UAV PHOTOGRAMMETRY COMPARED TO TRADITIONAL RTK GPS SURVEYING

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ABSTRACT:

Fearless Eye Inc. is a twenty-four year old company specializing in surveying, mapping, inspection and computer visualization services. The company uses a variety of measurement equipment and techniques to gather data at specific resolutions for clients from industries including Accident Reconstruction, Failure Analysis, Natural Resource Management, Environmental Remediation, Engineering and Construction, among others.

A technology that Fearless Eye has increasingly used is UAV (Unmanned Aerial Vehicle) photogrammetry to capture natural and manmade surface data including topographic, cadastral, utility, engineering and construction information.

Having supplied clients with measurement data for more than 20 years, it is crucial for them to clearly understand the accuracy of our UAV photogrammetric surveying and mapping methods, as well as the time it takes to capture and process the data.

The Test Site

A 60 acre retail shopping area was chosen as our test site because it afforded a variety of features including green space, parking lots, retail buildings, power lines, light poles, roads and an active construction area. A UAV was flown at an altitude of 300 feet over the test area in a typical multi-row pattern with an 80% overlap for both front and side photographs. Conditions were clear and sunny with 15 to 20 mph winds. A 12 Megapixel 15 mm lens camera was fixed to a Zenmuse gimble, taking pictures every five seconds.

Figure 1: Aerial Photo of the Survey Site

GPS Ground Control Points

10 ground control point (GCP) markers were placed at areas throughout the site and surveyed using a Topcon Tesla RTK GNSS GPS and receiver. The GPS has a spatial accuracy in the range of 10 mm horizontally and 15 mm vertically. The coordinate system used was NAD 1983 Kansas State Plane. Points were measured multiple times to validate the coordinates.

Figure 2: Hybrid Topcon Tesla RTK GPS

UAV Aerial Photography

The UAV camera was used to take 348 geo-located photographs at 300 feet above the average ground level. The camera aperture and white balance was calibrated and optimized to the brightness and lighting for the conditions. The camera resolution was set to 12 Megapixels, the lens was adjusted to 12 mm and the shutter was set to take pictures every 5 seconds. A flight speed of 12 mph was chosen, enabling the capture of photos with an 80% overlap. The UAV was flown in an East/West corn-row pattern.

Figure 3: Orthomosaic Aerial Photo produced from 348 Individual Photos

Photogrammetry Processing

Before processing, the GCP data list was imported into photogrammetry software. Using the photos, centers points of each GCP were selected. UAV photography and the GCPs were then, together, processed simultaneously. This process aligns the photos, produces a scaled orthomosaic aerial photo and geo-references the elevation and the site UTM location. The photogrammetry processing generated 1,235 tie points and a dense point cloud. The sampling distance between each point was 1.63 inches and 25.8 million total points were generated for the site.

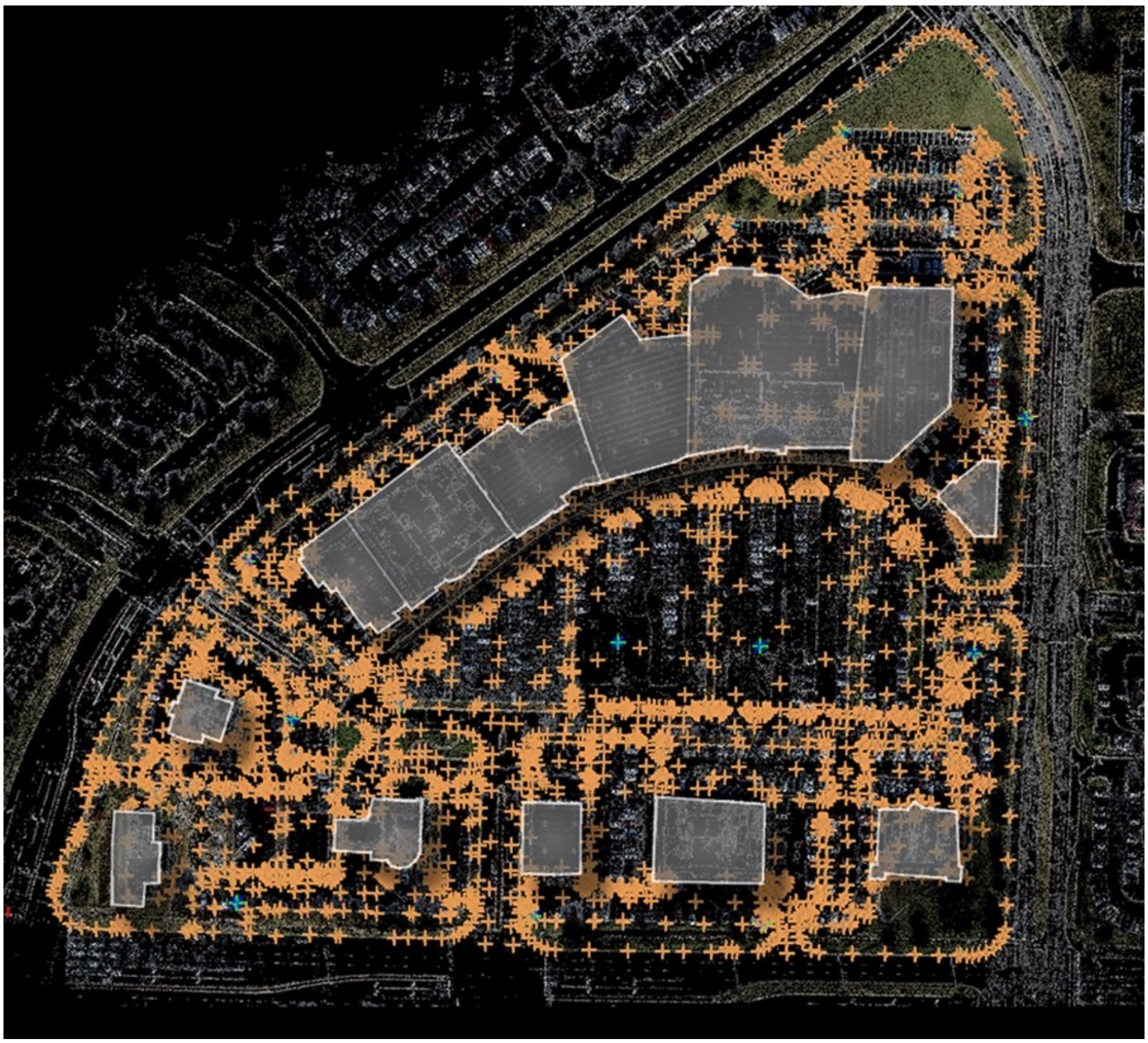

Figure 4: Ground Control and Tie Points

CADD Modeling

Following Photogrammetry Processing, point cloud data was subsequently imported into AutoCAD Civil 3D and a digital terrain model including one foot contour intervals was generated. The client requested additional information such as square footages of parking lots, roof surfaces, and green space, as well as an inventory of structures such as security lights and AC roof units. Additional CADD layers for each of these data sets were produced.

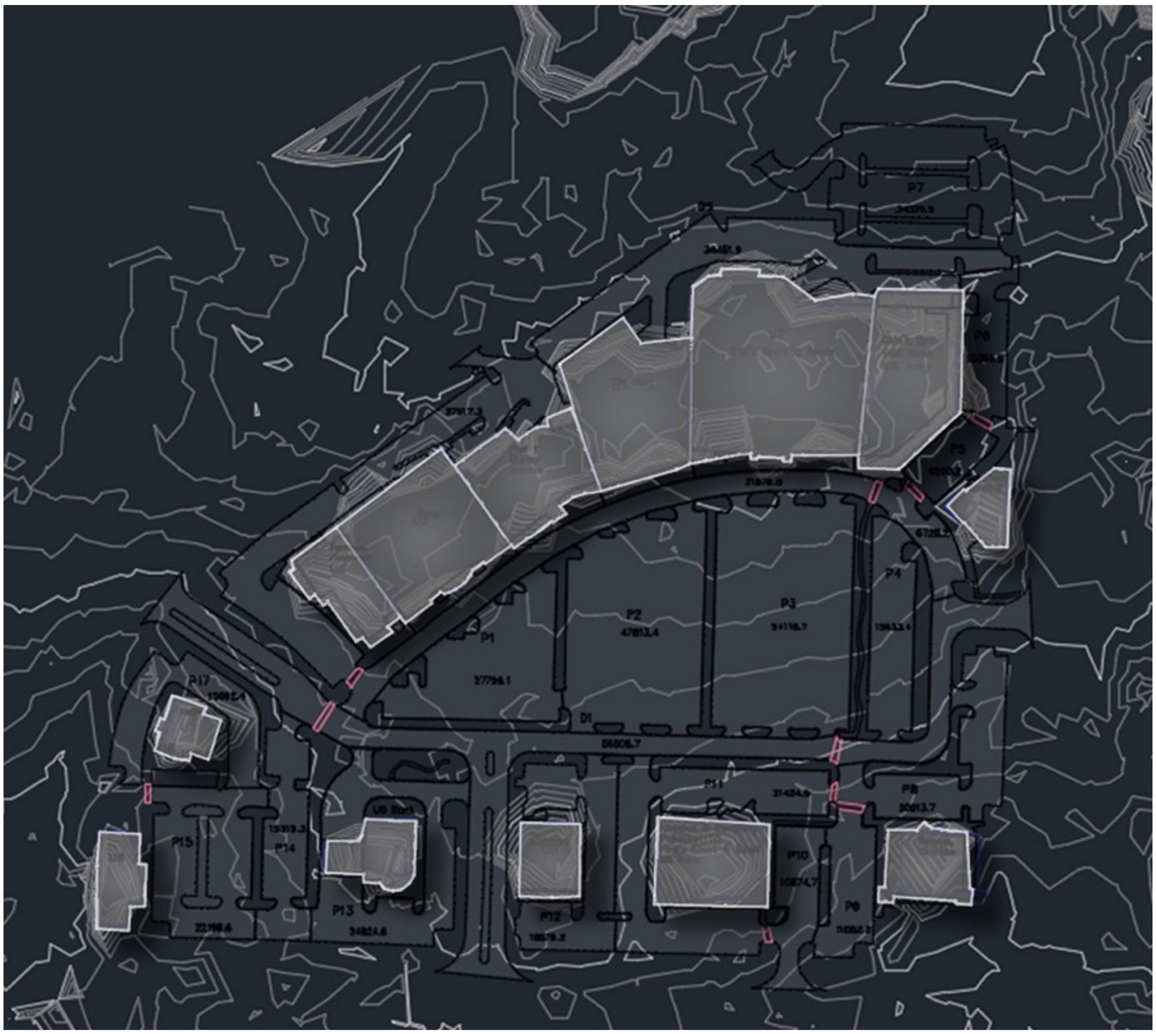

Figure 5: One Foot Contours derived from Digital Terrain Model

Accuracy Results

Following production, GCP coordinates and processed photogrammetry coordinates were then compared at the same marker positions.

The accuracy results were impressive. For the 10 comparative locations, an accuracy reliability of less than 52 mm for vertical points was achieved. For the horizontal positions, the accuracy was even higher.

GCP vs. UAV Photogrammetry Elevation Accuracy

GPS Ground Control Points	GPS Elevations (Meters)	UAV Photogrammetry Elevations (Meters)	Difference (Meters)	Difference (Centimeters)	Absolute Difference (Centimeters)
101	319.759584	319.759	0.000584	0.0584	0.0584
102	321.673728	321.667	0.006728	0.6728	0.6728
103	325.61784	325.632	-0.01416	-1.416	1.416
104	323.563488	323.555	0.008488	0.8488	0.8488
105	322.069968	322.071	-0.001032	-0.1032	0.1032
106	320.55816	320.555	0.00316	0.316	0.316
107	320.677032	320.688	-0.010968	-1.0968	1.0968
108	319.256664	319.261	-0.004336	-0.4336	0.4336
109	321.564	321.565	-0.001	-0.1	0.1
110	320.774568	320.773	0.001568	0.1568	0.1568
				Average Difference (cm)	0.52024

Figure 7: Control Point Accuracy Calculations

Time Results

Approximately 4.5 hours were spent at the 60 acre site. Work consisted of planning, preparing and flying the UAV, surveying the GCPs with the RTK GPS and taking additional perspective photos and video for reference. The total post field work, office time spent was 2.5 days, which included both computer processing time and manual software labor time.

It would not have been possible, using traditional total station or GPS surveying methods, to produce the same amount of rich data that was generated using the UAV photogrammetry methods employed in this example.

The ability to combine 3D point data with an up-to-date orthomosaic aerial photo, simultaneously revealing comprehensive and fine details, made the UAV photogrammetry strategy a significantly better way to visualize, understand and make better informed engineering decisions for topographic, construction and various types of land use needs.

Conclusions

The main point of this paper was to answer the question “Are UAV photogrammetry methods accurate and fast enough to replace current GPS and total station surveying methods for the vast majority of engineering and construction surveys.” The answer is a resounding “Yes”.

Even though UAV technology is still in its beginning stages, relatively speaking, advances in hardware, software and complex user development methodologies are moving forward rapidly. It is easy to see that it will revolutionize the world of surveying in terms of increasing data quality and richness while reducing the data capture costs and the time it takes to conduct topographical surveys.