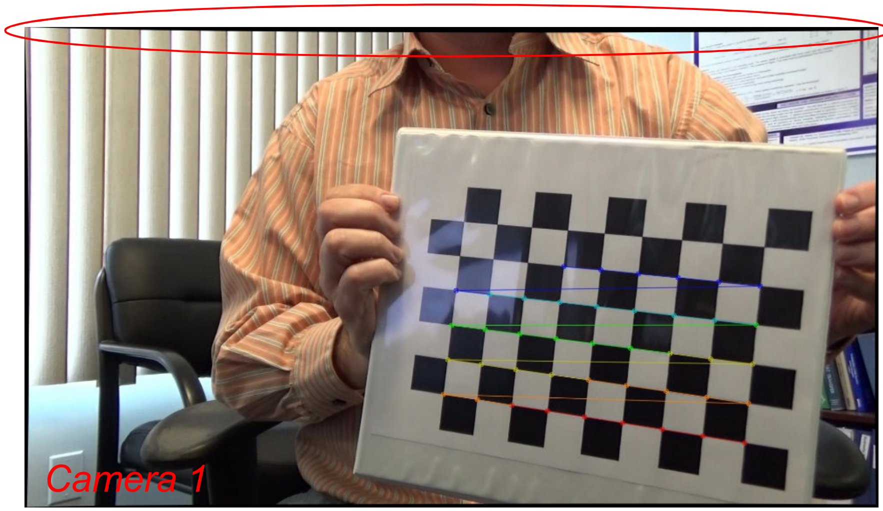


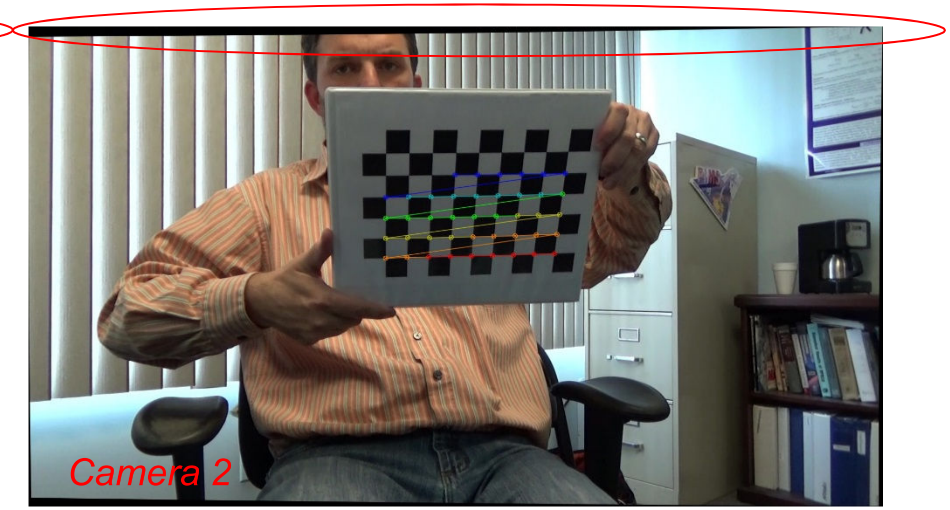
- OpenCV recognizes standard pattern
- Using checker board corners calculates distortion parameters
- “Sweep” Over Field of View (similar to wand calibration in MoCap)

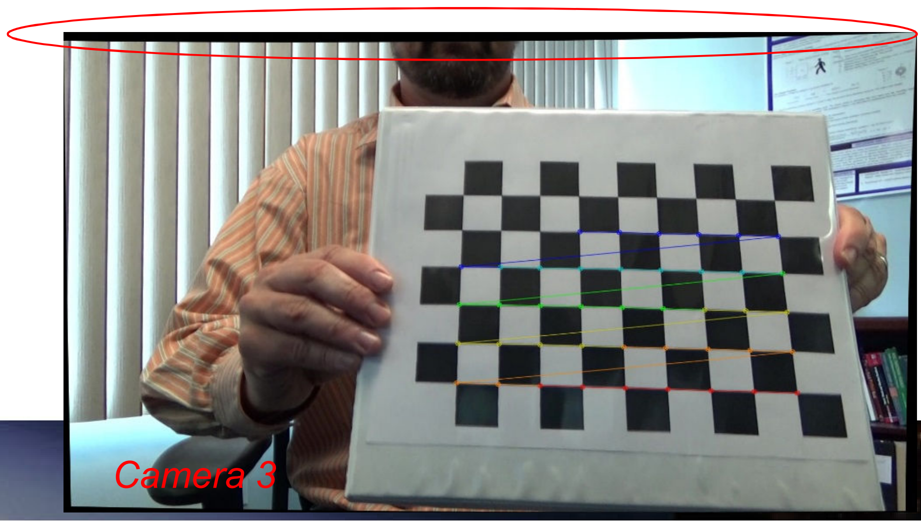


Intrinsic Calibration cont.

- Each camera has its own calibration
  - Each camera is different – the calibration is intrinsic to the individual camera
  - Post calibration shown below – note edge adjustment

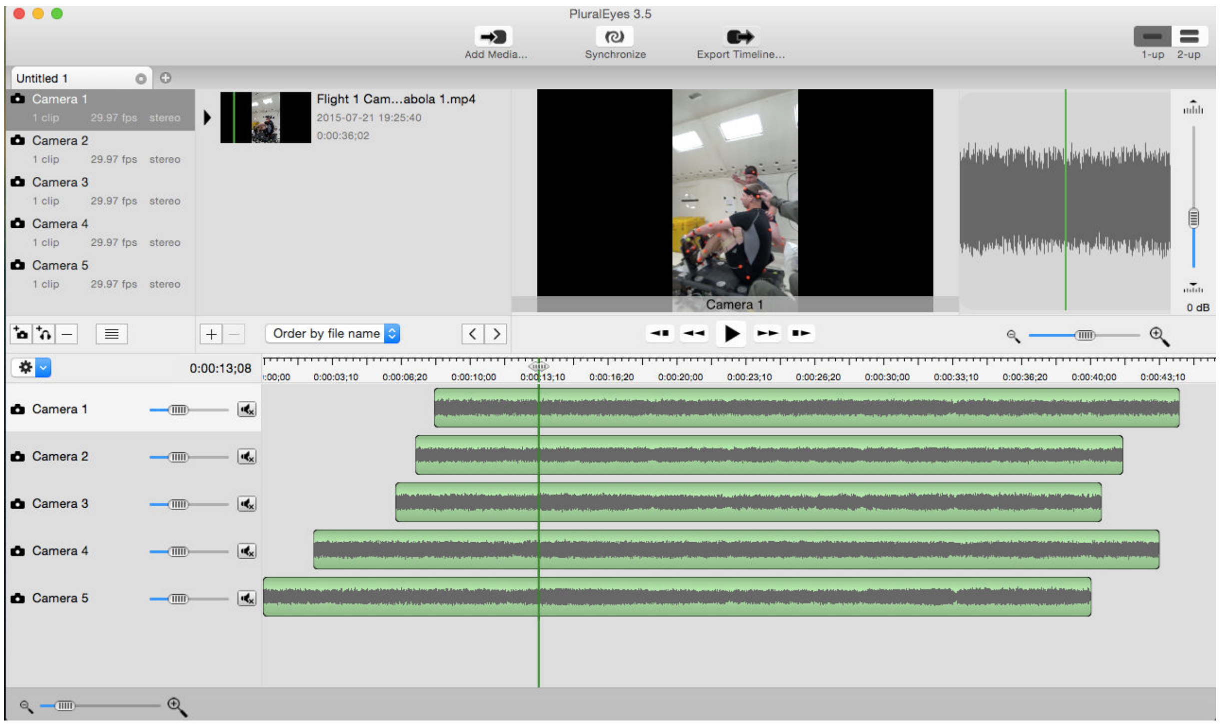






Post Flight Editing

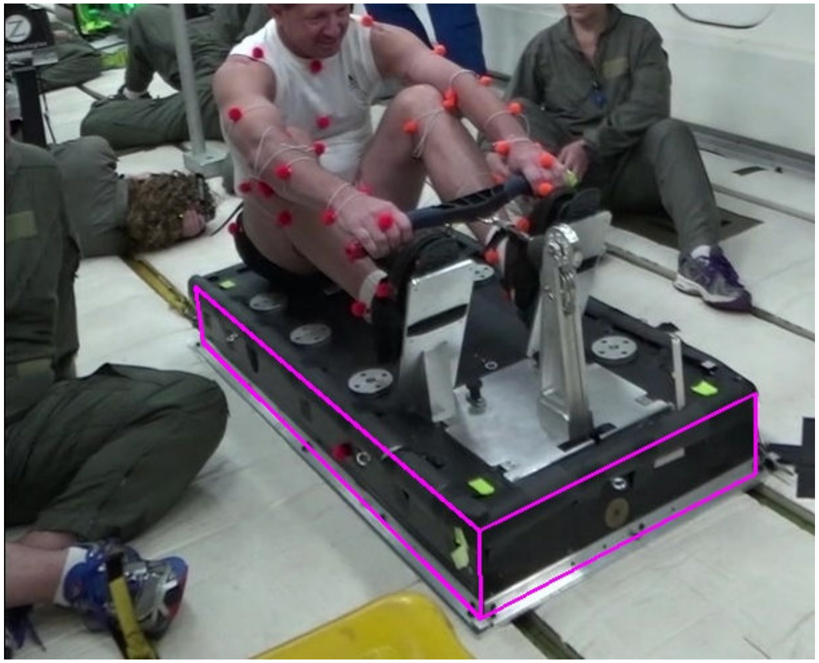
- Data collection during flight
  - Long video clips (cameras started/stopped 1-2 times per flight)
- Synch and Trim Editing (most manual intensive operation)
  - Video was sliced to isolate each parabola
  - Originally it was planned to use a LED light flash to synch
    - Unreliable due to operations
    - Must be visible in all cameras simultaneously
    - Utilized automated audio synch instead



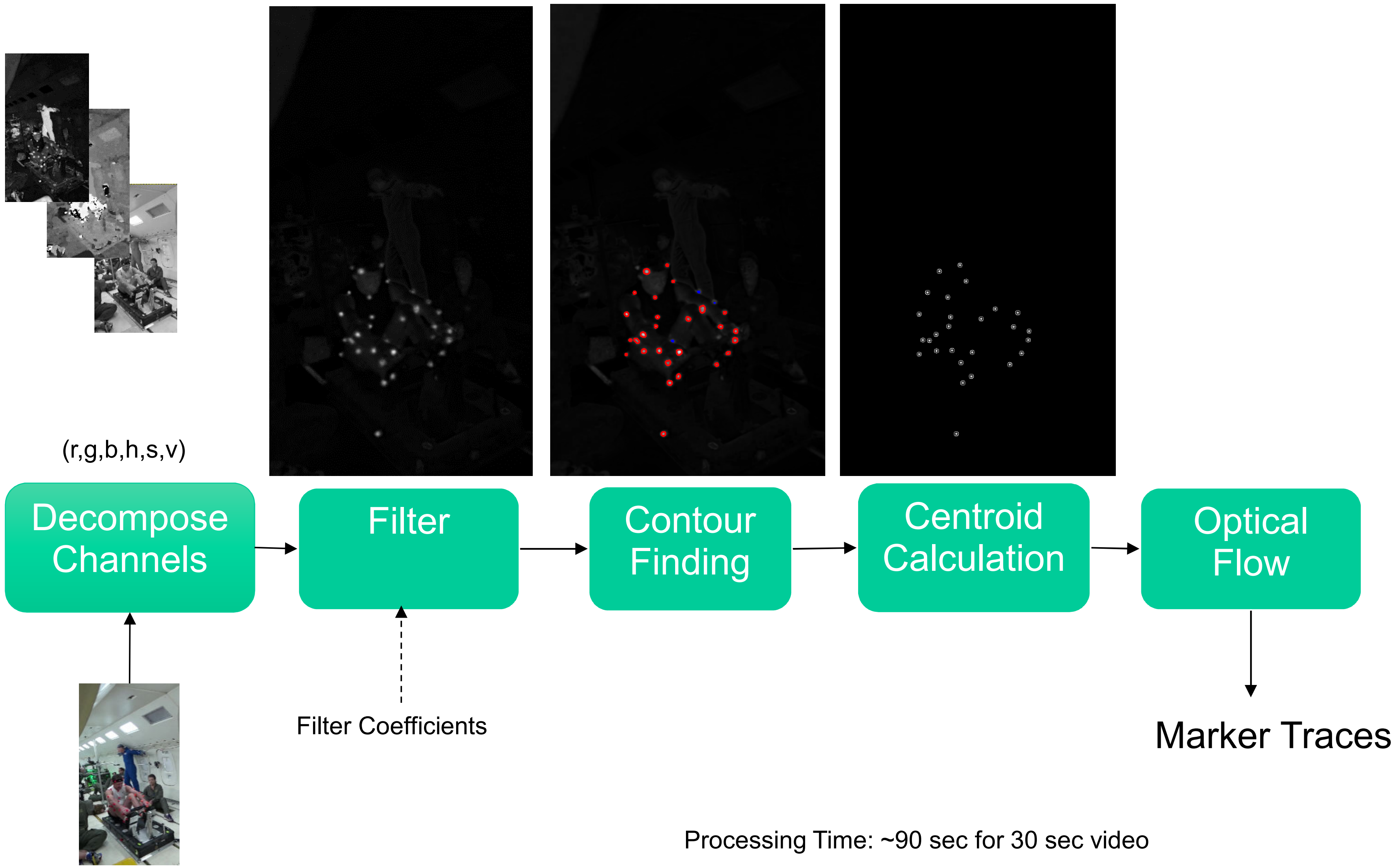
Post Flight Analysis - Calibration

Extrinsic Calibration

- Planned to use wand data, but inadvertent camera movement did not allow this.
- Utilized fixed known locations and homography to determine homogenous transformation matrix of the camera (x,y,z location & rotation matrix)



Post Flight Analysis – Marker Isolation



Processing Time: ~90 sec for 30 sec video

Post Flight Analysis – Marker Isolation

3D Reconstructions & Volume Representation

3D Reconstruction and Direct Linear Transformation

- Camera distortion characteristics
- Camera positions and orientation
- Now use a some linear algebra – Direct Linear Transformation to get x,y,z locations in 3D space

Volume Representation

Goal: Provide a visual qualitative reference for the use of the available MPCV exercise volume.

How: Utilize the all ready available intrinsic and extrinsic calibration information, multiple synched cameras, and homography to draw the volume on the zero gravity flight video.

Caveats:

1. The Location of the volume is arbitrarily chosen to be the front edge of the exercise device on the Zero Gravity flight (it's not been optimized)
2. The volume shown is only 24" wide to allow for better visualization, the current flight volume is thought to be 51"

Homography and Volume Representation

Lessons Learned

1) Minimization of operational steps during flight is paramount
2) Audio sync over visual sync (i.e. calling out parabola number)
3) Our markers worked well
4) Place good fixed markers to use for extrinsic calibration (wand cal is not practical)
5) Lot’s of cameras. Plan for Gluteus Interuptus

Acknowledgements

- John DeWitt
- Nathan Funk
- Justin Funk
- Devon Griffin
- Marsha Nall
- Nate Newbie
- Gail Perusek
- Chris Sheehan