

COMPARISATION OF SPATIAL ACCURACY OF DATA ACQUIRED FROM MONO AND STEREO IMAGES :A CASE STUDY OF CAMPUS AREA KONYA –TURKEY

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Commission IV, WG IV-9

KEY WORDS: High Resolution IKONOS Images, Feature Points, Geodetic Methods, Ortho Photo

1. ABSTRACT:

Nowadays, high resolution IKONOS images for map productions, local municipality studies, communications, agriculture, forestry, energy and infrastructure, monitoring of environment, disaster management, determination of natural resources, pipeline, transportation, security, defence and GIS studies. Accuracy of spatial is the most important factor in view of the map production using IKONOS images. In this study, digital ortho photo maps have been produced using 1 m resolution mono and stereo IKONOS images. Mono and stereo images have been covered the same area. Some feature coordinates have been measured from the produced ortho photo maps of selected test area. The same feature points surveyed using electronic total stations according to geodetic methods. Ortho photo coordinates and geodetic coordinates have been compared. Differences have been calculated and results have been given.

1. INTRODUCTION

Nowadays, satellite images have been used for many applications intensively. For example, updating existing maps, land use mapping, urban planning, disaster monitoring, and so on. To use high resolution satellite images in such fields, they had to be rectified. Rectification process is done by points, which coordinates are known in both land and image. The selected points may indicate either measured points in the field or/and can be designated as visible points in images. These points may represent; building corner, road cross, painting objects, etc.

The launch of IKONOS by Space Imaging opens a new era of high-resolution satellite imagery collection and also promotes the mapping applications of satellite imagery. The IKONOS satellite simultaneously acquires 1m panchromatic and 4m multi-spectral images in four bands with 11-bit radiometric resolution that are suitable for high accuracy photogrammetric processing and mapping applications (Tao et al. 2004). Space Imaging provides a broad category of mono and stereo products including georectified, orthorectified and stereo imagery products with different accuracy levels (Dial 2000, Grodecki and Dial 2001). The specified horizontal accuracies of the Geo, Reference, Pro, Precision and Precision Plus IKONOS products are 25 m, 11.8 m, 4.8 m, 1.9 m and 0.9 m CE90 (Circular Error 90%), respectively.

Many investigations related to the accuracy of IKONOS imagery by means of some photogrammetric process have been reported so far. Zhou and Li (2000) showed the potential accuracy (2–3 m) of ground points gained using simulated 1 m IKONOS stereo images and the pushbroom imaging principle. Fraser and Hanley (2003) achieved submeter accuracy using one ground control point (GCP) for bias compensation in IKONOS RFs. Toutin (2003) evaluated the potential, the

accuracy and the robustness of the 3D parametric model under different conditions. It was concluded that 20 3-m accurate GCPs were a good compromise to achieve a 3- to 4-m error in the bundle adjustment, while 10 1-m accurate GCPs were enough to achieve a 2- to 3-m accuracy. Wang et al. (2005) presented four different models defined in both object space and image space to refine the rational function derived ground coordinates. It was demonstrated that if an appropriate model and GCPs were used, ground point errors could be reduced from

5–6 to 1.5 m in horizontal and from 7 to 2 m in vertical directions. Dial and Grodecki (2003) had tested Ikonos stereo accuracy without ground control. They had achieved to absolute accuracy at 6.2 m. horizontal, 10.1 m. vertical, and found out the most relative accuracy results for points more than 3 meters. Due to its superior geometric accuracy characteristics, IKONOS satellite imagery is particularly well suited for large scale mapping applications [Dial and Grodecki, 2002], [Grodecki et al., 2003]. As for geometric correction of high-resolution satellite imagery, acquisition of ground control points is important [Kadato and Takagi, 2002].

2. MATERIAL AND METHOD

2.1. Test area

Alaeddin Keykubat campus area of Selcuk University was selected as the test area in order to compare. The campus area is located from 20 km north of Konya city center which includes 10 faculties, 2 vocational high schools, dormitories, social facilities such as sports centers, health centers, cafeterias, shopping centers, etc (Mutluoglu, 2004). In this study, one pair of stereo IKONOS imagery (acquisition date 30/01/2004) and mono IKONOS imagery (acquisition date 03/05/2003) covering Selcuk University Campus, in the northern part of Konya city, were used (Figure 1).

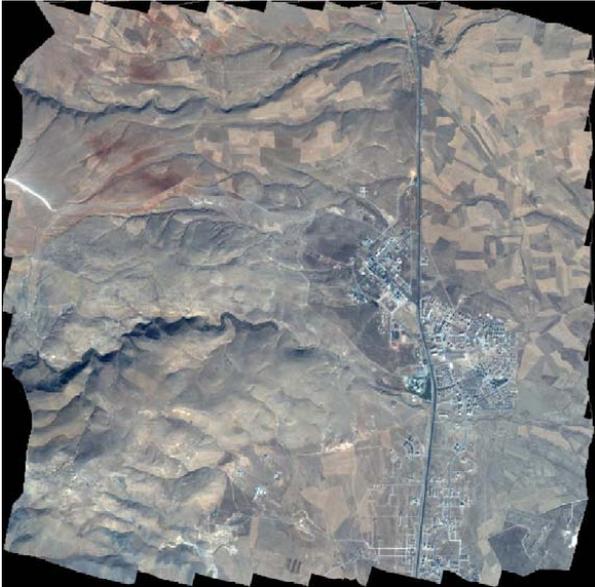


Figure 1. Stereo IKONOS imagery covering the related region.

The terrain is partly rough and the elevations in the region change between 1000 m. and 1500 m. In this region, there are Selcuk University Campus and small urban areas. The other parts of the terrain contain open fields without any trees. There are no high trees or plant cover. Rational Polynomial Coefficients (RPC) files are provided with the imagery. The RPC file provide camera model data for 3D photogrammetric compilation, for production of digital elevation model and orthorectification. The stereo reference images are the least processed images.

2.2. Field Studies and Measurements

2.2.1. Spatial data-acquisition with the conventional method

The main principle of “the conventional method” also named as “the polar method” is the determination of the horizontal and vertical position data of the detail points simultaneously by the help of the horizontal angle (β), vertical angle (Z) and the horizontal distance (S) observed at the detail points with an electronic tachymeter installed on the definite control points in which coordinates are known. The observations made with the electronic tachymeters are automatically recorded to the recording units and transferred to the computer environment in order to make calculations and drawings. In the conventional method, TOPCON GTS-701 electronic tachometry with $\pm 2''$ angle measuring accuracy and $\pm 2 \text{ mm} + 2 \text{ ppm.D}$ length measuring accuracy (m_s) was used. Evaluating the measurements obtained by the field studies with a CAD based professional computer program (NETCAD) after transferring them into the computer medium, the spatial data of the detail points were obtained and the related drawings were performed (Figure 2).

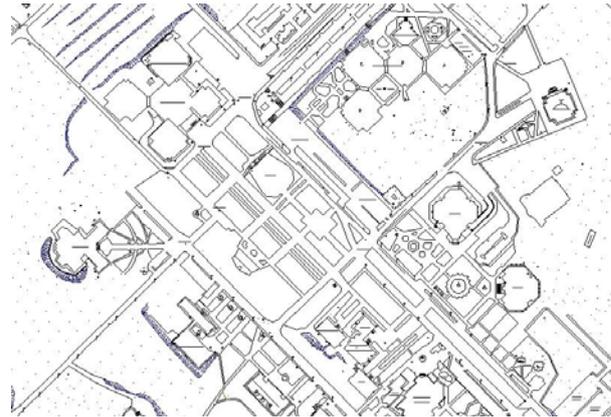


Figure 2. Test Area

2.2.2. Ground Control Points (GCPs) and Surveying

Acquisition of ground control points (GCPs) is particularly important for geometric correction of high resolution satellite images. GCPs are measured with a static GPS receiver (Leica SR 9500 dual frequency) for 30 minutes measurement and postprocessed with a stable GPS point of Turkish National GPS Network (for mono IKONOS imagery 8 GSPs , Stereo IKONOS Imagery 26 GCPs). The accuracy of the measured GCPs is thought to be lower than 0.1m. The processing and adjustment of the GPS observations were made using the SKI Pro software of Leica. The points are marked on the ground as three lines containing one dot in the centre (Figure 3). The marking accuracy of the GCPs is assumed to be 0.5-1.0 m. The distribution of the points is seen in (Figure 4).

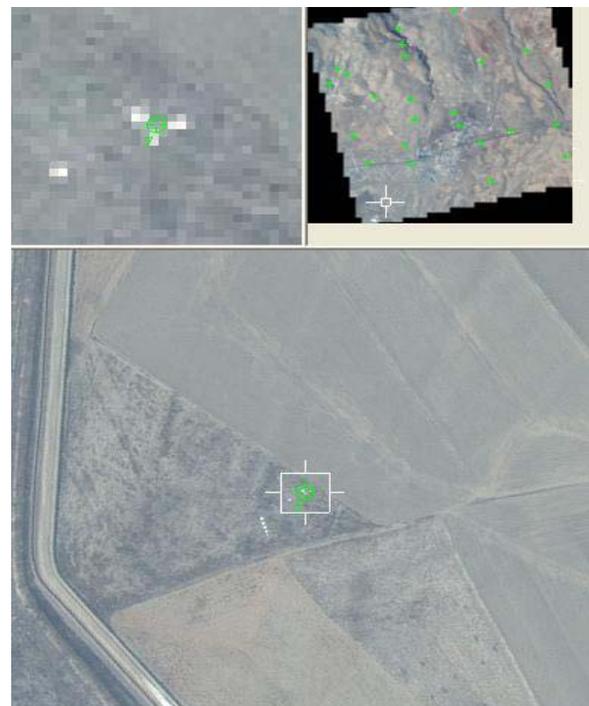


Figure 3. A GCP marked on the ground.



Figure 4. Distribution of the used GCPs on the image.

2.3. Office Works

2.3.1. Production of Digital Elevation Model (DEM)

One way of the correction of geometrical deformations due to topographical height differences which cause shift or horizontal changes in spatial position of features on images is orthogonal rectification of images. For mono images, DEM were acquired from maps. Used maps were generated from topographical maps, Which is scale 1/5000 (contour interval 5 m.). 9 kontrol points have been used to accomplish adjustment procedure. Digital Elevation Model has been produced with automatically in 5 m interval from stereo images.

2.3.1. Production of Orthophoto

The orthorectification operation of the mono IKONOS image was carried out with ±0.5588 pixel accuracy by the help of the OrthoBase Erdas Imagine software using the digital elevation model (DEM) and the assigned position 8 control points. The orthorectification operation of the stereo IKONOS image was carried out with ±0.4855 pixel accuracy by the help of the OrthoBase Erdas Imagine software using the digital elevation model (DEM) and the assigned position 9 control points.

2.3.2. Comparing of features points

Erdas Imagine Orth Base Software was used to obtain orthorectified images (mono and stereo). 220 feature points have been measured from orthorectified images which external DEM. , and 145 feature points have been from orthorectified images which produced stereo.

In calculating the point position errors of the spatial data-acquisition methods, the coordinates (Y_K , X_K) obtained by the geodetic method was accepted as the reference (Table 1), and then the point position errors of the other methods were calculated using the following equations.

$$V_Y = Y_G - Y_K \tag{1}$$

$$V_X = X_G - X_K$$

$$m_x = \pm \sqrt{\frac{[V_X V_X]}{n}} \tag{2}$$

$$m_y = \pm \sqrt{\frac{[V_Y V_Y]}{n}} \tag{3}$$

$$m_p = \pm \sqrt{\frac{[V_X V_X + V_Y V_Y]}{n}} \tag{4}$$

Where;
 Y_G , X_G : coordinates obtained by another methods
 n: is the number of points.

Methods	Number of points	Accuracies (rms)		
		m_y (cm)	m_x (cm)	m_p (cm)
Mono IKONOS	220	±103.0	±89.6	±139
Stereo IKONOS	145	±88.2	±98.3	±132

Table 1. The point position accuracies of the methods are given in.

3. CONCLUSION

In this study, digital ortho photo maps have been produced using 1 m resolution mono and stereo IKONOS images. Mono and stereo images have been covered the same area. Some feature coordinates have been measured from the produced ortho photo maps of selected test area. The same feature points surveyed using electronic total stations according to conventional methods. Ortho photo coordinates and geodetic coordinates have been compared. Differences have been calculated and results have been given. Obtained spatial accuracy results close each other. Stereo images much more expensive than the mono images. Its cost can be increase 4-5 times. Control points have been needed distributed on the terrain before the capturing images. DEM can be produced automatically and this is an advantage of stereo images. If it is possible to obtain DEM, which cover study area using convenient distributed control points, orthophoto maps can be produced with mono images in a short time and more economically.

ACKNOWLEDGMENT

This authors wish to acknowledge for the cooperation and financial assistance given by the Scientific Research Found (BAP) of Selcuk University.(poject number 2003/127)

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