Evaluation of Accuracy of 3D model from QuickBird Stereo Imagery

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KEYWORDS: High-resolution-Satellite, Quickbird, Three-dimensional-Accuracy, Stereoscopic, Mapping

ABSTRACT:
In this study, we used a stereo-pair of QuickBird imagery of Yokosuka City, JAPAN and evaluated the 3D spatial accuracy and distortion by comparing coordinates measured from imagery with GPS survey results at 60 checkpoints. The components of average of error vector were 13.12m in longitude, 2.78m in latitude and 1.38m in vertical. One GCP improved the error vector to 0.74m in longitude and 0.79m in latitude. Using linear regression improved the vertical accuracy to 0.29m. The results show that a few GCP is enough to correct for topographical mapping. Considering the previous study on the discrimination of feature, the high-resolution satellite imagery is effective for topographic mapping.

1. INTRODUCTION

The Geographical Survey Institute (GSI) is researching on the application of high-resolution satellite imagery to topographical mapping, especially for 1:25,000 topographical maps, which are the base maps of Japan.

The studies of the application of IKONOS and SPOT5 imagery for mapping were already published. They showed that to use high-resolution satellite imagery was effective for mapping (Iida et al., 2001, Iida et al., 2002, Kobayashi et al., 2002, Iida et al., 2003). The 3D accuracy and bias compensation of IKONOS imagery were already studied (Fraser et al., 2002, Fraser et al., 2003). The evaluation of discrimination of features and the horizontal spatial accuracy for a QuickBird mono image with DEM was also published (Noguchi et al., 2003). It indicates discrimination is good and the image has a constant positional shift.

In this study, we evaluate the accuracy and try to correct the distortion of the 3D model of QuickBird Stereo Imagery by using a stereo-pair with 60 checkpoints (measured by GPS) arranged densely.

2. METHOD OF EVALUATION

The coordinates of sixty checkpoints measured from imagery (coordinates A) are compared with those of GPS survey results (coordinates B). Fig.1 shows the distribution of checkpoints.

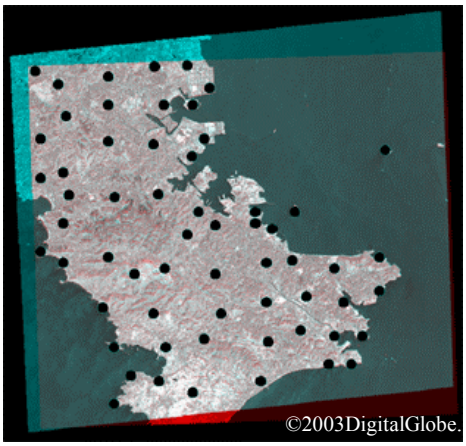

Fig.1 Distribution of checkpoints
(Background is QuickBird stereo images)

2.1 Test field

We selected Yokosuka City and its surroundings nearby Tokyo as a test field. It is located in a hilly district. The elevation ranges from 0m to 241m (Fig.2).

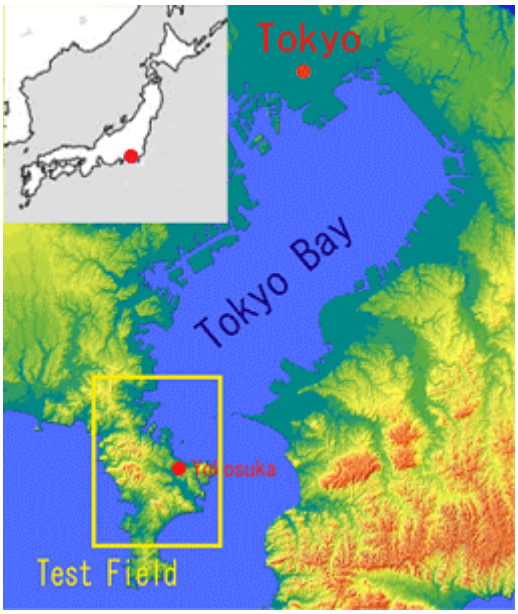

Fig.2 Location of test field

2.2 Image data

Evaluated images are 'QuickBird panchromatic basic imagery' with the radiometric correction and the sensor characteristic correction. The observation date of images is April 22, 2003, and their ground resolution is 0.78m. The area of each image is 450km^2 (21.2km*21.2km). The off-nadir angle of the forward view is 28.7 degree and that of the backward view is 27.2 degree. The Overlap is about 90%.

2.3 3D model

The evaluated 3D model is a RPC model by using parameters distributed with images.

2.4 Image measurement

The 60 checkpoints were selected from obvious objects in images (*e.g.,* an intersection of lines at parking area, Fig.3). Then 3 dimensional coordinates are measured on the 3D model by stereoscoping at a digital photogrammetric system. Each point is measured twice and calculated the average as the coordinates A. The standard deviation of the differences between the two measurements is 0.19m in longitude, 0.15m in latitude and 0.23m in vertical.

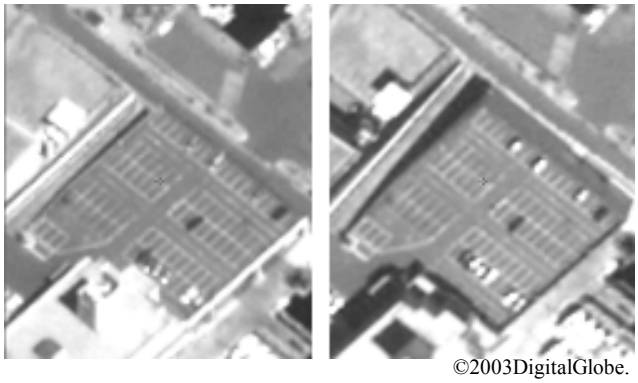

Fig.3 An example of check points
(Left: forward-view, Right: backward-view)

2.5 GPS survey

The checkpoints were also surveyed by fast-static GPS (Fig.4). The reference station is one of permanent GPS stations of the GEONET (GPS Earth Observation Network of the GSI, Hatanaka et al., 2003). The observation time of each point is 30 minutes and PDOP of each observation is less than 6.

Fig.4 GPS survey

3. RESULTS

3.1 Evaluation of horizontal spatial accuracy

The horizontal component of error vectors (coordinates A – coordinates B) are indicated in Fig.5. Starting point is the coordinates B as correct value. The vector displays error's magnitude and direction.

As a result, shifts to west are observed at all points. The average of the longitude component of the shifts is 13.12m and that of latitude component is 2.78m. The standard deviation of the longitude component is 0.73m and that of latitude component is 0.95m.

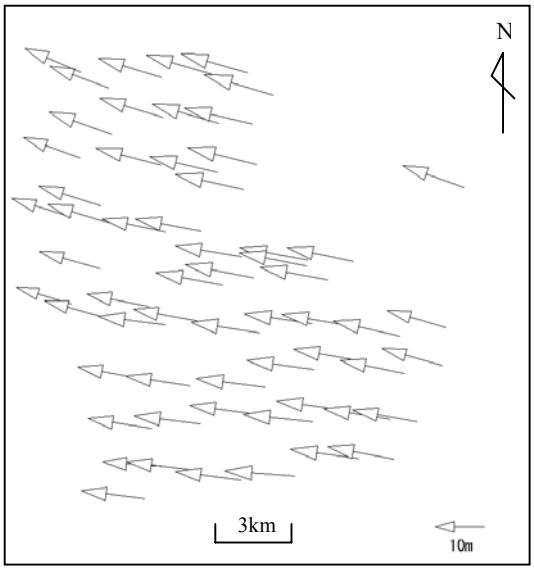

Fig.5 Horizontal component of error vectors

We tried to correct the shifts by fixing one point as a ground control point (GCP) because all vectors have the same tendency. Fig.6 shows the result of correction when the center point of images is used as a GCP. The average of the longitude component of shifts decreases to 0.74m and that of the latitude component decreases to 0.79m.

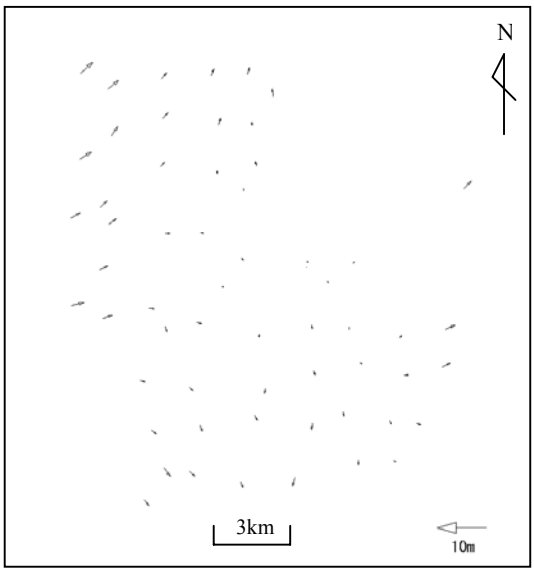

Fig.6 Horizontal component of error vectors
(after correction)

3.2 Evaluation of vertical accuracy

The average of vertical differences between coordinates A and coordinates B is 1.38m and the standard deviation of that is 1.42m. Fig.7 displays the error as a gradation map. We see the south-north tilt of –1.90m to 2.90m.

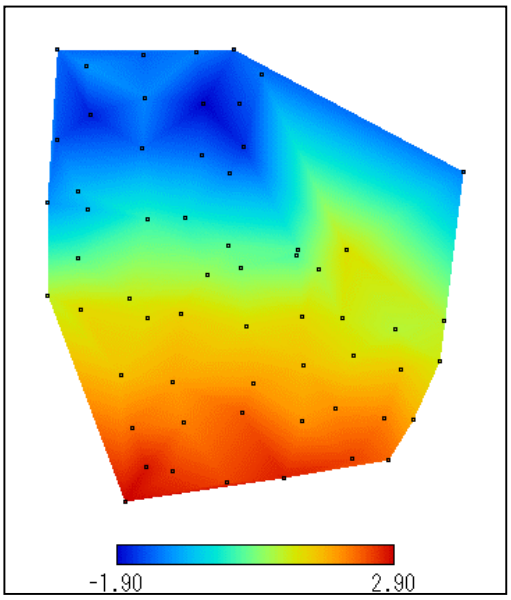

Fig.7 Vertical component of error vectors

Fig.8 is gradation map after the correction of the tilt of the whole 3D model by linear regression. The average of errors decreases to 0.29m and the standard deviation decreases to 0.37m.

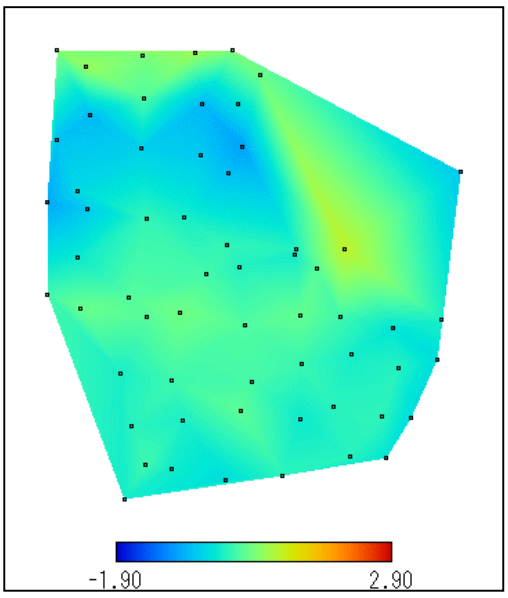

Fig.8 Vertical component of error vectors (after correction)

4. Conclusion

In this study, the accuracy of QuickBird basic stereo images is evaluated and the distortion of the 3D model is definite. A few GCP is enough to correct for topographical mapping. The small number of the required GCP makes easy to introduce high-resolution satellites imagery even in a mountain region or an isolated island.

References:

Fraser, C.S., Hanley, H.B. and Yamakawa, T. (2002): Three-dimensional positioning accuracy of Ikonos imagery, The Photogrammetric Record, vol.17, no.99, 465-479.

Fraser, C.S. and Hanley, H.B. (2003): Bias Compensation in Rational Functions for Ikonos Satellite Imagery, Photogrammetric Engineering and Remote Sensing, vol.69, no.1, 53-58.

Hatanaka, Y., Iizuka, T., Sawada, M., Yamagiwa, A., Kikuta, Y., Johnson, J.M. and Rocken, C. (2003): Improvement of the Analysis Strategy of GEONET, Bulletin of the Geographical Survey Institute, vol.49, 11-38.

Hitachi Soft co. (2002): QuickBird Imagery Products Guides

Iida, Y., Matsuo, K. and Sato, J. (2001): A Study of Making 1:25,000 Topographic Maps by Using High-resolution Satellite imagery, Proceedings of Regular Conference of Japan Cartographers Association.

Iida, Y., Yarai, E. and Noguchi, M. (2002): A Study of Making 1:25,000 Topographic Maps by Using Digital Ortho Imagery, Proceedings of Annual Conference of Japan Society of Photogrammetry and Remote Sensing, 223-226.

Iida, Y., Kobayashi, D. and Sato, J. (2003): A Study of Making 1:25,000 Topographic Maps by Using SPOT5 Ortho Imagery, Proceedings of Annual Conference of Japan Society of Photogrammetry and Remote Sensing, 109-112.

Kobayashi, D., Iida, Y. and Noguchi, M. (2002): A Test of Making 1:25,000 Topographic Maps by Using IKONOS Stereo-pair Imagery, Proceedings of Autumn Conference of Japan Society of Photogrammetry and Remote Sensing, 187-192.

Noguchi, M., Iida, Y. and Shimono, T. (2003): A Study of Making Topographic Maps by Using QuickBird Imagery, Proceedings of Annual Conference of Japan Society of Photogrammetry and Remote Sensing, 105-108.