ORTHORECTIFICATION ACCURACIES OF VHRS IMAGERY UNDER THE CHARACTERISTICS OF GROUND CONTROL POINTS

Luong Chinh Ke
Warsaw University of Technology
Institute of Photogrammetry and Cartography
1 Plac Politechniki, Warsaw, Poland
lchinhke@gazeta.pl

ABSTRACT

In recent year, orthomaps can be created from Very High Resolution Satellite (VHRS) imageries using IKONOS, QuickBird and other ones having Ground Sampling Distance (GSD) lower than 1m. Three main important sources for establishing GIS are the orthomap of 1:5 000 scale with Ground Sampling Distance (GSD) of 0,5m, DEM/DTM data with height error of ±1,0m and topographic map of 1: 10 000 scale. Orthorectification accuracy of VHRS imagery is strictly dependent on three essential factors: the characteristics of Ground Control Points (GCPs); sensor geometrical models and DTM/DEM accuracies. Four characteristics of Ground Control Points (GCPs) affected to orthorectification process are the shapes, configurations, accuracies and number of GCPs. The paper presents, at first, investigation results over the influences of four characteristics of GCPs on the accuracy of orthoimage from QuickBird. At the end of the paper, basing on the orthomaps generated in 1:10000 scale with GSD = 1,0m from IKONOS and with GSD = 0,6m from QuickBird, possibilities of creating database for GIS from IKONOS Pan and QuickBird Pan have been presented.

1 INTRODUCTION

In the last years Very High Resolution Satellite (VHRS) images such as IKONOS, QuickBird, OrbView, EROS, SPOT 5, etc., have been more and more widely used for different purposes not only in defense military, but also in economical development. It is a very important information available to establish database of GIS. VHRS images are in particular suitable to investigate the climatic changes, natural risks such as a floods, earthquakes etc., (*Tao, Jacobsen and Sohn, 2006*)

For managing land administration in urban development and other purposes the digital orthomap of Ground Sampling Distance (GSD) of 0,5m elaborated with VHRS images is one of the essential sources needed for GIS (*Jacobsen, 2003*). Its reliability is dependent on accuracy of created orthomap. It is clear that the accuracy of digital orthomap is affected with technology of its generation such as orthorectification process, orthomosaic and resampling. The factors that influence on the accuracy of orthorectification process are the features of Ground Control Points (GCPs); DEMs accuracy and mathematical models used in orthorectifying (software of ImageStaion System).

This paper deals with GCPs features. In the experimental part the accuracy analysis of orthorectification process will be concentrated on four features of GCPs such as the chosen shapes; distribution; accuracy and number of GCPs. Experimental results presented in the paper are taken from the works realized in our Institute (*Wolniewicz et al., 2005*).

2 TEST FIELD PRESENTATION

In this paper the data related with our investigation is QuickBird image of test field „WAR". The test field „ WAR" is located in Warsaw city. It is a flat terrain with undulation no exceeding 80m.

Some parameters of QuickBird image of the test field „WAR" are described in table1. A part of test field „WAR" in color QuickBird image is presented on figure 1 (*Wolniewicz et al., 2005*).

DEM applyed to orthorectify QuickBird image of test field WAR have been taken from DTED level 2 (Digital Terrain Elevation Data) with GRID of 30mx30m and height accuracy of ±0,66m.

System used for orthorectifying QuickBird image is **PCI Geomatica**, *9 OrthoEngine* version (Canada) with software mode of parametrical model. Basing on the coordinates before and after orthofectifying of Independent Control Points (ICPs) accuracy analysis will be carried out.

Table 1. QuickBird's parameters of test field "WAR"

Parameters	**QuickBird**
Date of imaging	May 04, 2003
Time of imaging	9:35
Inclination angle	5°
Type of image	PAN/MS
Image product	Basic Imagery
Radio resolution	16 bit
Pixel size GSD	0,61m
Image size	16km x 16km
Percent of cloud	2 %

3 RESULTS AND ANALYSIS

Figure 1. A part of QuickBird MS of test field "WAR"

The features of Ground Control Points (GCPs) that affect on the accuracy of orthorectification process are:

- The shapes of GCPs,
- Distribution of GCPs,
- The accuracy of GCPs,
- The number of GCPs.

In sequence, particular feature of GCPs will be analyzed.

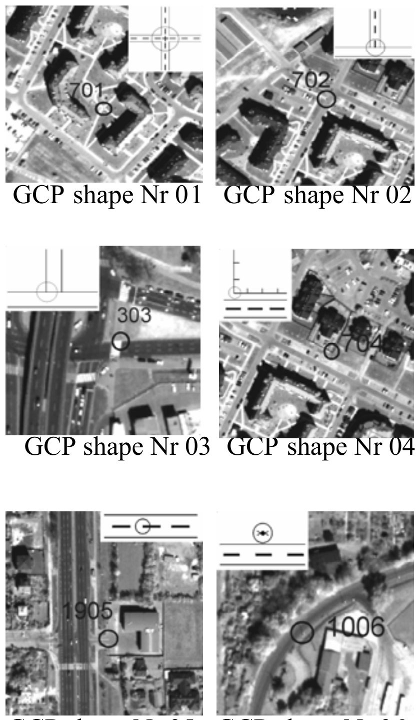

Figure 2. The shapes of GCPs

3.1 The shapes of GCPs

There are 6 types of shapes of natural GCPs numbered from 01 to 06 used to analyse. Their locations on QuickBird image of test field WAR and their geometrical symbols are described on the figure 2. Root Mean Square Errors (RMSE) of Independent Control Points (ICPs) after orthorectifying are presented in table 2.

Table 2. The influences of GCP shapes upon the accuracy of orthorectifying

GCP shapes	Number of GCP/ICP	Nr 01	Nr 02	Nr 03	Nr 04	Nr 05	Nr 06
RMSE of ICP after orthorec. [m]	13/56	**1,19**	1,35	1,32	1,50	1,45	1,39

It is clear from table 2 that the GCPs with the shape like Nr 01 have highest accuracy (smallest error). It is not efficient to choose the natural GCPs in linear shape like Nr 05. In practice, the best shape of natural GCPs must be selected as the crossing points.

3.2 The distribution of GCPs

There are 10 configurations of GCP on the QuickBird image, marked with letter from (a) to (j) as shown in the figure 3. For example, GCPs are located as a cross (black coulor) but only in the image center (fig. 3, a). GCPs are located on four corners and image borders in the square form with one point located in the image center (fig. 3, d), etc. The results and analysis have been presented in table 3.

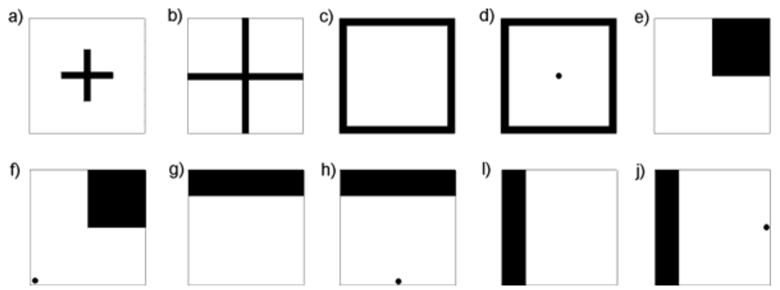

Figure 3. Distribution of Ground Control Points on test image

Table 3. The influences of GCPs contribution upon the accuracy of orthorectifying

GCP Distribution	Number of GCP / ICP	RMSE of ICP after orthorectifying [m]		
		m_X	m_Y	m_S
a)	13/56	8,64	7,24	11,27
b)	13/56	2,00	1,16	2,31
c)	13/56	1,00	0,54	1,14
d)	**13/56**	**0,78**	**0,53**	**0,94**

e)	13/56	2,20	6,54	6,90
f)	13/56	1,70	1,39	2,20
g)	13/56	11,51	4,54	12,37
h)	13/56	0,94	1,18	1,51
i)	13/56	12,73	4,96	13,58
j)	13/56	1,59	1,53	2,21

Basing on the acquired results in table 3 there is conclusion that the configuration (d) gives highest accuracy, next configuration (c). The configurations (a) and (g) have lowest accuracy (biggest errors).

3.3 The accuracy of GCPs

Three accuracy levels of GCPs are chosen: The coordinates of GCPs are taken from topographic map in scale 1: 10 000 with the errors in (±3m - ±5m); The coordinates of GCPs are taken from GPS Pathfinder with the errors of (±2m – ±3m); The coordinates of GCPs are taken from DGPS FastStatic with the errors of (±0,2m - ±0,4m).

Basing on the configuration (fig. 3, d) QuickBird image became orthorectified with 10 GCPs. The results and accuracy analysis using 59 ICPs are presented in table 4.

Table 4. The influences of GCP errors upon the accuracy of orthorectifying

Methods of GCPs measuring	RMSE of GCP [m]	Number of GCP / ICP	RMSE of GCP after orthorec.		RMSE of ICP after orthorec.	
			m_X [m]	m_Y [m]	m_X [m]	m_Y [m]
DGPS FastStatic	**±0,2**	**10 / 59**	**0,56**	**0,25**	**0,94**	**0,65**
GPS Pathfinder	±2 - ±3	10 / 59	0,52	1,17	1,29	1,81
Topogr. Map 1:10 000	±3 - ±5	27 / 59	3,61	2,07	1,31	1,50

Table 4 confirms that GCPs with error of ±0,2m give best accuracy for orthorectifyingVHRS images. Using GCPs taken from topographic map of 1:10 000 scale for orthorectifying QuickBird the acquired accuracy is not satisfactory.

3.4 The number of GCPs

In order to evaluate the influence of GCPs number on the orthorectification accuracy two software modes of parametrical (*Luong and Wolniewicz, 2005*) and RPC approaches installed on the PCI Geomatica have been investigated. In the table 5 there are Root Mean Square Errors (RMSE) of 17 ICPs and their maximal differences for concrete case using 10

GCPs with two approaches. Figure 4 presents the relation between the GCPs number and RMSE of 17 ICPs after orthorectifying.

Table 5. The accuracy of orthorectifying using 10 GCP and 17 ICP

Geometric models	GCP/ICP	RMSE of ICP after orthorec. [m]		Max differences of ICP after orthorec. [m]	
		m_X	m_Y	ΔX	ΔY
RPC approach	10/17	1,31	1,05	3,93	1,94
Parametrical approach PM	10/17	**0,94**	**0,64**	2,35	1,44

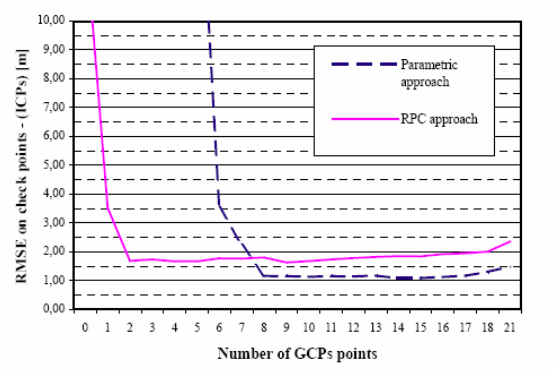

Figure 4. The influence of number of GCPs on orthorectifying accuracy

We can come to some conclusions basing on the fig.4 as follows

- Using 3 GCPs for RPC approach (coefficients of RPC model taken from image distributor) orthorectification accuracy of QuickBird image can be available with RMSE between ±1,5m - ±2,0m.
- Using 8 GCPs for parametrical approach orthorectification accuracy of QuickBird image can be available with RMSE between ±1,0m - ±1,2m.
- The parametrical approach gives better orthorectification accuracy than RPC.

3.5 Practical example

Investigation results of possibility of generating database for GIS from IKONOS Pan and QuickBird Pan have been presented in figure 5. Basing on the orthomaps in the scale 1:10000 with GSD = 1,0m from IKONOS and in the scale 1:5000 with GSD = 0,6m from QuickBird four object levels have been extracted:

a. Hydraulic network,
b. Roadway and railway networks,
c. Buildings and man-made objects,
d. “Other objects”.

From practical creating database some conclusions are:

- 100% hydraulic system became extracted,
- Minimum 90% of roadway and railway system became extracted, the others of about 10% in shadow of trees.

- 100% possibility of updating the old database of communication systems as a motor traffic and railway service,
- 100% possibility of updating the old database of building and man-made objects, 80% possibility of creating their new database,
- 80% possibility of creating new database for “Other object”.


IKONOS Pan


QuickBird Pan

Figure 5. Extraction of some objects on the part of Warsaw orthomaps in scale 1:10000 and 1:5000, respectively generated from IKONOS Pan and QuickBird Pan

4 CONCLUSION

From acquired results in this investigation there are some conclusions following:

1 – The shapes of natural Ground Control Points used for orthorectifying very high resolution satellite image such as QuickBird can be chosen as a crossing of roads, perpendicular corners of houses or single objects.

2 – Best configuration of GCPs distributed on the omage border is in the square form with one point in image center like fig. 3, d.

3 – In order to establish orthomap with 0,5m of GSD (Ground Sampling Distance) in scale 1:5000 from QuickBird image the GCPs accuracy must to be measured with DGPS of errors no bigger than ±0,5m.

4 – Using 8 GCPs the parametrical model can be applied to orthorectify QuickBird image with position errors no exceed ±1,5m. This accuracy is sufficient to establish orthomap in scale 1:5000 with GSD of 0,5m.

REFERENCES

Jacobsen K., 2003. Geometric potential of IKONOS and QuickBird images. *Photogrammetric Week’03,* Germany, (on CD-ROM).

Luong C. Ke, Wolniewicz W., 2005. Geometric models for satellite sensors. *Geodesy and Cartography, Vol. 54, No 4,* Warsaw, Poland.

Tao V., Jacobsen K., Sohn G., 2006. Mapping from high resolution satellite imagery. *Photogrammetric Engineering & Remote Sensing, Vol. 27, Nr 5,* May/2006, USA.

Wolniewicz W., Kurczynski Z., Luong C. Ke, Kujawa L., Różycki S., 2005. Geometric correction of very high resolution satellite images and their utilization for establishing topographic database. *Research Project Nr 5 T12E 00724*, Institute of Photogrammetry & Cartography, Warsaw University of Technology, Poland (in Polish).

Wolniewicz W., Luong Ch. Ke, 2006. Geometric modelling of VHRS Imagery. *ISPRS International Calibration and Orientation Workshop EuroCOW 2006, 25-27 January 2006, WG I/3*, Castelldefels, Spain.