

BLOCK ADJUSTMENT FOR PHOTOGRAMMETRIC PRODUCTION OF MAP OF IRAN

Optimal GCPs with Onboard GPS

The collection of Ground Control Points (GCP) for block adjustment is a costly and time-consuming operation. Onboard GPS enables a reduction in the number of GCPs without loss of accuracy. The authors tested configurations of GCPs when using onboard GPS for achieving optimal accuracy in production of an overall map of Iran.

The use of GPS in photogrammetric mapping began almost from the inception of GPS technology. Initially, GPS was used to obtain the coordinates of GCPs. GPS saved time and labour as compared to conventional surveying methods, producing more reliable coordinates whilst reducing costs. In the next stage, GPS receivers were placed inside the aircraft to measure the location of the camera directly at moment of exposure, so that the number of GCPs could be minimised. To obtain the needed accuracy a second dual-frequency geodetic GPS receiver is placed on a point with known coordinates. Both receivers collect carrier-phase data during the flight with sampling rates of either 0.5 or 1 second and on-the-fly integer ambiguity-resolution techniques. GPS can also be used to derive the angle parameters of exterior orientation. These, however, have a precision of around 1' of arc, while better than 10" of arc is required.

Error Sources

Although the use of onboard GPS saves time and cost, integration of the GPS receiver with the aerial camera introduces additional sources of error which have to be treated carefully. These error sources include:

- the camera shutter possibly showing considerable random variability as to the time the shutter is open, causing synchronisation errors (time bias) with the GPS receiver
- GPS antenna and camera physically not being at the same location: for acceptable results the offset between the GPS antenna and the perspective centre of the camera has to be accurately known within the image coordinate system. This value can also be introduced into the adjustment by constraining the solution or by treating it in the stochastic process. The best place for the GPS antenna is in the direction of the optical axis. Offset measurement is by measuring a micro network: Table 1 shows the achievable accuracy
- prior to a GPS photogrammetric mission the height between GCP and antenna needs to be measured accurately
- since time of exposure does not usually coincide with the time the GPS receiver samples the position, interpolation has to be carried out; differing algorithms have varying characteristics, which could introduce error
- radio interference can cause problems, particularly onboard the aeroplane; a receiver that can filter out this noise should be used.

Flight Planning

The key to success in applying GPS is accurate planning. First the onboard receiver requires proper initialisation to fix integer ambiguities. Next, when planning the flight lines loss of lock on the satellites has to be prevented. Unlike ground-based measurements, the whole photogrammetric mission could be lost if a cycle slip occurs and the receiver cannot resolve the ambiguity problem. Software can solve short-term ambiguity, but long-term (more than 10 seconds) disconnection caused by, for example, the wings of the aircraft, cannot be resolved. Depending on the location of the onboard receiver, wide banking turns of the aircraft may result in long-term loss of GPS signal. Banking angles of 25° or less are recommended, which results in longer flight lines. The location of the base receiver must also be considered during planning. Furthermore, the flight time should be chosen such that six or more satellites can be received with minimum change in coverage. The PDOP should be not less than 3, to ensure optimal geometry. A compromise may thus have to be made between favourable sun angle and favourable satellite availability. These issues can be somewhat released when additional drift parameters are used in the photogrammetric block adjustment.

Camera Position

The GPS receiver is pre-set to sample data at a certain rate, for example with intervals of one second. The GPS sample time may not coincide with actual exposure time. Therefore it is necessary to determine the coordinates of the exposure station by interpolating GPS observations. Accurate timing is essential. For example, if a plane is moving at a speed of 200km/hr (56m/sec), then a 1 millisecond

difference results in a 6cm coordinate error. Since receivers have an accurate atomic base of time and most receivers have the possibility of cable connection to the camera, it is recommended to save exposure time at the receiver rather than the camera.

Block Testing

As most of the photogrammetric blocks are rectangular, GCPs can be distributed over the block according to three configurations:

- Case 1: One full GCP at each corner
- Case 2: One full GCP at each corner and a chain of height points around the borders of the block
- Case 3: In the corners one full control point and one height control point, and tow cross lines of flight on each side.

To examine the achievable accuracy of the above three cases a test was conducted using a part of a block captured for photo-grammetric production of the overall map of Iran: specifications are given in Table 2. Furthermore, a program was written in Visual C++ and the results checked by comparison with the results of an Independent Model approach with sufficient GCPs.

The photo control points were captured with a DSR14 analytical plotter with 10-micron accuracy, and GCPs by GPS receivers collecting position data in static mode with 10-cm accuracy.

Results

Table 3 shows that the accuracy improves when using tow cross strips, one at the beginning and another at the end of strips. It is better to use four GCPs instead of one in corners, and to use the best combination of these in the adjustment. Bundle adjustment is more sensitive to input of machine coordinates than to reading accuracy, and therefore we recommend use of accurate instruments for pricking and reading. The use of GPS leads to an increase in cost of triangulation of around 25% compared to conventional methods, where the costs include tow cross strip flight, photo cost and work done for transfer of points.

Further Reading

- Ackermann, F., 1993, GPS for Photogrammetry, The Photo-grammetric Journal of Finland, 13(20), pp 7-15.
- Habib, A., Novak, K, 1994, GPS Controlled Aerial Triangulation of Single Flight Lines, Proceedings of ASPRS/ACSM Annual Convention and Exposition, Vol. 1, Reno, NV, April 25-28, pp 225-235.

<https://www.gim-international.com/content/article/optimal-gcps-with-onboard-gps>
