

# Aerial Photogrammetry for Volcanology

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# Outline

## Introduction

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Photo Taking Technique

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Mission Planner and APM

Canon Hack Development Kit

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# What Is Photogrammetry?

- ▶ Also known as *structure from motion*
- ▶ Parallax from photos taken from different positions
- ▶ Reconstruct 3D model of object
- ▶ No need to know camera positions! (although it helps...)
- ▶ Used by Google for Google Earth
- ▶ Building Rome in a day (150,000 Flickr images, 496 cores, 21 hours):



# Taking Photos

**Facade (Incorrect)**



# Taking Photos

**Facade (Correct)**

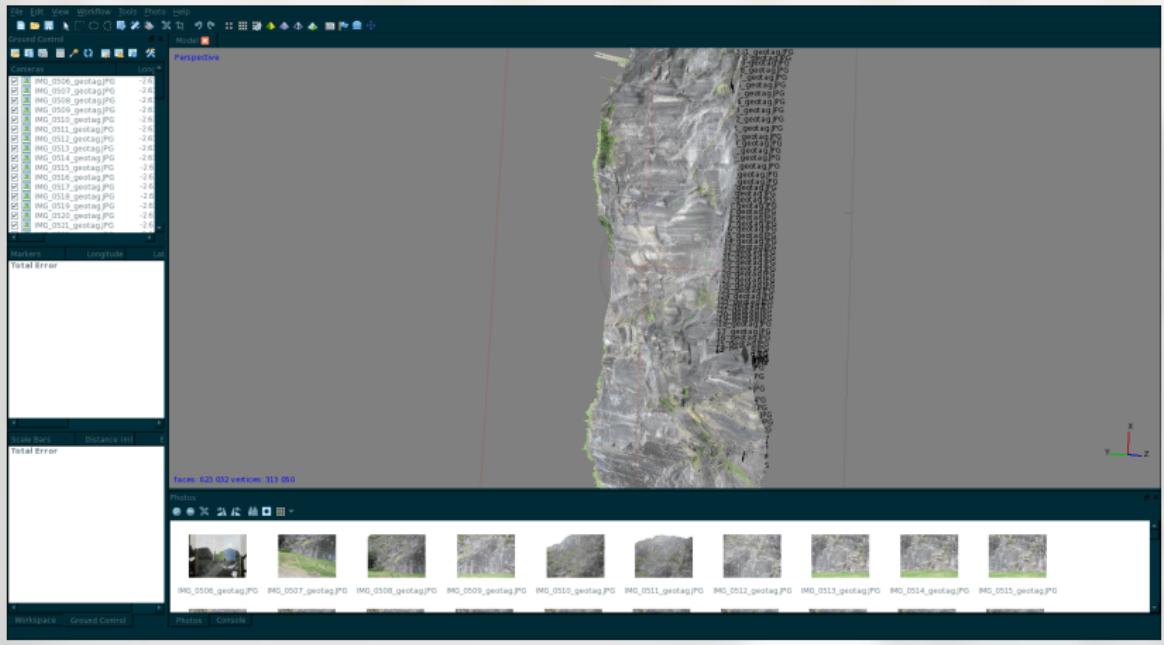


# Agisoft Photoscan

- ▶ Input photos of an object from different positions
- ▶ Uses parallax to generate sparse point cloud
- ▶ Uses sparse point cloud to generate dense point cloud
- ▶ Uses dense point cloud to generates mesh (connect the dots)
- ▶ Overlaps texture from photos on top (texture)

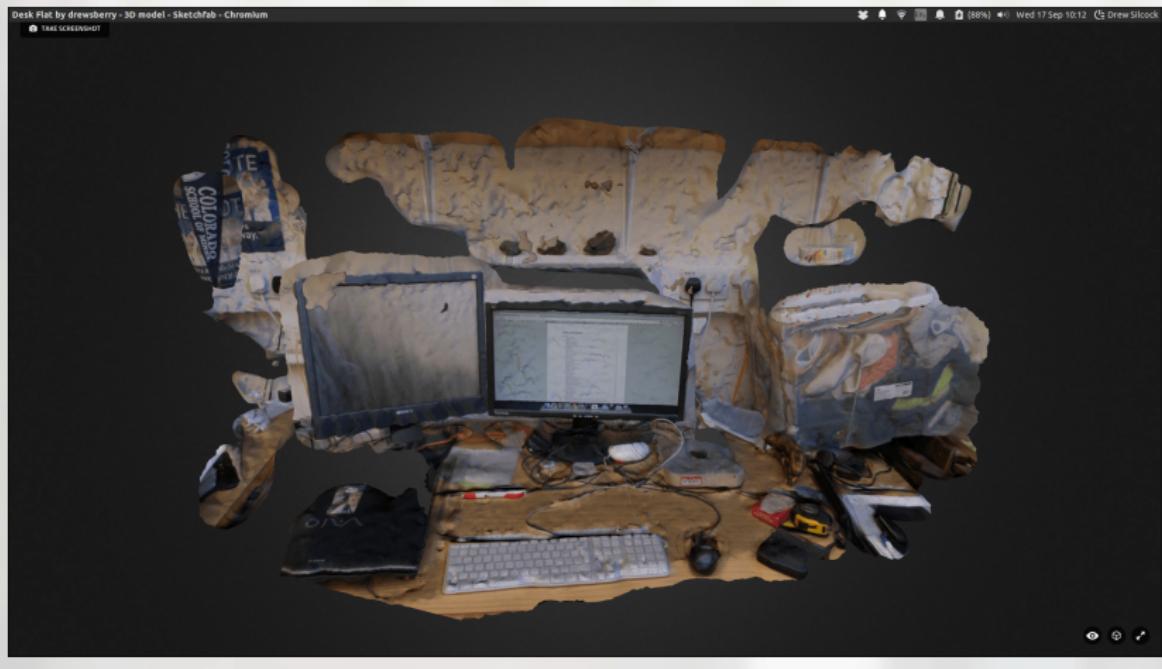
# Agisoft Photoscan

Here's what it looks like in action:



# Agisoft Photoscan

Here's what it produces:



# Mission Planner and APM

- ▶ ArduPilot Mega (APM): autopilot for UAV
- ▶ Takes instruction from Mission Planner (MP)
- ▶ MP can:
  1. Set waypoints for UAV
  2. Tell UAV to hover
  3. Tell UAV to take photos (theoretically)
  4. Geotag photos from log or time offset  
(more on this later)



# Canon Hack Development Kit

- ▶ Pretty cool hack for Canon cameras
- ▶ Allows you to set camera to take pictures every 5 seconds, take photos on electronic input, etc.
- ▶ Executes scripts written in Lua or UBASIC



# Uses

- ▶ As with Lidar (see Oscar's presentation)
- ▶ Studying lava flow
- ▶ Lava flow prediction
- ▶ UAVs able to get where traditionally it was not possible
- ▶ Cheap (buy simply point and shoot from Amazon)
- ▶ Light (especially useful for putting on UAVs)

# Taking Photos

Two options:

**Time delay** Tell CHDK to take pictures every 5 seconds, strap it onto your UAV and you're ready to go

**CAM messages** Tell CHDK to take photos whenever it receives an electronic signal of a particular kind (Pulse Width Modulation). APM then logs this event.

Latter is better for geotagging (next slide), but also a huge pain to get to work...

# Geotagging - Time Delay

- ▶ APM keeps a log of GPS location, time, yaw and roll
- ▶ Tell MP offset between first photo and first log message (take picture of screen), give it log and photos and it geotags them
- ▶ Two types of logs:

## Telemetry logs (.tlog)

Taken while MP connected to APM by USB and saved to MP computer

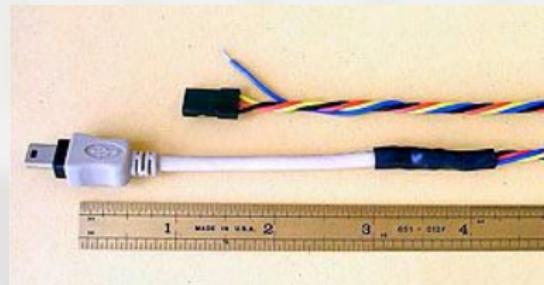
## Dataflash logs (.log)

Taken while the copter is armed and saved to APM flash storage; download later when connected to MP

- ▶ Dataflash used when aerial

# Geotagging - CAM Messages

- ▶ APM tells CHDK to shoot
- ▶ APM logs CAM message:  
time, location, roll and  
yaw

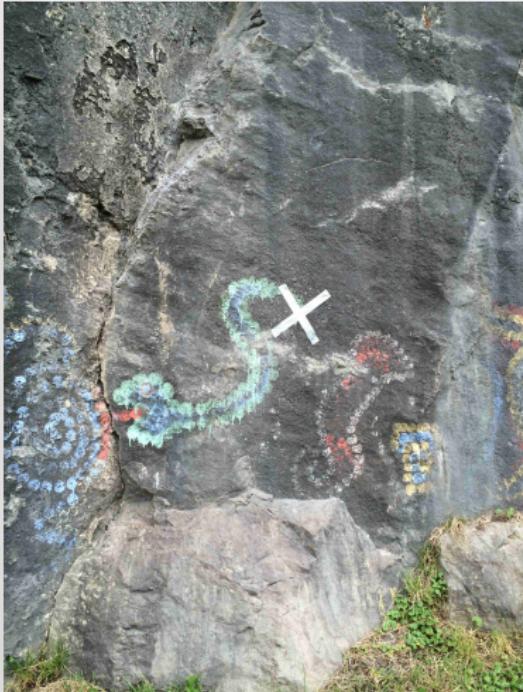


- ▶ CAM log message specified by:  
`FMT, 18, 27, CAM, IHLLeccC, GPSTime, GPSWeek, Lat, Lng, Alt, Roll, Pitch, Yaw`
- ▶ So look out for something in your log that looks like:  
`CAM, 57263726, 1790, 54.4136582, -3.5039962, 62.74, 7.12, 8.56, 12.01`
- ▶ Give MP your photos and your .log, and it automatically geotags them for you

# Ground Control Points

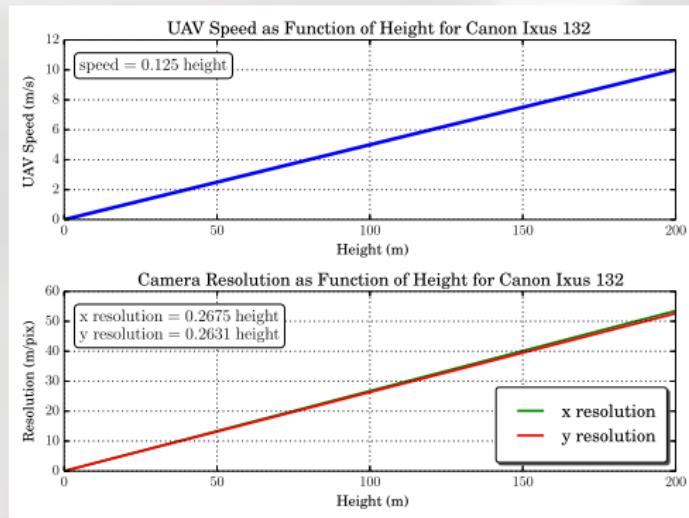
- ▶ To help with the photogrammetric reconstruction, we employ GCPs
- ▶ Measure in the exact location of a coordinate, marked with a distinguishable feature (e.g. cross)
- ▶ Tell PhotoScan where that mark is geographically as co-ordinates in local reference or WGS 84
- ▶ PhotoScan optimises point cloud generation
- ▶ Improved accuracy and precision

# Ground Control Points



# Accuracy and Precision

- ▶ Meters per pixel as function of height
- ▶ Minimum UAV speed needed to give required overlap (80%)
- ▶ Agisoft generated reports give m/pix, error in pix, DEM error in pix



# Results

## Aerial Survey

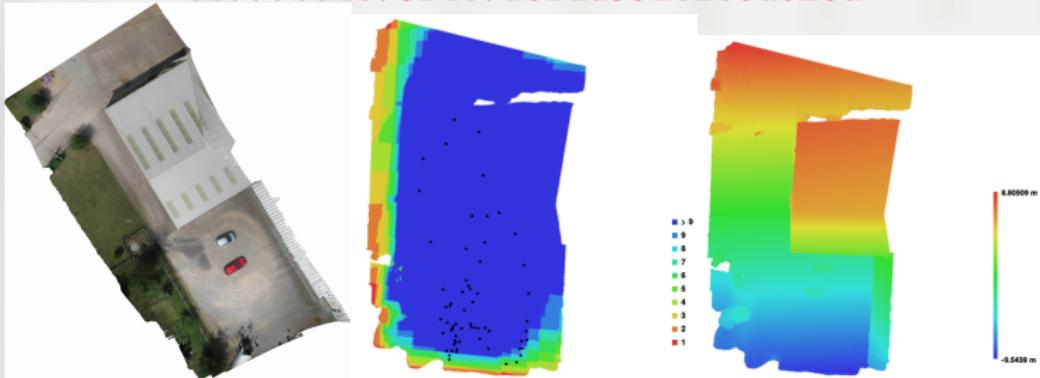
- ▶ Long Ashton field
- ▶ Partly mapped, before everything broke
- ▶ PhotoScan generated DEM, orthophoto, photo overlap, GCP data and accuracy

## Avon Gorge

- ▶ Avon Gorge, big rock with cool fractures
- ▶ Horizontal instead of vertical
- ▶ PhotoScan generated DEM, orthophoto, photo overlap and accuracy

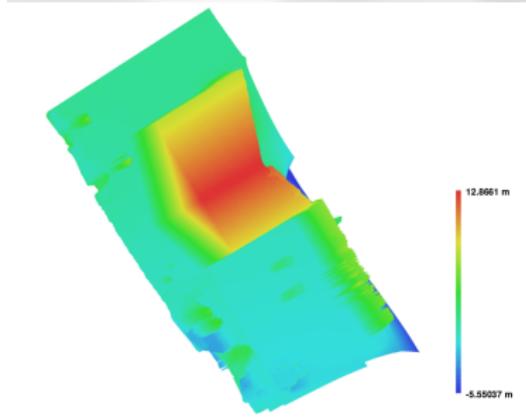
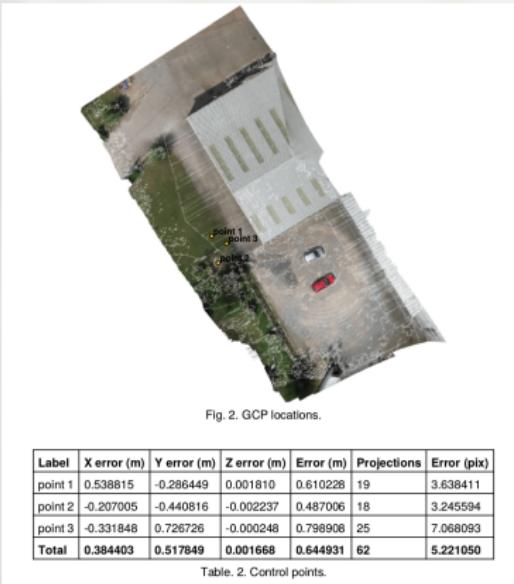
# Aerial Survey Without GCPs

[https://sketchfab.com/models/  
ec777be4b73f4e7a8fdd992c2b8d026a](https://sketchfab.com/models/ec777be4b73f4e7a8fdd992c2b8d026a)



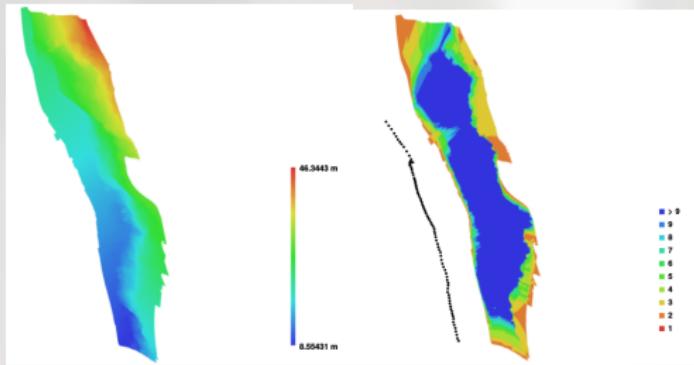
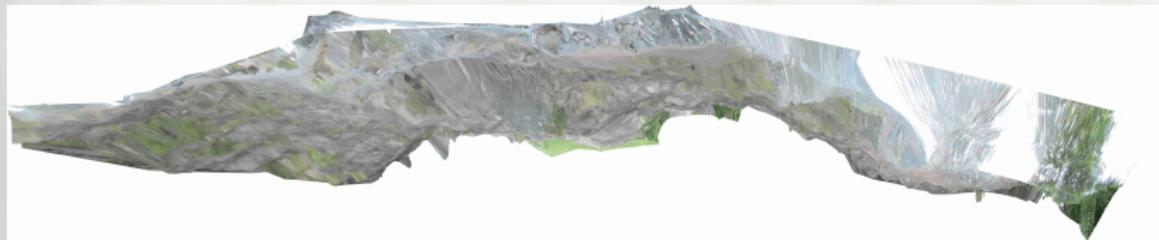
Number of images:	63	Camera stations:	63
Flying altitude:	14.3375 m	Tie-points:	137326
Ground resolution:	0.00277927 m/pix	Projections:	403205
Coverage area:	0.000513568 sq km	Error:	0.960084 pix

# Aerial Survey With GCPs



# Avon Gorge

<https://sketchfab.com/models/ad8a1d9f8c324eb592a9e4beabc5a51e>



# Future Projects

- ▶ Figure out how to get MP to tell CHDK to take photos at waypoints
- ▶ Investigate more possible uses for Earth Science/Volcanology
- ▶ Write manual for future UAV/photogrammetry researcher
- ▶ Rerun reconstruction of Avon Gorge with GCPs

# Lidar vs. Photogrammetry

## Pros of Photogrammetry

- ▶ Cheap (doesn't matter if you drop it in some lava)
- ▶ Light (good for putting on UAVs)

## Pros of Lidar

- ▶ Very accurate and precise
- ▶ Real-time measurements - can make measurements of dynamic, moving objects