Practical Test of Direct Georeferencing with GPS/INS Photogrammetry

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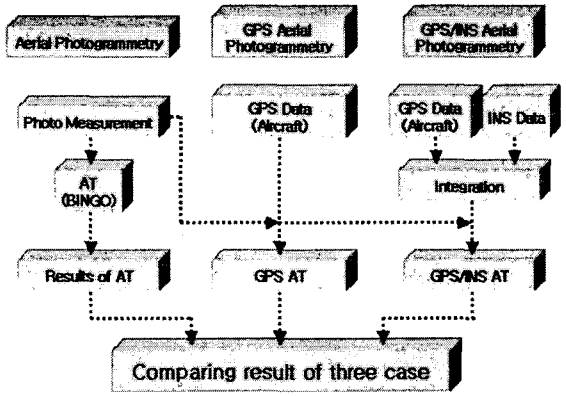
1. Introduction

GPS photogrammetry or the GPS/INS photogrammetry, which are based on the direct measurement of the projection centers and attitude at the moment of camera exposure time through loading the GPS receiver or IMU in aircraft. Both photogrammetric methods can offer us to acquire the exterior orientation parameters with only minimum ground control points, even the ground control process could be completely skipped. Consequently, we can drastically reduce the time and cost for the mapping process.

The flowchart of study



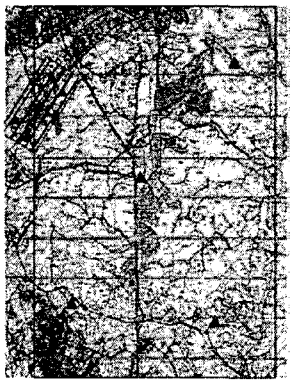
2. Test Description and Primary Data Acquisition

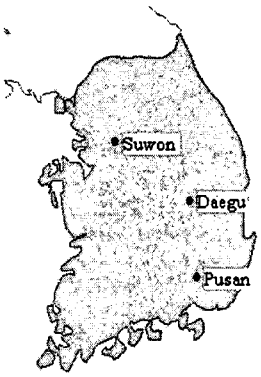
Background and purpose of the experimental test are as follows: since the recent years direct georeferencing with GPS/INS is becoming a standard method for sensor orientation in many foreign lands for the shortening of time and costs in aerial surveying and also for the rapid and accurate acquisition of GIS data. But the situation in inland is not so same. Therefore we want to get the know-how and facilitate the use of GPS/IMU technology in photogrammetry through the experimental test.

- Based on the above described purposes Korea National Geography Institute has started to conduct a test flight investigate to the performance of integrated sensor orientation using GPS and IMU in comparison of classical aerial triangulation.
- The Korean Association of Surveying and Mapping acts as research center for the test and is in charge of evaluation of GPS/IMU performance in aerial triangulation. Primary data acquisition and pre-processing including the organization of test flights and necessary filed work were carried out by HIST.

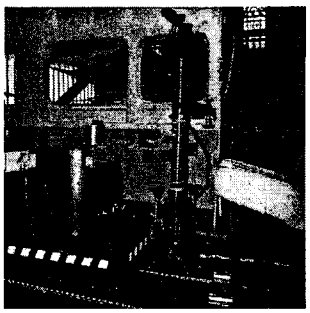
- Two test flights were realized by photographing in image scale of 1:5,000(Kwacheon, inner rectangle in fig.1) and 1:20,000(Suwon, outer rectangle in fig.1), which are located in near NGI, about 40km apart from Seoul. Due to the limited paper content, the case of 1:5,000 is only presented in this paper.
- For the flight of 1:5,000 image scale wide angle camera (RC30, f=153mm) integrated with Applanix's POS/AV510 is used in the flying height of 900m. Block size is approximately 4 x 5km2(p=70%, q=40%) which contains 5 strips in flight direction. Each strip has 17 to 21 photographs. The total amount of 88 ground control points are measured by GPS surveying with accuracy of 2-3cm. Fig.2 shows the installation of all necessary hardware on board and on the top of the aircraft.

Test field Suwon and Kwachon(links) and the location of DGPS base station(rights)

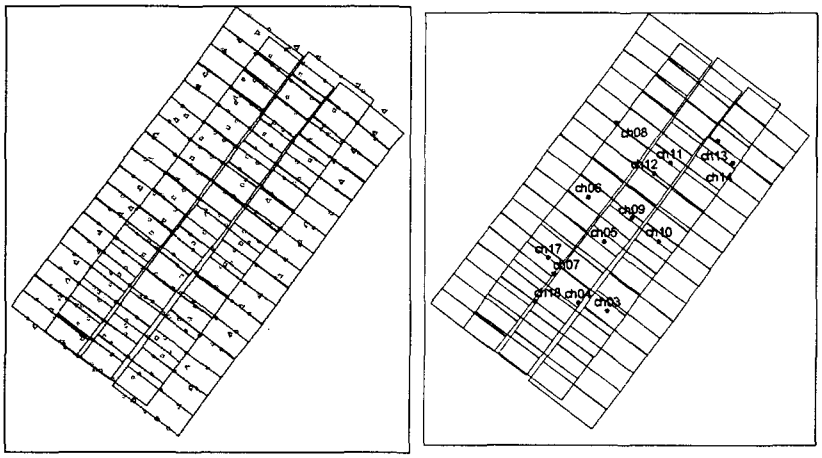




Hardware installation : GPS antenna on the top of aircraft(links) and Applanix POS/AV 510 on board(rights)



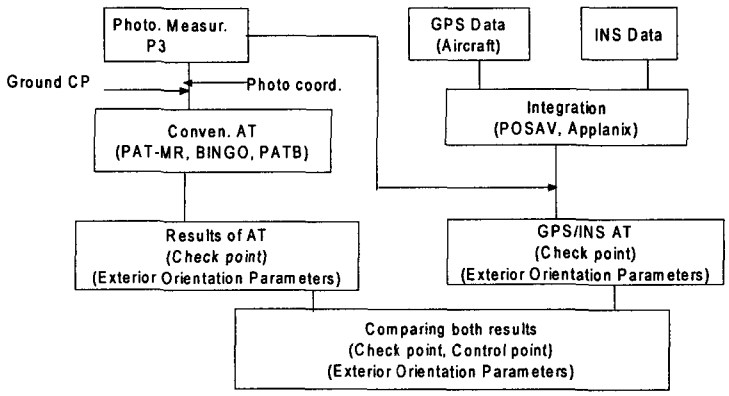
Distribution of GCP(link) and check point(rights)



3. Data Processing and analysis scheme

- The photogrammetric measurement was carried out by analytical plotter P3.
- GPS/INS data were processed by the software POSPac of Applanix.
- Aerial triangulation was conducted by BINGO-F for the conventional AT(aerial triangulation) as well as integrated GPS/IMU AT. The analysis scenario for the performance of GPS/IMU AT is shown as figure and described in following two steps:
- - Conventional AT using all control points for the reference adjustment
- - Combination of aerial triangulation with GPS/IMU observation.

Scheme of data processing and result analysis



4. Test Results

4.1 Accuracy of GPS/INS AT at independent check points

- comparison of residuals at check points between conventional AT and GPS/IMU AT

Number of GCP	RMS at check points (m)		
	$\pm S_X$	$\pm S_Y$	$\pm S_Z$
88	0.07/0.07	0.06/0.07	0.15/0.14
20	0.09/0.07	0.070.06	0.21/0.15
10	0.09/0.06	0.08/0.08	1.91/0.12
8	0.10/0.08	0.08/0.09	2.30/0.14
6	0.08/0.10	0.10/0.07	2.38/0.25
4	0.12/0.08	0.13/0.11	4.04/0.15

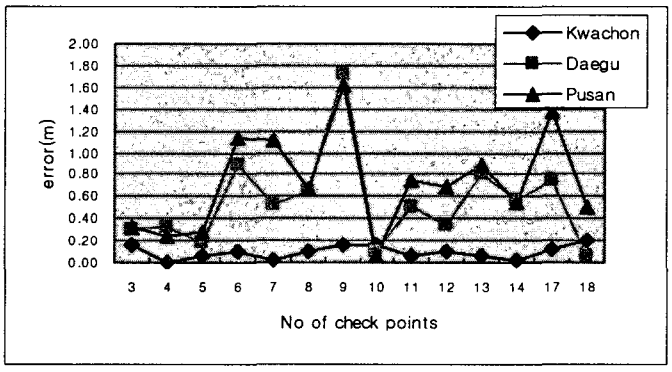
4.2 Accuracy of GPS/INS exterior orientation

- comparison of residuals of exterior orientation parameters between conventional AT and GPS/IMU AT

Number of GCP		RMS of perspective center (m)			RMS of rotation angle(")		
		±SXo	±SYo	±SZo	$\pm S_{\varphi}$	$\pm S_{\omega}$	$\pm S_{\kappa}$
88	Conv. AT	0.09	0.09	0.04	19	19	7
	GPS/IMU AT	0.09	0.09	0.04	18	18	7
20	Conv. AT	0.09	0.09	0.08	19	19	11
	GPS/IMU AT	0.06	0.06	0.06	13	13	11
10	Conv. AT	0.12	0.11	0.07	29	26	8
	GPS/IMU AT	0.07	0.07	0.08	14	13	10
8	Conv. AT	0.15	0.13	0.10	36	31	9
	GPS/IMU AT	0.08	0.07	0.09	15	14	10
6	Conv. AT	0.16	0.14	0.14	38	33	8
	GPS/IMU AT	0.09	0.07	0.10	17	15	11
4	Conv. AT	0.37	0.44	1.27	96	115	11
	GPS/IMU AT	0.10	0.09	0.14	18	16	11

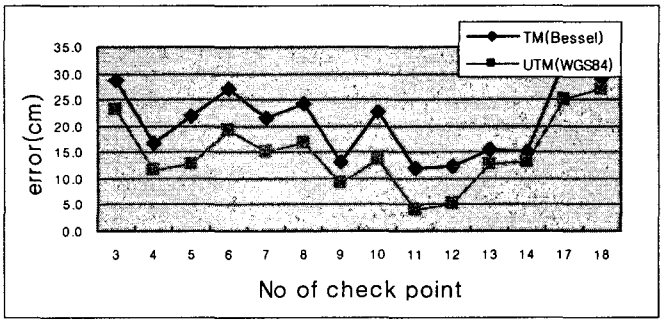
4.3 Accuracy regarding to DGPS base lines

Residuals at check points regarding to DGPS base line



4.4 Accuracy analysis according to the used reference coordinate system

- Residuals at check points regarding to the used reference coordinate system



5. Conclusions

- The contribution of this research is the investigation of an evaluation for precise positioning and attitude determination in photogrammetry using a commercial direct georeferencing system based on GPS/IMU. To prove the possibility of practical use of GPS/INS photogrammetry, a survey flight was conducted loading with all necessary measurement systems. The observed data set by GPS/INS photogrammetry were analyzed and compared to those of conventional photogrammetry in various points of view. The main results of test are summarized in the following. The necessary ground control points are dramatically reduced by bundle adjustment with GPS/IMU data comparing to those of conventional method.

- In case of test field Kwacheon area of 20km2, while conventional AT needs more than 80 control points, GPS/INS AT needs only 20 control points without accuracy degradation. Especially, whereas it is impossible to do aerial triangulation by conventional method with only 4 control points due to exceeding 4m in height, GPS/IMU AT can provide the required accuracy of 15cm. It is highly desirable to set up a DGPS reference station within the block area, because GPS/INS accuracy is dependent on the length of base line between aircraft and reference station.
- Finally, the error caused by coordinate transformation according to the used earth ellipsoid of TM does not significantly differ from that of UTM in height, but it is about 6cm in planimetry. However, this level of error resulting from coordinate transformation could be neglected for the practical use of GPS/INS photogrammetry.