Infrastructure Monitoring: Sensing for Change Detection, Volume Estimation, and Proactive Remediation

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Project Goals

- sUAV platforms and trajectory optimization
- Quatify improved computer vision with sensor telemetry
- Determine accuracies that can be achieved with sUAV-mounted hybrid sensing and analysis
  - Electro-optical
  - LiDAR
  - Thermal Imaging
  - μSAR ?

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Objectives and Tasks

Year 1 (current year):

- ✓ Computer vision expertise with addition of Dr. Ryan Farrell
- ✓ Use a controlled test environment for quantifying accuracy
- ✓ Assess accuracy of computer vision for detecting/measuring displacements in the controlled environment
- sUAV flight optimization for computer vision models in the field

Year 2:

- Develop field test sites for evaluating displacements in a pipeline, a soil slope/embankment, an asphalt/concrete pavement, and a rock fall
- Assess accuracy of computer vision for detecting/measuring field displacements
- Compare and combine multiple sensing data sources

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Ryan Farrell

- Recently joined the Computer Science Dept. at BYU
- Research Areas: Computer Vision, Object Recognition, Tracking

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UAS – an “Unknown Aerial System”

Photographs by Frode Jacobsen (CCUB NABirds)

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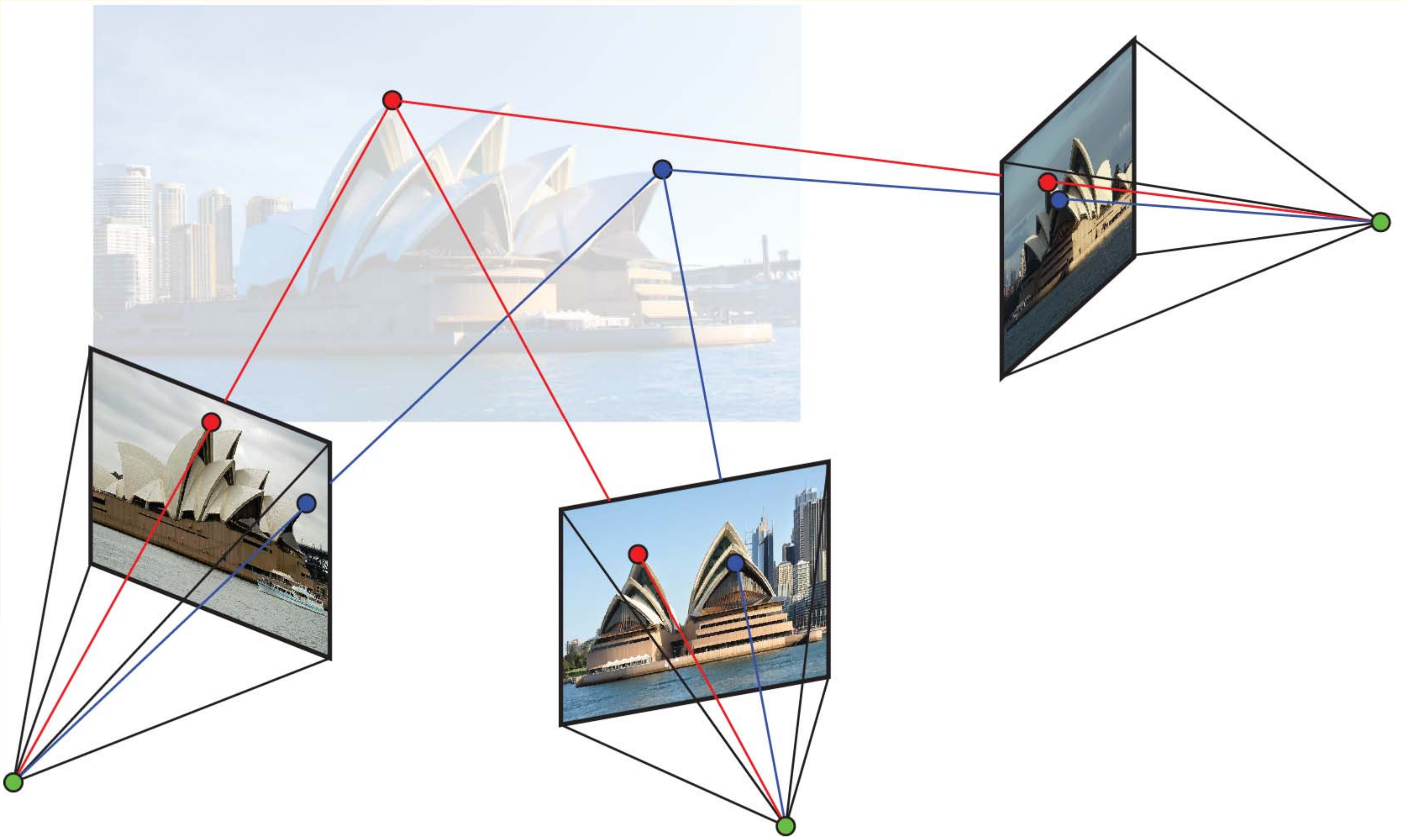
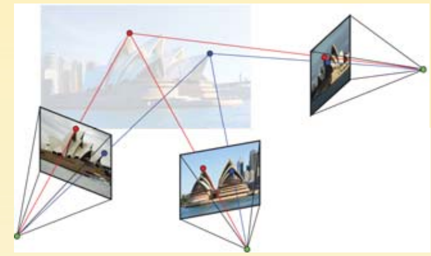
Building Models (SfM)

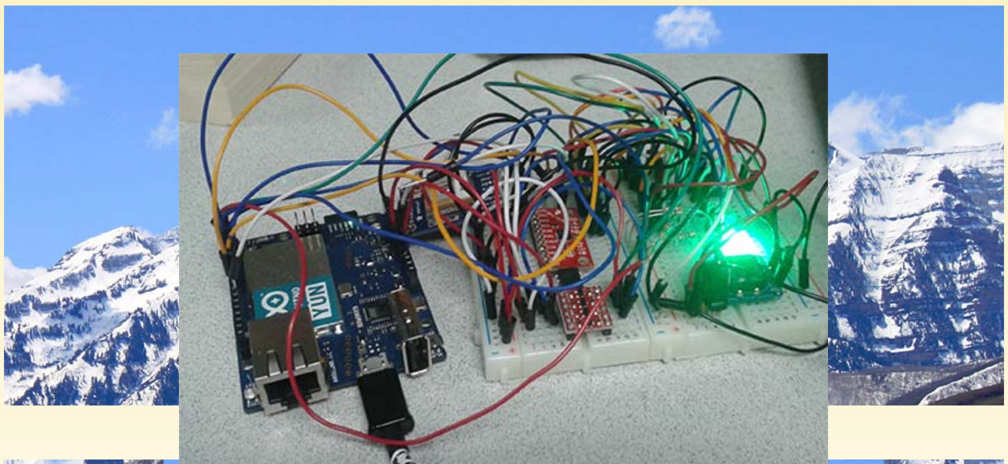


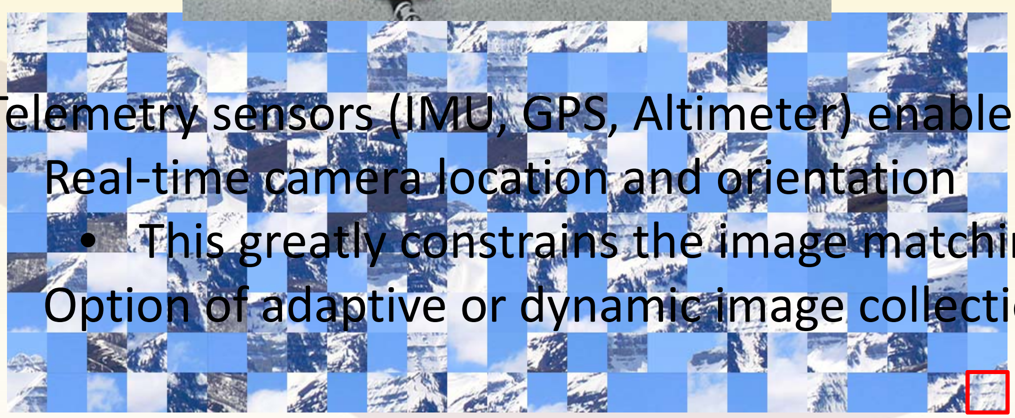
Images: CC - jdegenhardt, Bob Snyder, Jacques van Nierkerk, Kyle Wagaman, (Flickr)

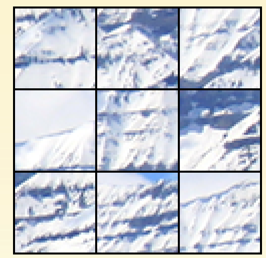
Building Models (SfM)

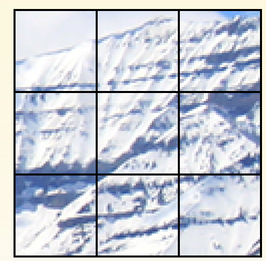
- SfM traditionally requires comparison of all pair of images (500K comparisons for 1K imgs)











Telemetry sensors (IMU, GPS, Altimeter) enable:

- Real-time camera location and orientation
  - This greatly constrains the image matching
- Option of adaptive or dynamic image collection

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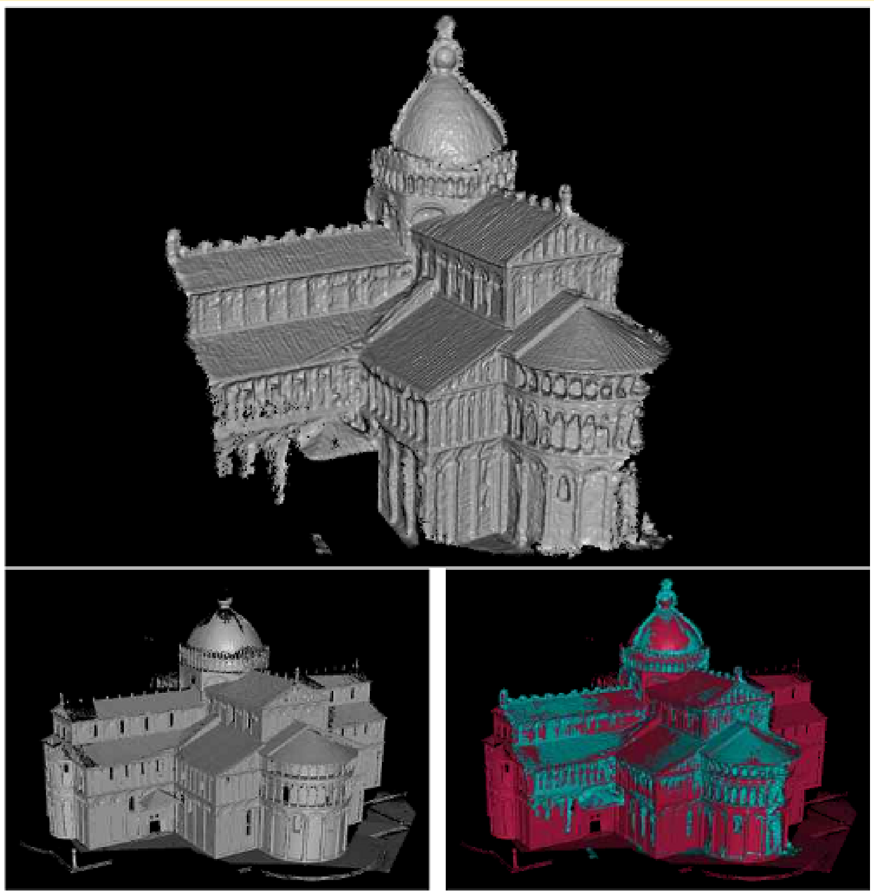
Image: CC - carfull (Flickr)

LiDAR and Computer Vision



- LiDAR and Imagery are complimentary
- LiDAR will allow:
  - better quantification of accuracy for computer vision models
  - better and more useful models by combining these modalities
- We are in the process of acquiring LiDAR and multi-spectral sensors

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Illustration: Michael Goesele etal., 2007

Image Collection Optimization

Camera Path Optimization Workflow

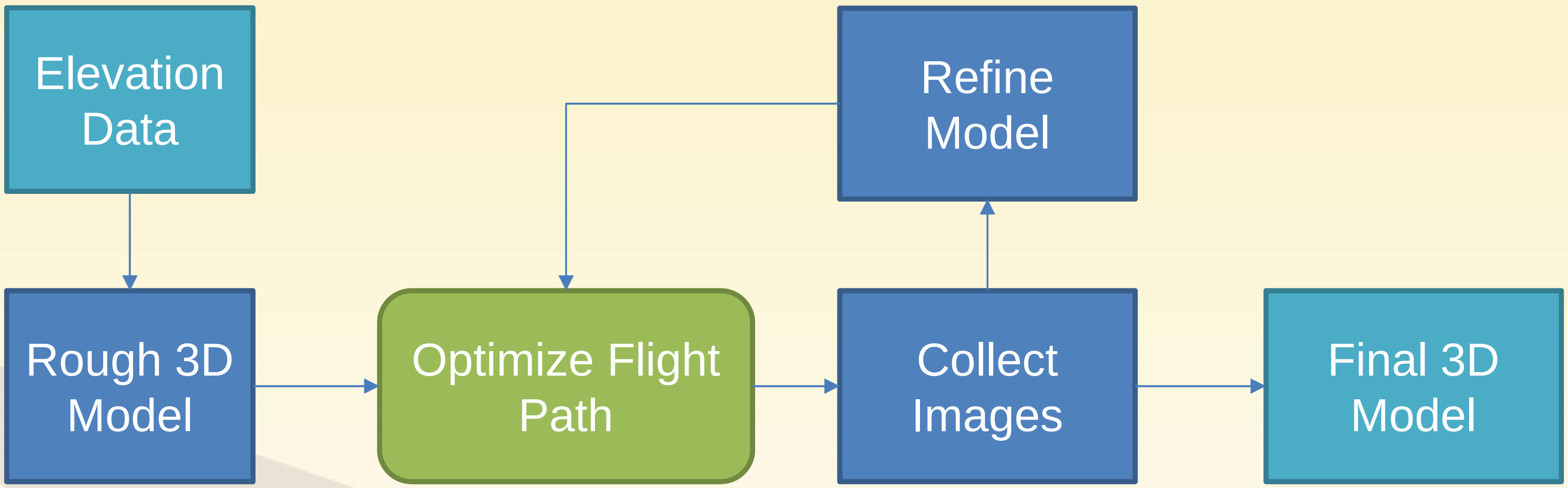
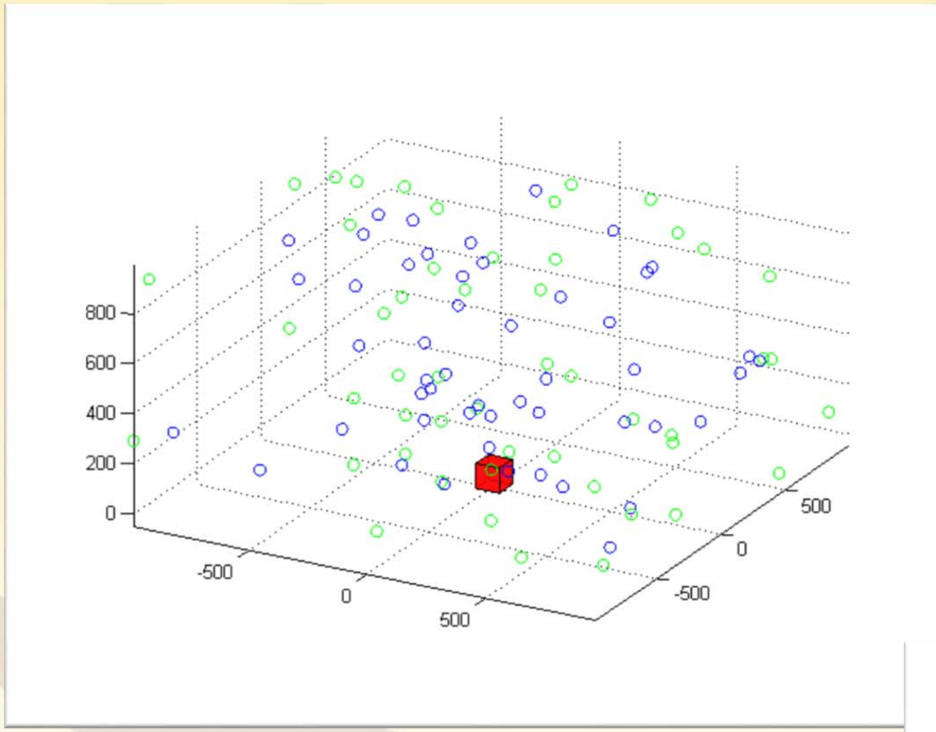
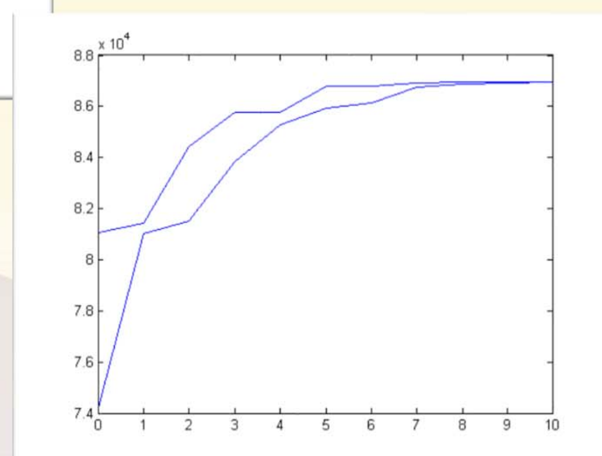


Image Collection Optimization



- Multicopter Platform
- Genetic Algorithm
- Calculate optimal camera positions for 3D reconstruction



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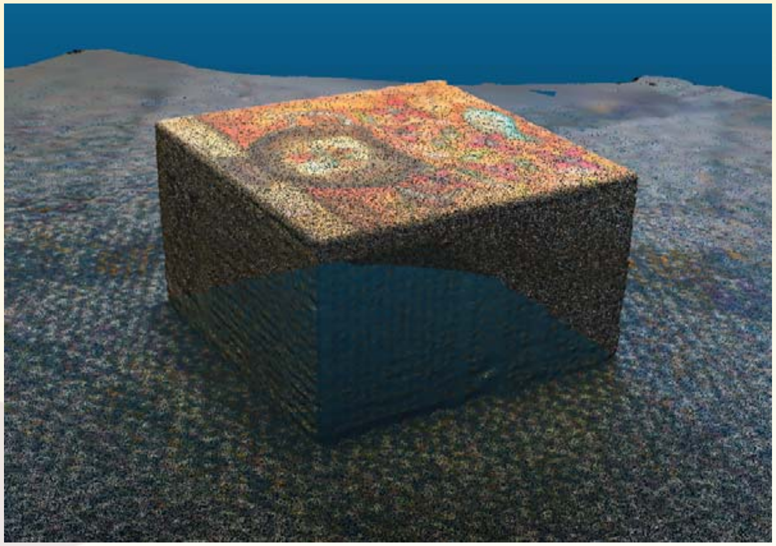
Volume Estimation

Lab Study: Box

Actual Volume: 1,256 cm^3
Model Volume: 1,267 cm^3
Error: 0.81%

Surface Measurement
RMSE: 0.56 mm



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Joe’s Valley – Dam Inspection

- Quantification of Model Accuracy

Fly-over image of Joe’s Valley Reservoir Dam

Computer vision model of Joe’s Valley Reservoir Dam

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Platform Selection for Accuracy

- Improvement of 7% with quadcopter vs. flying wing
  - Distance measurements
  - Pending: quantify surface feature accuracy for displacement detection

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Progress Summary

- Current Progress
  - Quantification of accuracy of volume estimation
  - Improvement of 7% with quadcopter vs. flying wing
  - Scalable computing on Amazon EC2
  - Field testing on earthen levee spillway
- Planned Progress
  - Enhanced accuracy with LiDAR Velodyne
  - Integrated telemetry for enhanced SfM
  - Selection of field test site for pipeline monitoring

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