# Geometrical Comparisons between Rigorous Sensor Model and Rational Function Model for Quickbird Images

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**ABSTRACT**: The objective of this investigation is to compare the geometric precision of Rigorous Sensor Model and Rational Function Model for QuickBird images. In rigorous sensor model, we use the on-board data and ground control points to fit an orbit; then, a least squares filtering technique is applied to collocate the orbit. In rational function model, we first use the rational polynomial coefficients provided by the satellite company. Then the systematic bias of the coefficients is compensated by an affine transformation using ground control points. Experimental results indicate that, the RFM provides a good approximation in the position accuracy.

**KEY WORDS**: Rigorous Sensor Model, Rational Function Model, QuickBird.

## 1. INTRODUCTION

The Rigorous Sensor Model (RSM) has been recognized as with the highest precision in the geometric processing for satellite images. The model fully describes the geometric relationship among object points, image points, and orientation parameters. On the other hand, the Rational Function Model (RFM) uses the ratios of polynomials to represent the geometric relationship between image space and object space. The high resolution satellite images have small field of view in common. Thus, RFM provides a good approximation in the geometric correction for the images when the coefficients are derived from precision orientation parameters. Each QuickBird image data set includes on-board data for RSM and RPCs for RFM. Thus, the data is adequate for the accuracy comparisons of the two methods.

In RSM, we propose a collocation procedure to determine the precision orbit. Using on-board ephemeris data, we first fit an orbit using ground control points. Then, a least squares filtering technique is applied to collocate the orbit. In RFM, we use the rational polynomial coefficients (RPCs) provided by the satellite company rather than the ones directly derived from ground control points. The transformation bias of RFM is then compensated by an affine transformation.

## 2. RIGOROUS SENSOR MODEL

The major step in validating the positioning accuracy for an image is to model the orbit parameters and the attitude data. The position vectors and the attitudes of the satellite are expressed with low order polynomials in terms of sampling time [1]. Due to the extremely high correlation between two groups of orbital parameters and attitude data, we only correct the orbital parameters. A collocation procedure is included to improve the accuracy. Three steps are included in the orbit modeling. The first step is to initialize the orientation parameters using on-board ephemeris data. We then fit the orbital parameters with low order polynomials using GCPs. Once the trend functions of the orbital parameters are determined, the fine-tuning of an orbit is performed by using Least Squares Collocation technique [2].

## 3. RATIONAL FUNCTION MODEL

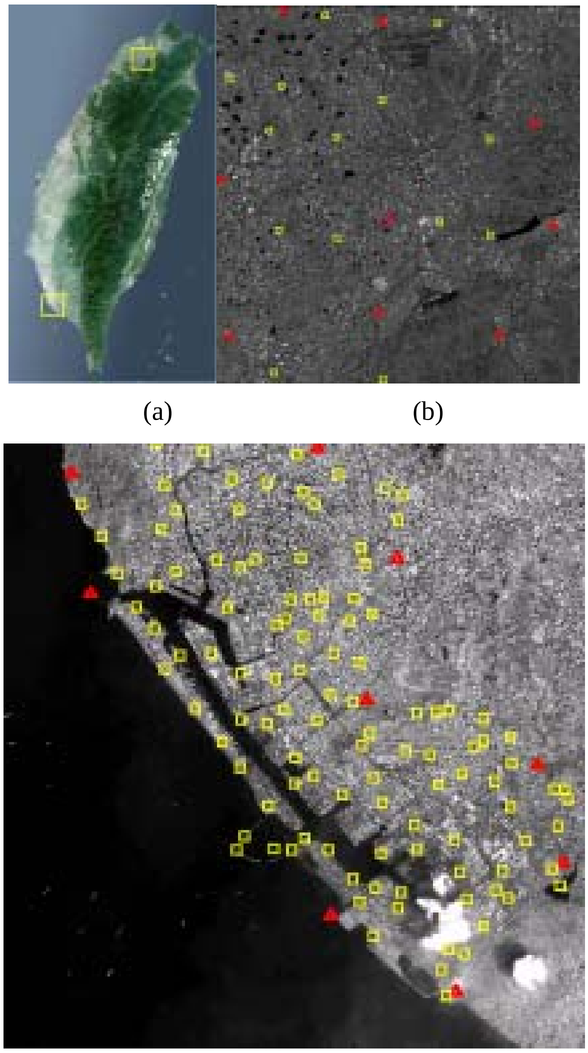
Rational function model has recently being applyed in high resolution satellite images such as Ikonos and Quickbird [3]. The RFM is a transformation between the 2D image space and 3D object space. It uses a ratio of two polynomials function to perform the transformation.

The RPCs provided by the satellite company perform high accuracy; it is because the RPCs are derived from the high accuracy on-board data [4]. Usually, the RFM is in third orders; hence, 80 RPCs are given. In order to correct the systematic bias of RPCs, we use an affine transformation to correct the error in image space. The affine transformation coefficients can be calculated from ground control points [5].

## 4. EXPERIMENTAL RESULTS

The test data includes two sets of QuickBird basic images as shown in figure 1, which cover areas in northern and southern of Taiwan, respectively. The ground control points and ground check points were measured from 1/1000 scale topographic map. Also shown in figure 1, we measured 24 points in case I, and 121 points in case II. The tests include the comparisons of accuracy between RSM and RFM. In RSM, we use the proposed method, called CSRSR. In order to further test the RSM, a commercial package of PCI is also compared.

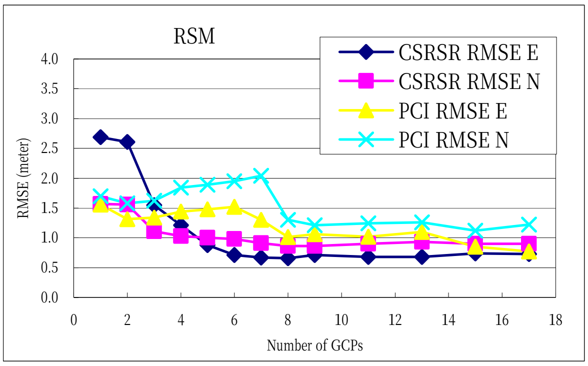
Figure 2 and Figure 3 demonstrate the accuracy performance for the two cases when different number of GCPs were employed. The accuracy tends to be stable when nine GCPs were employed. Thus, a comparison of accuracy is summarized in Table 1. It is observed that the two methods of RSM, i.e., CSRSR and PCI, perform similarly in both cases. The accuracies of CSRSR and PCI interlace when different number of GCPs were employed. The results of CSRSR are slightly better than the RFM in the first case. Different behaviors are observed in the second case.



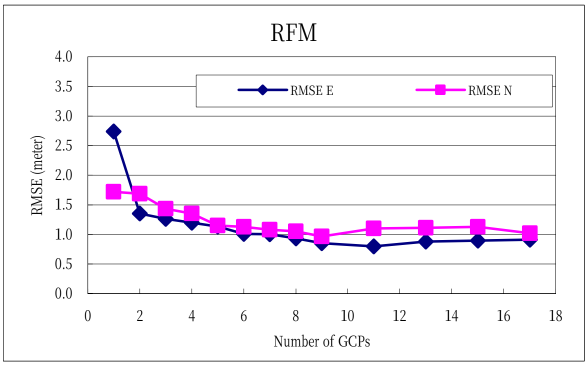
(a) (b)

(c)

Fig. 1. Test images.
(a) Location of test images,
(b) Case I image,
(c) Case II image.

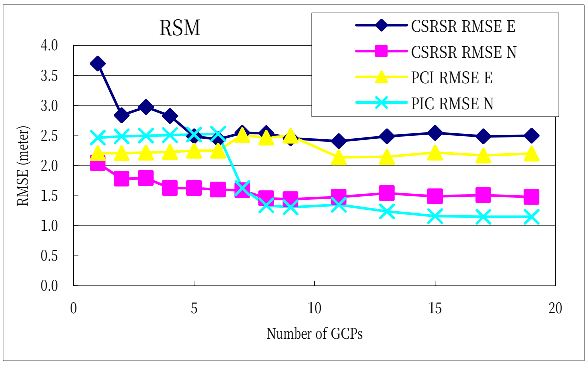



(a)

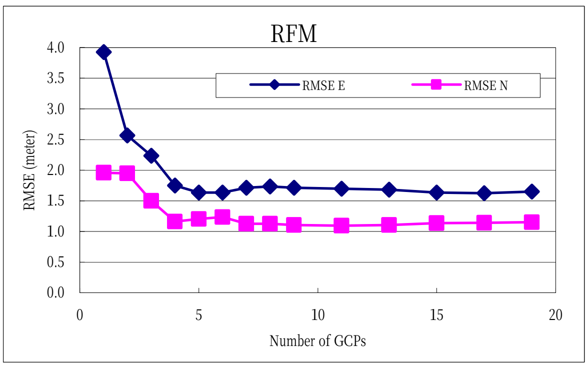



(b)

Fig. 2. RMSE of CHKPs with Different Number of GCPs: Case I




(a)




(b)

Fig. 3. RMSE of CHKPs with Different Number of GCPs: Case II

Table 1. RMSE of check points

| | RSM(CSRSR) | | RSM(PCI) | | RFM | |
|---|---|---|---|---|---|---|
| Unit: meter | RMSE E | RMSE N | RMSE E | RMSE N | RMSE E | RMSE N |
| Case I | 0.71 | 0.86 | 1.06 | 1.21 | 0.85 | 0.96 |
| Case II | 2.46 | 1.44 | 2.50 | 1.31 | 1.71 | 1.12 |

## 5. CONCLUSIONS

This paper compares the positioning accuracy of RSM and RFM for QuickBird images. The two methods, CSRSR and PCI, of RSM perform similarly in both cases. The results of CSRSR are slightly better than the RFM in the first case but not in the second one. A further investigation for Case II is needed.

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