INTERNATIONAL JOURNAL OF
ENERGY AND ENVIRONMENT

Volume 6, Issue 4, 2015 pp.403-410
Journal homepage: www.IJEE.IEEFoundation.org

Accuracy evaluation of different topographic regions in Iraq using geometrics methods

Israa H. Mohammed, Abdul Razzak Ziboon

Building and Construction Engineering Department, University of Technology, Ministry of Higher Education & Scientific Research, Baghdad, Iraq.

Abstract
In this paper, different mathematical models 3D case are investigated and comprised in order to assess the accuracy of these models under different conditions of terrain topography depend on Geomatics methods. Three high resolution satellite QuickBird images (panchromatic 0.6 m in spatial resolution) of three different study areas, with respect to their topography (a flat area, a hilly area and a mountain area) in Iraq have been used in this work. The flat area is chosen in Baghdad in the middle of Iraq while, the hilly and mountain areas are chosen in Irbil in the north of Iraq. The 3D mathematical models which were used, 1st, 2nd order 3D polynomial, and direct linear transformation model. All these methods are applied for each study area and evaluated through the Matlab environment facilities. The results of 3D models in the three studied areas indicate that the best accuracy is achieved with 2nd order 3D polynomial and DLT models while the worst accuracy is obtained with 1st order 3D polynomial model. Therefore, in the case of using 3D models, the 2nd order 3D polynomial and DLT models is recommended to achieve high geometric accuracy.

Keywords: Geometrics methods; 3D polynomial model; Direct linear transformation model.

1. Introduction

Remote sensing system gathered data in many forms and techniques. In all these systems, there are numerous errors associated with gathered data. Therefore, it is usually necessary to preprocess the remotely sensed data priory to analyzing it in order to remove these errors.

Image restoration is usually implemented to correct distortion, to remove degradation, and to reduce noise introduced during the image process. Image restoration produces a corrected image that is as close as possible, both geometrically and radio metrically, to the radiant energy characteristics of the original scene. To correct the remotely sensed data, internal and external errors must be determined. Internal errors are created by the sensor itself. They are generally systematic (predictable) and may be determined from prelaunch or in-flight calibration measurements. External errors are due to platform perturbations and the modulation of atmospheric and scene characteristics, which are variable in nature. Such unsystematic errors may be determined by relating points on the ground (i.e., ground control points) to sensor system measurements. Radiometric and geometric errors are the most common types of errors encountered in remotely sensed imagery, [1].

2. Geometric correction models

A simple geometric model usually involves mathematical functions, which are easier to understand and do not require the knowledge of image sensor physics, [2]. In this respect, simple geometric models require mathematical functions to relate the image space and object space. The mathematical function parameters are solved with the help of the GCPs collected throughout the image by using the least squares adjustment process. Once the mathematical function parameters are determined, the correct positions of each pixel in the image can be estimated by these functions, [3]. In this paper, some of 3D transformation used with numbers of ground control points. These models are generally available within most of remote sensing image processing systems. These models can be used to provide sufficient insight about the ground elevation effects on the metric integrity of the rectified images, [1].
The mathematical models used in this paper are:

- 3D Polynomial Model.
- Direct linear transformation model.

The following sub sections discuss the models characteristics.

2.1 (3D) Polynomial model

The 3D polynomial functions are an extension of the 2D polynomial function by adding Z-terms related to the third dimension of the terrain, [2]. However, because they are similar to the 2D order polynomial functions, the problems of the 2D order polynomial functions are also valid for these functions except for the topography. They still require accurate, numerous and evenly distributed GCPs. The order of the 3D polynomial model, generally between one and three, [4]. The following equations are used to express the general form of the polynomial models in 3D case, [5]:

- 1st order (3D) polynomial.

$$x = a_o + a_1X + a_2Y + a_3Z \tag{1}$$

$$y = b_o + b_1X + b_2Y + b_3Z \tag{2}$$

- 2nd order (3D) polynomial.

$$x = a_o + a_1X + a_2Y + a_3Z + a_4XY + a_5XZ + a_6YZ + a_7X^2 + a_8Y^2 + a_9Z^2 \tag{3}$$

$$y = b_o + b_1X + b_2Y + b_3Z + b_4XY + b_5XZ + b_6YZ + b_7X^2 + b_8Y^2 + b_9Z^2 \tag{4}$$

where (x, y) are the image coordinates, (X, Y) are the ground coordinates and (a, b) are the polynomial coefficients to be determined by the least square adjustment, [5].

2.2 Direct Linear Transformation (DLT)

Direct Linear Transformation (DLT) model initially used by Abdel-Aziz and Karara in 1971 for non metric cameras in close range photogrammetry and Novak in 1997 for geometric correction of satellite images, [6]. The DLT model is the transformation between the image pixel coordinate system and the object space coordinate system as a linear function. It has been widely used in close-range photogrammetry and can also be used for the satellite image geometric correction. Actually, the DLT model is often used to derive the approximate initial values of unknown parameters for the collinearity equations, [4, 7]. The model can be expressed as, [2]:

$$x = \frac{L_1X+L_2Y+L_3Z+L_4}{L_9X+L_{10}Y+L_{11}Z+1} \tag{5}$$

$$y = \frac{L_5X+L_6Y+L_7Z+L_8}{L_9X+L_{10}Y+L_{11}Z+1} \tag{6}$$

where (x, y) are coordinates of a point in image space and (X,Y,Z) are coordinates of same point in ground space and $(L_1, \ldots, L_{11})$ are transformation parameters between two dimensional image space and the three dimensional object space to be determined by least square adjustment with minimum of (6) GCPs, [2].

3. Study areas

3.1 Study area (1)

The first study area is chosen in Baghdad city in the middle of Iraq. The area has an elevation range of between (32-47 m), and can be considered as flat area. The distribution of ground control points and check points have been shown in Figures (1) and (2) respectively.

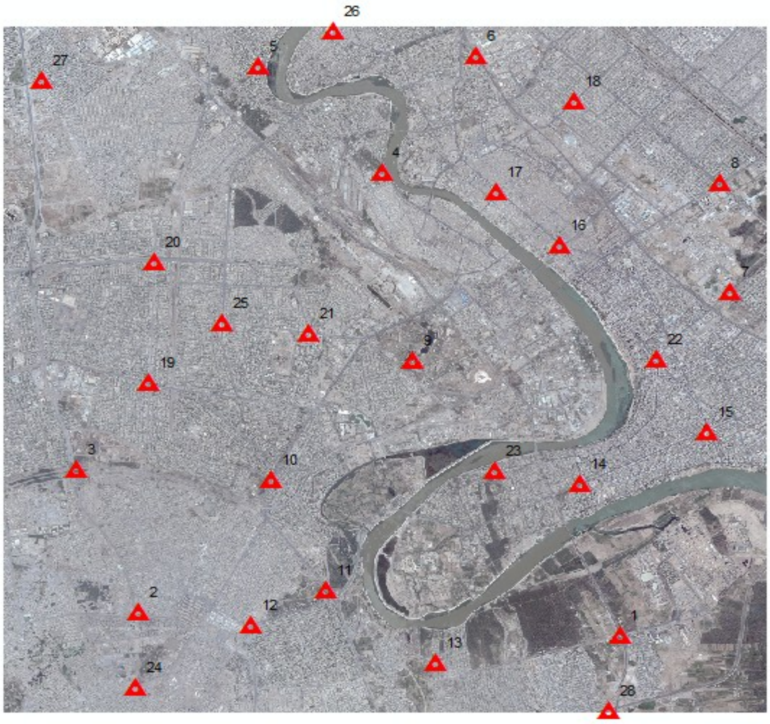

Figure 1. The first study area with GCPs distribution

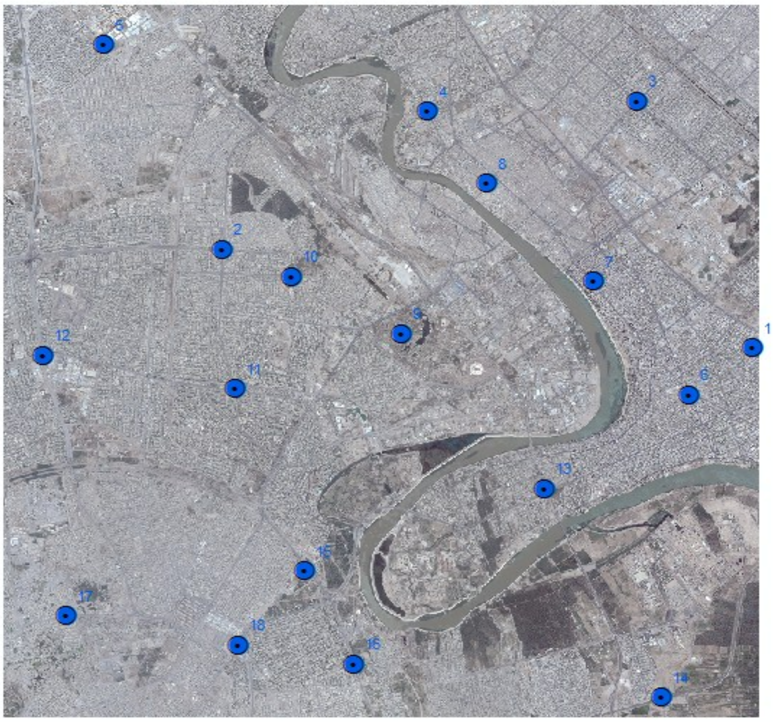

Figure 2. The first study area with CPs distribution

3.2 Study area (2)

The second study area is chosen in the center of Irbil city at the north of Iraq. This area has an elevation range of between (377-528 m), and can be considered as hilly area. The distribution of ground control points and check points have been shown in Figures (3) and (4) respectively.

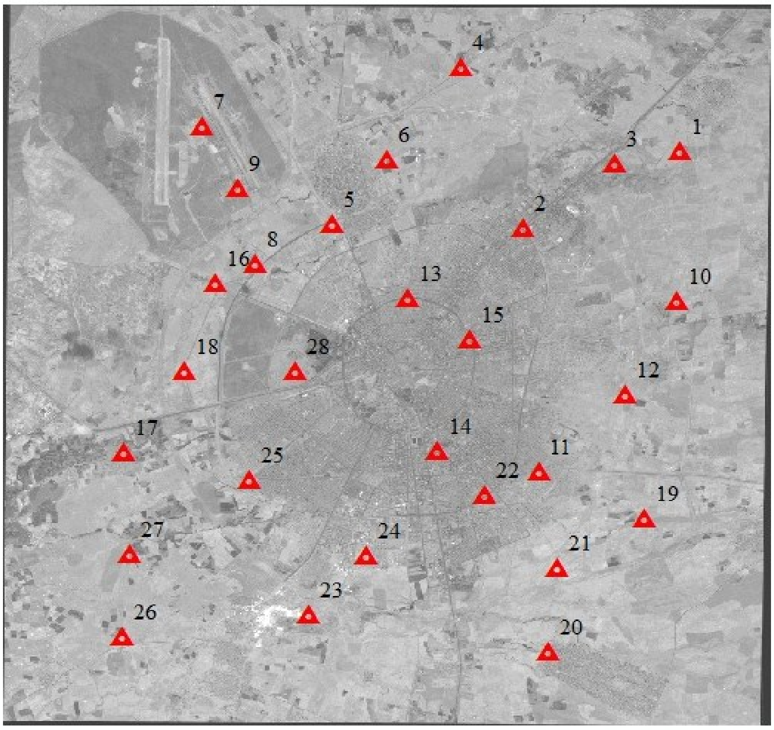

Figure 3. The second study area with GCPs distribution

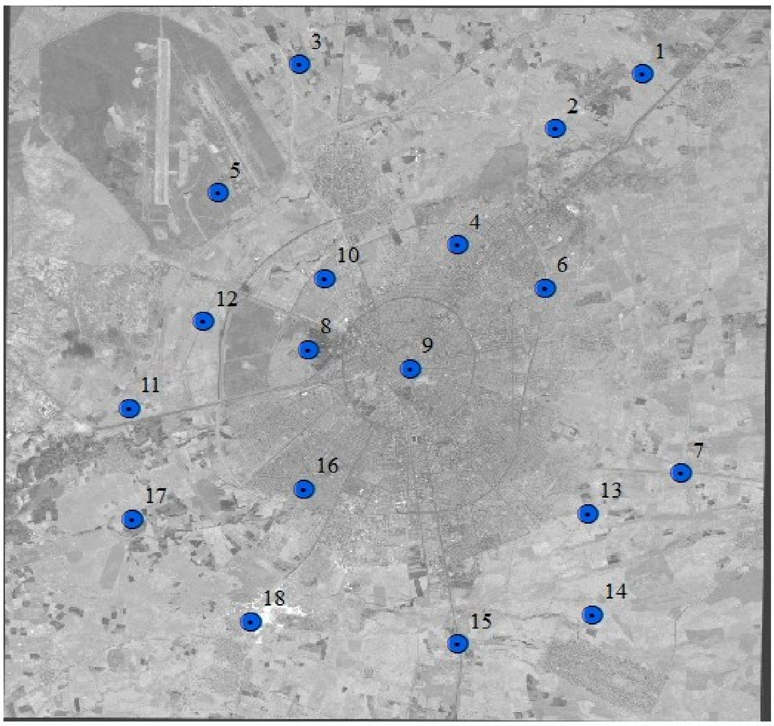

Figure 4. The second study area with CPs distribution

3.3 Study area (3)

The third study area is chosen in Soran, Irbil city at the north of Iraq. The area has an elevation range of between (1450-3150 m), and can be considered as mountain area. The distribution of ground control points and check points have been shown in Figures (5) and (6) respectively.

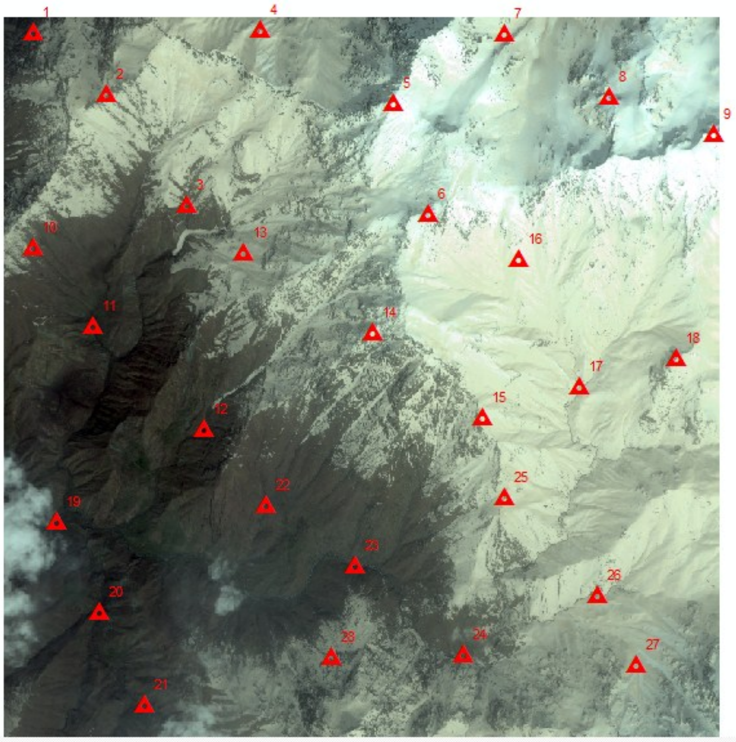

Figure 5. The third study area with GCPs distribution

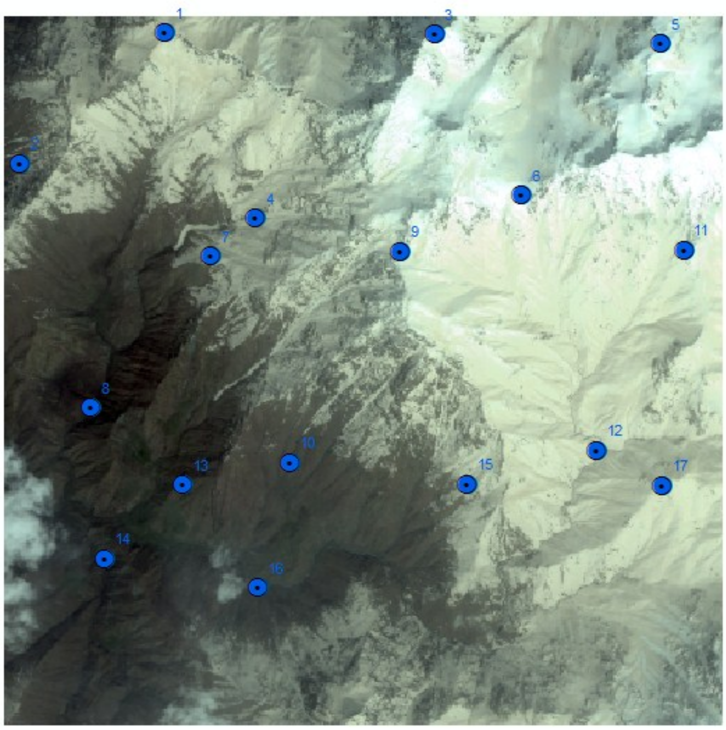

Figure 6. The third study area with CPs distribution

4. Mathematical models results and discussion

In this paper, different geometric correction mathematical models are applied using three high resolution satellite QuickBird images (panchromatic 0.6 m in spatial resolution) of three different study areas, with respect to their topography (flat area, hilly area and mountain area) in Iraq. All the geometric models which are used, utilized the ground control points GCPs in order to establish the mathematical relationship between image and corresponding ground coordinates. A total number of (46) GCPs were selected, well distributed over each of the three study areas, (28) points were used as control points and the rest of them were considered as check points. The ground coordinates of all GCPs were collected through the DGPS, type (Leica GPS SR20). The selection of GCPs targets is accurate as more as possible. The (TRMSE) for GCPs and check points have been calculated for all models in order to find the best model. All these models are evaluated through the Matlab environment facilities, [8].

The geodetic parameters used in DGPS coordinates characteristics and the images information can be given in Table 1, this information was used in all methods.

Table 1. The used geodetic parameters and images information

Parameter	QuickBird (1)	QuickBird (2)	QuickBird (3)
Image type	Panchromatic	Panchromatic	Panchromatic
Spatial Resolution	0.6m	0.6m	0.6m
Map Projection	UTM	UTM	UTM
Datum	WGS 84	WGS 84	WGS 84
Zone Number	38	38	38
Acquisition Date	2008	2008	2008
Measurement Method	DGPS	DGPS	DGPS

The summary of results and TRMSE conclusion using the three models for the three study areas can be illustrated in Table 2.

The results of this table show that the 2nd Order 3D Polynomial model is the best model because the best accuracy is achieved with this model. This is due to the nonlinear curve fitting of this model for GCPs distribution. These results ensure that the higher the order of the function, the better fit to the GCPs. Also transformation of the 2nd order or higher are nonlinear transformation that can be used to correct nonlinear distortions such as Earth curvature and camera lens distortion, [9]. On the other hand, the worst accuracy is obtained with 1st order 3D polynomial model and the accuracy of DLT model is nearly similar to the accuracy of 2nd order 3D polynomial model. Also this results show that there is a substantial stability of the error in the flat, hilly, and mountain areas. Therefore, the 3D models assured great results for all terrain types.

Table 2. The summary of results for the three study areas

Model	TRMSE (pixel) flat area		TRMSE (pixel) hilly area		TRMSE (pixel) mountain area	
	Control	Check	Control	Check	Control	Check
1st Order 3D Polynomial	0.5903	0.6393	0.6441	0.7097	0.7239	0.7769
2nd Order 3D Polynomial	0.5176	0.6085	0.5520	0.6282	0.5250	0.5976
Direct Linear Transformation	0.5760	0.6281	0.5999	0.6427	0.5973	0.6406

5. Conclusion

1. The results of 3D models in the three studied areas indicate that the best accuracy is achieved with 2nd order 3D polynomial and DLT models while the worst accuracy is obtained with 1st order 3D polynomial model. Therefore, in the case of using 3D models, the 2nd order 3D polynomial and DLT models is recommended to achieve high geometric accuracy.
2. The accuracy of 2nd order polynomial model is better than the accuracy of 1st order polynomial model. This is due to the better fitting of nonlinear curve to GCPs distribution.

3. In the results of 2nd order 3D polynomial and DLT models there is a substantial stability of the error in the flat, hilly, and mountain areas. Therefore, the 3D models assured great results for all terrain types.
4. In the process of calculating the coefficients of 3D mathematical models by least square adjustment solution, the results of gauss elimination method is more accurate than the results of inverse method especially in the case of complex models such as 2nd order 3D polynomial. This is due to the more complicated equation and huge matrices of these models that required in calculating these coefficients.

References

[1] Jensen, J. R. Introductory Digital Image Processing, 2nd ed. prentice Hall upper saddle River, New Jersey USA, 1996.

[2] Toutin, T. Three Dimensional Topographic Mapping with ASTER Stereo Data in Rugged Topography. IEEE Transactions on Geoscience and Remote Sensing, 2002,Vol. 40, No. 10, pp. 2241-2247.

[3] Ali, O. Accuracy Assessment of the DEM and Orthoimage Generated from ASTER, M.Sc. Thesis, Middle East Technical University, (2005),.

[4] Tao, C. and Hu, Y. A Comprehensive Study of the Rational Function Model for Photogrammetric Processing. Photogrammetric Engineering and Remote Sensing, 2001, Vol. 67, No. 12, pp. 1347-1357.

[5] Hosseini, M. and Amini, J. Comparison Between 2-D and 3-D Transformations for Geometric Correction of IKONOS images, (2005) Department of Geomatics Engineering, Faculty of Engineering, University of Tehran.

[6] Samadzadegan, F., Milanlak, A. and Majdabadi, M., "Geometrical Correction of Satellite Images by Generic Models", ISPRS Journal of Photogrammetry and Remote Sensing.

[7] Mikhail, E. M., Bethel, J. S. and McGlone, C. J. Introduction to Modern Photogrammetry", Wiley, 2001.

[8] The Math Works, MATLAB® The Language of Technical Computing, Version 6, 2001, The MathWorks, Inc, USA.

[9] Ali, B. H. Enhancing The Accuracy of Geometric Correction of High Resolution Satellite Images, M. Sc. Thesis, 2006, University of Baghdad, Iraq.

Israa H. Mohammed, Assistant Lecturer at Building and Construction Engineering Department, University of Technology. M.Sc. In Geomatic Engineering, Building and Construction Engineering Department, University of Technology, Iraq. Specialization: Application of Geomatics Engineering, Environmental Remote Sensing, Digital Image Processing, Graduation Date: 2012. B.Sc. In Building and Construction Engineering Management, Building and Construction Engineering Department, University of Technology, Iraq. Specialization: Building and Construction Engineering, Graduation Date: 2002. Research Interests, Environmental Remote Sensing, Digital Image Processing, Photogrammetry.
E-mail address: israa_hatem@yahoo.com

Abdul Razzak Ziboon, Prof at Building and Construction Engineering Department, University of Technology. Ph.D. Surveying Engineering (Remote Sensing & GIS)), Building and Construction Engineering Department, University of Technology, Iraq. Specialization: Application of Surveying Engineering, Environmental Remote Sensing, Digital Image Processing, Graduation Date: 1995. M.Sc. In Surveying Engineering (Remote Sensing), Building and Construction Engineering Department, University of Technology, Iraq. Specialization: Application of Geomatics Engineering, Environmental Remote Sensing, Digital Image Processing, Graduation Date: 1978. B.Sc. In Surveying Engineering, Building and Construction Engineering Department, University of Technology, Iraq. Specialization: Building and Construction Engineering, Graduation Date: 1979. Research Interests, Environmental Remote Sensing, Digital Image Processing, Photogrammetry.
E-mail address: razzak1956@Yahoo.com