EVENT 38

UNMANNED SYSTEMS

Aerial Surveying with Intellishoot PPK GPS and Sony RX1R II

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Contents

Overview

Aerial surveying using PPK GPS systems to accurately geotag each photo is becoming more popular as an alternative to manually collecting ground control points (GCPs). Using PPK GPS does not require the operator to travel throughout the mapped area which could be labor intensive and dangerous. Processing PPK GPS is also less labor intensive than applying GCPs, as GCPs require multiple manual target identifications each.

In cases where time on site is limited or where fewer satellites are typically visible, it is desirable to use a GPS system capable of dual frequency reception. Dual frequency receivers collect information from each satellite over two frequencies. By using the two frequencies together, it is possible to obtain a fix faster than when using a single frequency alone. This can reduce time on site and reduce the chance of losing fix during flight.

Fixed wing UAS can not fly as low or slow as multirotors, so it is usually not possible to collect imagery at very high resolutions. Using a Sony RX1R II full frame 42MP sensor allows data collection at 1.35cm/pixel even when flying at a typical safe altitude for a fixed wing aircraft. It may be possible to obtain higher accuracies when using a similar sensor suite on a multirotor as the Ground Sample Distance (GSD) could be improved, and the forward motion of the aircraft would be reduced. 1.35cm resolution is more than adequate for the majority of surveys. In cases where large areas must be covered, a fixed wing UAS with the RX1R II and Dual Frequency GPS can maintain this level of accuracy for areas exceeding 1,500 acres.

Equipment and Setup

The E384-Heavy configuration, a Sony RX1R II and the Intellishoot L1L2 PPK GPS were used to gather the data needed for this test. Full details of each piece of equipment are recorded in the tables at the end of this section.

The E384-Heavy configuration was used for its ability to carry the larger RX1R II as well as the GPS receiver. The E384 was flown with a Pixhawk 1 autopilot and used a separate, standard GPS module for navigation. The PPK GPS antenna was mounted directly above the camera and the geotag altitude was adjusted to account for the height difference.

The Sony RX1R II was flown with a 35mm ZEISS Sonnar T-Lens and collected data at 1.35cm/pixel from 100m AGL flying height. It has a full frame sensor which allows it to collect high quality imagery at 1/2000th of a second shutter speed with low noise. Its high speed sync port was used to precisely record a timestamp mid-exposure.

The Event 38 Dual Frequency PPK GPS module is powered by the Piksi Multi. For this test, GPS L1/L2C and GLONASS G1/G2 were used. Future software upgrades are expected to enable BeiDou B1/B2, Galileo E1/E5b, QZSS L1/L2 in the near future. SBAS has already been added at the time of this writing. The antennas used in the air and on the base station were the

Maxtena M1227HCT-A2-SMA and the Piksi L1/L2C GPS/GLONASS/BeiDou Mini Survey Antenna respectively.

Specification	**Value**
Aircraft Configuration	E384-Heavy
Autopilot	Pixhawk 1
All Up Weight	3.95kg

Table 1: Aircraft Configuration

Specification	**Value**
Lens	35mm ZEISS Sonnar T-Lens
Sensor	35.9 x 24.0 mm; 42MP (7952 x 5304 pix)
Weight	507g
Exposure	Shutter 1/2000th, ISO/F-Stop Auto

Table 2: Sensor Configuration

Specification	**Value**
Air Side Antenna	Maxtena M1227HCT-A2-SMA
Ground Side Antenna	Piksi L1/L2 GPS/GLONASS/BeiDou Mini Survey Antenna
Satellites	GPS L1/L2C, GLONASS G1/G2
Firmware	PiksiMulti-v1.4.10

Table 3: PPK GPS Module Configuration

Method

The survey mission was flown in a cross grid pattern using 70% overlap and 40% sidelap. Normally sidelap is set to at least 60%, but in the case when a cross grid is flown, the amount of overlap can become excessive. A lower sidelap in cross grid missions reduces excess data collection and reduces the time taken to fly the mission, while ensuring the entire area is visible in at least 7-8 photos. Most cameras aren’t able to maintain 70% overlap at 100m AGL due to the high shutter refresh rate required, but the RX1R II is able to take photos at more than 0.5Hz continuously.

Prior to flying the mission, the aircraft and GPS were powered on and allowed to obtain a fix and collect satellite information for 22 minutes. Ground control points were collected using a Trimble R6-4 and a unit identical to the one being flight tested. The Trimble points were collected and provided by a licensed surveyor. The points collected by Event 38 were post-processed using OPUS with at least 15 minutes of data at each point.

Root Mean Square Error (RMSE) was calculated using the formula below, where E is the horizontal or vertical error as measured using QGIS and P is the number of points collected.

$$RMSE = \sqrt{\frac{\Sigma(E^2)}{P}}$$

Post-Processing

Agisoft Photoscan Professional version 1.4.2 was used to post-process the imagery and create an orthomosaic and digital elevation model (DEM). Settings used to post-process the imagery are recorded below in Table 4.

RTKLib was used to process the Rinex observation file from the aircraft against one recorded on the ground by an identical GPS receiver. The Event 38 Image Utility was used to adjust geotag height to compensate for the difference between the camera’s focal plane and the antenna mounting location. It was also used to interpolate the positions between coordinates provided by the GPS receiver. Even at a refresh rate of 20Hz, the highest forward speed seen during the flight could have resulted in over 50cm of error if the nearest coordinate provided by the GPS were selected.

Processing Step	Settings
Geotag Accuracy	2cm
Alignment	High Accuracy, Reference Preselection
Optimize	f,cx,cy,k1,k2,b1,b2,p1
Dense Cloud Generation	High Quality, Aggressive, Calculate Colors
Mesh Generation	Height field, Dense cloud, Face Ct High

Table 4: Agisoft Photoscan Processing Settings

Results

The flight resulted in 223 images covering approximately 16 Hectares (40 acres), each automatically geotagged with a Q1 solution. Weather conditions on the day of the flight were sunny, with the flight taking place at approximately 11AM. Winds were out of the East at 4m/s. Groundspeeds during the flight averaged 12m/s with a maximum and minimum of 21 and 7m/s respectively.

	Latitude	Longitude	GCP Alt	DEM Alt	X/Y Error (cm)	Z Error (cm)
1	41.0371966	-81.5298135	260.6337	260.6046	1.303	-2.91
2	41.0371976	-81.5298147	260.6298	260.59967	1.103	-3.013
3	41.0372291	-81.5297755	260.6331	260.61023	0.7654	-2.287
4	41.037228	-81.5297741	260.6364	260.6416	0.8736	0.52
5	41.0372407	-81.5297592	260.637	260.61172	1.126	-2.528
6	41.0371571	-81.529673	260.6042	260.58197	2.389	-2.223
7	41.037166	-81.5297322	260.5307	260.5109	1.296	-1.98
8	41.0371678	-81.52974	260.5396	260.52484	1.48	-1.476
9	41.0371619	-81.5297423	260.5402	260.5209	1.586	-1.93
10	41.0371602	-81.5297346	260.5252	260.5088	1.355	-1.64
11	41.0370809	-81.5297249	260.6406	260.60416	1.274	-3.644
12	41.0375526	-81.530534	262.9453	262.904	1.858	-4.13
13	41.03652909	-81.53217492	260.568	260.52713	4.882	-4.087
14	41.0365296	-81.53218174	260.58	260.60587	5.641	2.587
15	41.03524437	-81.5283985	261.315	261.2637	2.869	-5.13
16	41.03528695	-81.52854442	261.45	261.411	1.369	-3.9
17	41.03524427	-81.52840668	261.34	261.26825	4.132	-7.175
18	41.03528702	-81.52854559	261.478	261.4138	2.279	-6.42
19	41.03523828	-81.52839837	261.312	261.2594	3.692	-5.26
20	41.03523816	-81.52840671	261.27	261.2662	5.739	-0.38
				RMSE:	2.821	3.62

Table 5: GCP coordinates, horizontal and vertical errors

Conclusion

Using the Event 38 Dual Frequency PPK GPS system with the Sony RX1R II camera flying at 100m AGL resulted in horizontal and vertical RMSE of 2.821cm and 3.62cm respectively. In order to reproduce these results, care must be taken to collect high quality data. Factors that were found to particularly affect results include accuracy of measuring the height of the base station and the difference in height between the aircraft's antenna and the camera's focal plane, as well as the overlap of imagery in every part of the mission area.

For cameras capable of a high refresh rate like the RX1R II, a cross-grid may not be necessary as a high overlap can be used in a standard mapping flight pattern. For slower cameras like the Sony R10C which require just over 2 seconds between images, flying a cross grid pattern would achieve higher overlap rates.

These data were collected after a relatively long 22 minute warm-up period on the ground because the receivers were only programmed to utilize GPS and GLONASS satellites at the time. In addition to GPS L1/L2C and GLONASS G1/G2 frequencies, SBAS support is now available which allows for faster time to first fix and improved fix reliability in areas with low satellite visibility. BeiDou and Galileo frequencies will be added in the future, further improving reliability and time to first fix.