Title: "enrGies_2016-04-08--MorganCountyAL_Tornado--LibbysAreaTrack__KMLtiles"

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1.0 Data Set Overview:

- "enrGies" is a commercial engineering and operations-based company located in Huntsville, AL that, among other items, provides expertise and services related to unmanned aircraft systems (UAS). In collaboration with the NOAA UAS Program Office, the University of Alabama in Huntsville, the Morgan County AL Emergency Management Agency, and the National Weather Service Weather Forecast Office in Huntsville, AL, enrGies donated expertise, operational time, GIS computer processing resources, and expertise toward the acquisition and delivery of aerial imagery of a damage path produced by an EF-2 tornado that occurred on the evening of Thursday March 31, 2016 along a ~9 mile track across parts of Morgan County, AL in support of Intensive Operations Period (IOP) #3 for the 2016 VORTEX-Southeast field campaign.

- The imagery for this dataset was obtained on date:
  04-08-2016

- The approximate center point of the collected imagery product is located at the following coordinates:
  34.510585 Latitude, -86.870287 Longitude

2.0 Instrument Description:

- The UAS was composed of the senseFly eBee platform, integrated with the CanonPowerShotS110 5.2 4000x3000 (RGB) camera as the optical sensor
- For more information regarding either this UAV platform or the optical sensor payload, please refer to the following internet links:
  https://www.sensefly.com/fileadmin/user_upload/sensefly/documents/brochures/eBee_RTK_en.pdf
  https://www.sensefly.com/fileadmin/user_upload/sensefly/documents/manuals/user_manual_s110_v3.pdf

3.0 Data Collection and Processing:

- The data was collected by the integrated camera payload from the eBee UAV platform at a nominal altitude ranging between approximately 300 to 400 feet AGL. A pre-planned semi-autonomous "lawnmower" flight pattern was utilized to cover the area of interest and collect the raw data, which was later processed to generate the finished two-dimensional orthomosaic product. Further GIS processing report and associate metadata, provided below.
- The original horizontal spatial resolution (aka: Ground Sample Distance) of the associated product was 3.91 cm/pixel; however, some slight degradation of this value can be expected due to the conversion and compression into the more versatile "tiled KML" data format.

4.0 Data Format:

- Tiled KML

5.0 Data Remarks:

- N/A

6.0 References:

- N/A

7.0 Processing Quality Report:

- See following pages, below

Quality Report

Generated with Postflight Terra 3D version 4.0.83

Important: Click on the different icons for:

Help to analyze the results in the Quality Report

Additional information about the sections

Click here for additional tips to analyze the Quality Report

Summary

Project	tornado - libbys n
Processed	2016-04-20 15:23:47
Average Ground Sampling Distance (GSD)	3.91 cm / 1.54 in
Area Covered	undefined

Quality Check

Images	median of 13382 keypoints per image	
Dataset	214 out of 304 images calibrated (70%), all images enabled, 3 blocks	
Camera Optimization	0.32% relative difference between initial and optimized internal camera parameters	
Matching	median of 2244.7 matches per calibrated image	
Georeferencing	no, no 3D GCP	

Preview

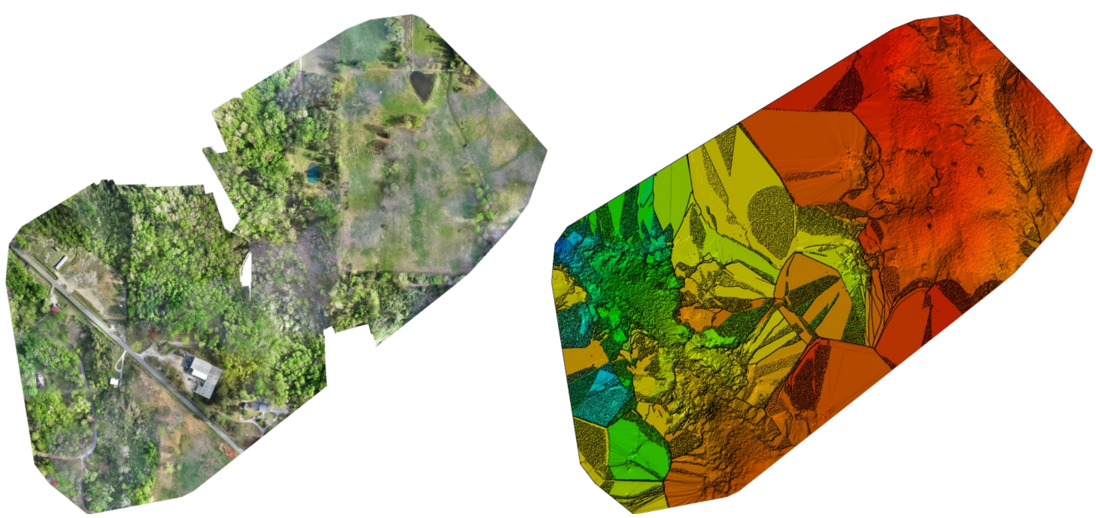


Figure 1: Orthomosaic and the corresponding sparse Digital Surface Model (DSM) before densification.

Calibration Details

Number of Calibrated Images	214 out of 304
Number of Geolocated Images	304 out of 304

Initial Image Positions

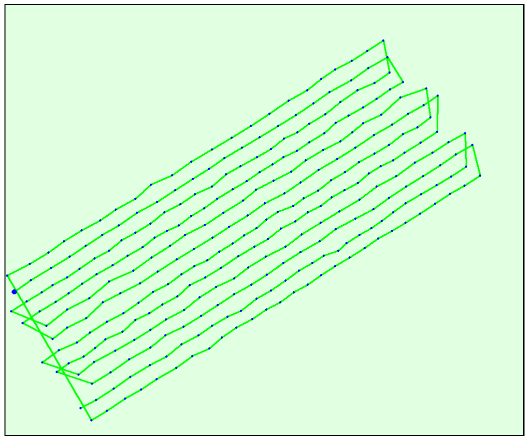


Figure 2: Top view of the initial image position. The green line follows the position of the images in time starting from the large blue dot.

Computed Image/GCPs/Manual Tie Points Positions

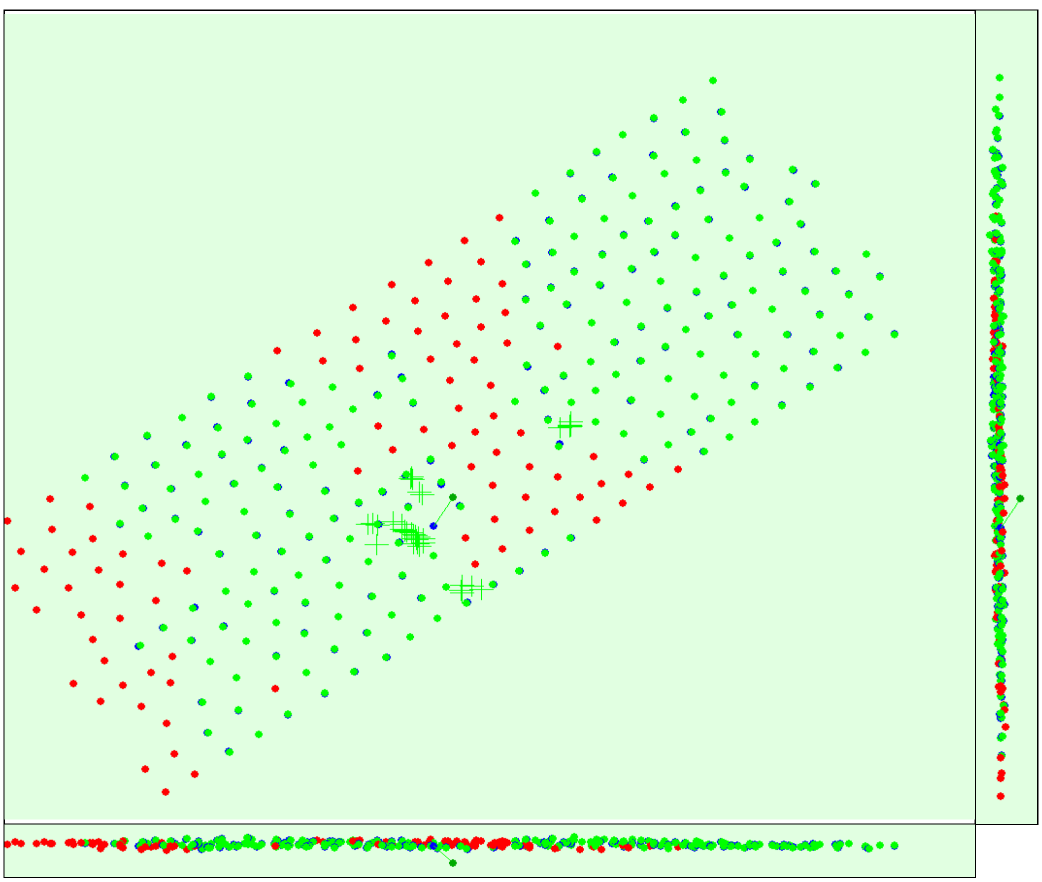


Figure 3: Offset between initial (blue dots) and computed (green dots) image positions as well as the offset between the GCPs initial positions (blue crosses) and their computed positions (green crosses) in the top-view (XY plane), front-view (XZ plane), and side-view (YZ plane).
Red dots indicate disabled or uncalibrated images.

Overlap

Figure 4: Number of overlapping images computed for each pixel of the orthomosaic.
Red and yellow areas indicate low overlap for which poor results may be generated. Green areas indicate an overlap of over 5 images for every pixel. Good quality results will be generated as long as the number of keypoint matches is also sufficient for these areas (see Figure 5 for keypoint matches).

Bundle Block Adjustment Details

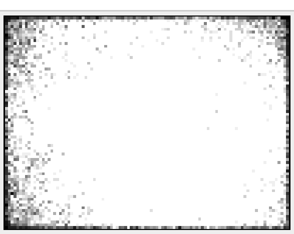
Number of 2D Keypoint Observations for Bundle Block Adjustment	491560
Number of 3D Points for Bundle Block Adjustment	202614
Mean Reprojection Error [pixels]	0.133508

Internal Camera Parameters

CanonPowerShotS110_5.2_4000x3000 (RGB). Sensor Dimensions: 7.440 [mm] x 5.580 [mm]

EXIF ID: CanonPowerShotS110_5.2_4000x3000

	Focal Length	Principal Point x	Principal Point y	R1	R2	R3	T1	T2
Initial Values	2860.478 [pixel] 5.320 [mm]	2047.508 [pixel] 3.808 [mm]	1494.393 [pixel] 2.780 [mm]	-0.040	-0.012	0.007	0.000	0.004
Optimized Values	2869.914 [pixel] 5.338 [mm]	1970.732 [pixel] 3.666 [mm]	1491.515 [pixel] 2.774 [mm]	-0.037	-0.013	0.010	-0.001	-0.002



The number of Automatic Tie Points (ATPs) per pixel averaged over all images of the camera model is color coded between black and white. White indicates that, in average, more than 16 ATPs are extracted at this pixel location. Black indicates that, in average, 0 ATP has been extracted at this pixel location. Click on the image to the see the average direction and magnitude of the reprojection error for each pixel. Note that the vectors are scaled for better visualization.

2D Keypoints Table

	Number of 2D Keypoints per Image	Number of Matched 2D Keypoints per Image
Median	13382	2245
Min	11550	1
Max	20463	5934
Mean	13378	2297

3D Points from 2D Keypoint Matches

	Number of 3D Points Observed
In 2 Images	156145
In 3 Images	27342
In 4 Images	9815
In 5 Images	4365
In 6 Images	2199
In 7 Images	1188
In 8 Images	644
In 9 Images	376
In 10 Images	213
In 11 Images	126
In 12 Images	93
In 13 Images	58
In 14 Images	27
In 15 Images	19
In 16 Images	4

2D Keypoint Matches

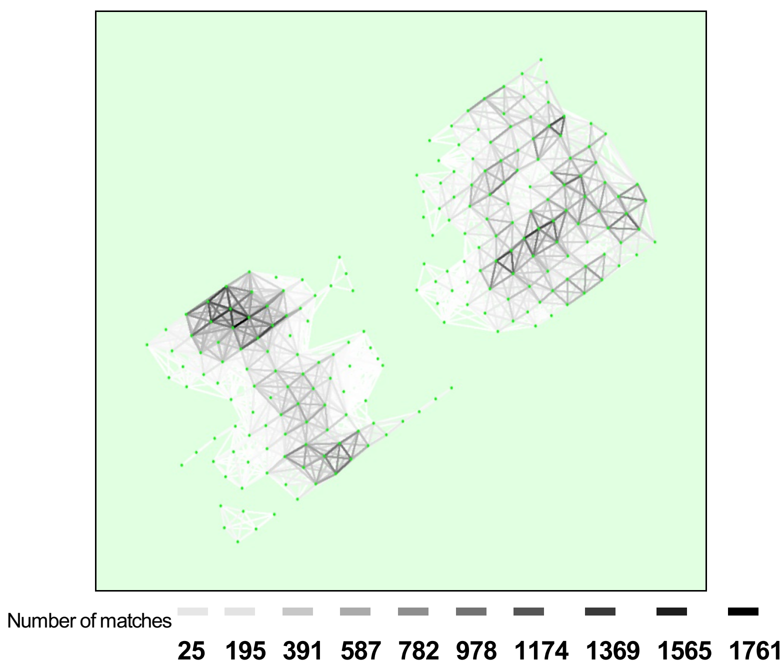


Figure 5: Top view of the image computed positions with a link between matching images. The darkness of the links indicates the number of matched 2D keypoints between the images. Bright links indicate weak links and require manual tie points or more images.

Manual Tie Points

MTP Name	Projection Error [pixel]	Verified/Marked
mtp133719	1.635	3 / 3
mtp14605	1.377	4 / 4
mtp114656	0.752	3 / 3
mtp114656_1	9.498	4 / 4
mtp114664	3.360	3 / 3
mtp120245	520.592	3 / 3
mtp114646	3.138	3 / 3
mtp114662	5.245	3 / 3
mtp10	8.325	8 / 8
mtp11_1	3.583	8 / 8
mtp12	0.025	2 / 2
mtp13	0.204	4 / 4
mtp14	0.362	4 / 4
mtp15	0.841	4 / 4
mtp16	0.257	3 / 3
mtp20	1.854	12 / 12
mtp21	0.682	14 / 14
mtp22	1.120	12 / 12
mtp23	1.455	5 / 5
mtp24	1.376	5 / 5
mtp25	2.020	5 / 5
mtp26	93.977	6 / 6
mtp27	16.617	8 / 9
mtp28	10.004	9 / 9
mtp29	3.392	6 / 6
mtp30	2.702	7 / 7
mtp31	2.469	7 / 7
mtp32	2.013	4 / 4
mtp33_1	4.276	5 / 5
mtp34	0.825	7 / 7
mtp35	2.008	6 / 6
mtp36	1.139	6 / 6
mtp37	1.301	12 / 12
mtp38	2.731	7 / 7
mtp39	1.325	9 / 9
mtp40	1.327	9 / 9
mtp41	1.094	7 / 7
mtp42	0.875	7 / 7
mtp43	1.187	9 / 9

Projection errors for manual tie points.The last column counts the number of images where the manual tie point has been automatically verified vs. manually marked.

Geolocation Details

Absolute Geolocation Variance

Min Error [m]	Max Error [m]	Geolocation Error X [%]	Geolocation Error Y [%]	Geolocation Error Z [%]
-	-4.23	0.00	0.00	0.00
-4.23	-3.39	0.00	0.00	0.00
-3.39	-2.54	0.00	0.47	0.00
-2.54	-1.69	0.47	0.47	0.00
-1.69	-0.85	4.23	6.10	14.08
-0.85	0.00	45.07	44.60	37.09
0.00	0.85	44.13	37.09	31.46
0.85	1.69	5.63	10.33	16.90
1.69	2.54	0.00	0.47	0.47
2.54	3.39	0.47	0.47	0.00
3.39	4.23	0.00	0.00	0.00
4.23	-	0.00	0.00	0.00

Mean [m]	-0.016134	0.015294	0.016309
Sigma [m]	0.590281	0.698881	0.729979
RMS Error [m]	0.590502	0.699049	0.730161

Min Error and Max Error represent geolocation error intervals between -1.5 and 1.5 times the maximum accuracy of all the images. Columns X, Y, Z show the percentage of images with geolocation errors within the predefined error intervals. The geolocation error is the difference between the intial and computed image positions. Note that the image geolocation errors do not correspond to the accuracy of the observed 3D points.

Relative Geolocation Variance

Relative Geolocation Error	Images X [%]	Images Y [%]	Images Z [%]
[-1.00, 1.00]	99.06	98.12	100.00
[-2.00, 2.00]	100.00	100.00	100.00
[-3.00, 3.00]	100.00	100.00	100.00
Mean of Geolocation Accuracy [m]	1.967188	1.967188	2.314897
Sigma of Geolocation Accuracy [m]	0.090888	0.090888	0.214251

Images X, Y, Z represent the percentage of images with a relative geolocation error in X, Y, Z.

Geolocation Orientational Variance	RMS [degree]
Omega	6.315908
Phi	5.735640
Kappa	13.927634

Geolocation RMS error of the orientation angles given by the difference between the initial and computed image orientation angles.

Processing Options

Hardware	CPU: Intel(R) Core(TM) i7-5820K CPU @ 3.30GHz RAM: 32GB GPU: NVIDIA GeForce GTX 970 (Driver: 10.18.13.5382)
Operating System	Windows 10 Pro, 64-bit
Camera Model Name	CanonPowerShotS110_5.2_4000x3000 (RGB)
Image Coordinate System	WGS84
Ground Control Point (GCP) Coordinate System	WGS84 / UTM zone 16N (egm96)
Output Coordinate System	WGS84 / UTM zone 16N (egm96)
Keypoints Image Scale	Custom, Image Scale: 0.5
Advanced: Matching Image Pairs	Aerial Grid or Corridor
Advanced: Matching Strategy	Use Geometrically Verified Matching: yes
Advanced: Keypoint Extraction	Targeted Number of Keypoints: Automatic
Advanced: Calibration	Calibration Method: Alternative, Internal Parameters Optimization: int_all, External Parameters Optimization: ext_all, Rematch: yes