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Direct georeferencing accuracy with SmartPlanes Post Processing Kinematic (PPK) GNSS

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Summary

The accuracy of direct georeferencing with Smartplanes PPK GNSS was validated by repeated aerial surveys of a test site with precisely measured point targets. A total of 11 flights were preformed over period of eighteen days representing a wide range weather and light conditions.

The results show that a high and consistent level of accuracy can be achieved even in challenging conditions. The overall planar accuracy was 18 millimeters, the height accuracy was 18 millimeters and the spherical (3D) accuracy was 26 millimeters which is better than what is typically achieved with terrestrial GNSS surveying methods.

Introduction

The SmartPlanes post processing kinematic (PPK) unit is powered by a state-of-the-art dual band GPS/GLONASS receiver provided by Septentrio. Direct georeferencing enables efficient production of Point Cloud, Orthophoto and DSM products with survey grade accuracy without the need for measured ground control points.

The unit is a plug-and-play type device designed to be fitted into the payload bay of Smartplanes Freya and SmartOne-C drones. The raw data is stored on-board thus eliminating the need for uninterrupted radio uplink of correction data during flight. In fact, the unit does not rely on any information from the drone and can even be used stand-alone for terrestrial surveying.

After flight the recorded data is processed together with corresponding reference base station data to compute the exact position of each camera exposure. The geotag information is added to the metadata header of each photo to enable direct import into photogrammetric software systems such as Pix4D Mapper and Agisoft Photoscan.

The aim of this study is to assess and validate the end-to-end accuracy of direct georeferencing using the Smartplanes PPK unit.

Methodology

The test site is a clear-felled forest stand on flat terrain located in northern Sweden (Lat. 63.64 Lon.19.80).

Figure 1. Test site with corner points (red triangles) measured by Static GNSS campaign. Remaining targets (white squares) were measured with total station (three repeat measurements).

Reference data

A total of 20 targets were distributed in a grid pattern within an area of approximately 200 x 200 meters. The survey started with a static GNSS-campaign with four reference points (signals) in the corners of the test field, three SWEPOS-stations[1] and four Fix-points[2]. The four reference points (2, 9, 18 and 20) received their coordinates from the static campaign and was then used as known points for the measurements of the other 16

[1] SWEPOS is the support system from the National Land Survey of Sweden. The system is built up by approximately 300 permanent reference stations for GNSS-measurements.

[2] Permanent point in bedrock included in the Swedish national height system.

points/signals. The 16 signals were measured by total station as free station setups. A total of three setups were made so that all signals were measured at least three times from three different setups. The terrestrial survey produced an absolute accuracy (RMS) in coordinates of the Swedish national grid SWEREF 99 (Horizontal projection 20 15) and RH 2000 (Height) of 4 mm (East), 3 mm (North) and 4 mm (Vertical).

The target coordinates were kept confidential and used only for the final accuracy assessment. The information was not available during the photogrammetric processing.

Figure 2 Static measurement of corner reference targets (left). Total station setup (right).

Flights

The test site was flown repeatedly over a period of 18 days collecting a total of 11 individual datasets representing a wide range of weather and light conditions. A majority of the flights were performed in dense overcast conditions and poor light. Wind conditions ranged from strong to mild being moderate on average. Ionospheric activity ranged from low to moderate for all flights. The nominal flying altitude was 90 meters with a lateral overlap between photo strips of 80 percent. During each flight the area was mapped in two overlapping blocks with photo strips oriented perpendicular to each other. A Ricoh GR camera which is the standard sensor of SmartPlanes Freya and SmartOne-C systems was used for all flights. The nominal Ground Sampling Distance (GSD) was 2.3 cm.

Figure 3. Orthophotos of the test area. 22nd of March (left) and 9th of April (right).

Processing

The recorded GNSS data and photo sets were processed together with base station data using the Septentrio Geotags software to generate precise camera exposure locations. A single reference base station located 7.5 km from the test site was used for all flights. The precision of individual camera coordinates indicated by the post processing software were typically 10-20 mm in plane and 20-25 mm in the vertical direction for Fixed solutions (98% of camera stations) and 50-70 cm for Float solutions (2% of the camera stations).

Photogrammetric processing was done with the Agisoft Photoscan software system (Ver. 1.2.4). In a first step image matching, triangulation and camera lens modelling was completed without use of any ground control information. In a second step the point targets were identified and measured. Finally, tables with ground surveyed and direct georeferenced coordinates were compiled for statistical analysis.

Statistics

The mean error shows the constant offset (bias) between the flight measured and ground measured coordinates. The standard deviation measures the variation around the mean. The metric is used to indicate the random variation or precision. The Root Mean Square Error (RMSe) is the standard measure for accuracy in the field of surveying. It includes both the constant (bias) and random (standard deviation) error components. Min and Max values show the total range of observations.

Results and analysis

Table 1. Results (in meters) for the 20 check points from a total of 11 flights during the timespan 22nd of March to 9th of April 2016, N=220.

	N	E	H	2D	3D
Mean error	0.007	0.004	-0.004		
Standard dev.	0.013	0.010	0.018	0.017	0.024
RMS_ε	0.015	0.011	0.018	0.018	0.026
Min. value	-0.031	-0.020	-0.031		
Max. value	0.035	0.033	0.044		

The accuracy levels (RMSe) are significantly better than the 1 x GSD (planar) and 3 x GSD (height) expected for conventional areal surveying.

Both the planar (2D) and Height (H) accuracy of 18 millimeters are better than what is typically achieved with terrestrial network RTK GNSS surveying.

The level of performance was achieved consistently, even in windy and non-optimal light conditions. This might be attributed to both the robust performance of Septentrio GNSS receiver and the optical quality and large imaging sensor of the Ricoh-GR camera.

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