Journal of University of Kerbala

Evaluation the Accuracy for High and Low Resolution Satellite Images for AL Kut city Using GPS

تقييم الدقة لصور الاقمار الاصطناعية ذات الوضوحية العالية والمنخفضة باستخدام نظام تحديد المواقع العالمي

Sinan H.Ali [1], Nawal K.Ghazal [2], Taghreed A.H. Naji1[3] , Mohammed Abdullah Lazim

[1]Department of Astronomy & Space, College of Science, University of Baghdad,[2] Department of physics , college of science, University of Baghdad, [3]Department of Physics, College of Education for Pure Sciences Ibn Al-Haitham, University of Baghdad, Baghdad, Iraq

Abstract

Remotely sensing images show the features on the earth surface which are geometrically distorted due the main errors related to the satellite positioning on its orbit or scanning process. In this work, using Global Positioning System (GPS) for geometric correction of satellite imagery to establish the relation between the image coordinate system and the GPS readout coordinate system. Measurements are presented for two satellite images high resolution Quick Bird and low resolution Land sat. The two –dimensional accuracies are low for Land sat image such as x and y coordinates error 0.9951 m, and 1.2036 respectively and total error is1.5617 m, While for Quick Bird image the two –dimensional accuracies are high where the errors are 0.3374 m and 0.2115 m respectively, and the total error is 0.3982 m. In the present study shows the ability to give high accuracy of georeferenced coordinate system of the Quick Bird image, while the Landsat image produces low accuracy.

Keyword: Geometrical correction, GPS, positional accuracy

المستخلص

تظهر صور الاستشعار عن بعد المعالم على سطح الارض والتي تحتوي على تشوهات هندسية بسبب الاخطاء الرئيسة ذات صلة بموقع القمر الاصطناعي مداره او عملية المسح . في هذا العمل تم استخدام نظام تحديد المواقع العالمي (GPS) للتصحيح الهندسي لصور الاقمار الاصطناعية لتحديد العلاقة بين نظام الاحداثيات للصورة ونظام الاحداثيات لقراءات ال (GPS) . أجريت القياسات لصورتين من صور الاقمار الاصطناعية Quick Bird (عالية الدقة) وLand sat (واطئة الدقة) . الدقة ذات البعدين واطئة لصورة القمر الاصطناعي Land sat حيث خطأ أحداثيات x وy هو 0.9951 m, 1.2036 m على التوالي والخطا الكلي هو1.5617 m.اما بالنسبة لصورة القمر الاصطناعي Quick Bird عالية الدقة فالاخطاء هي 0.3374 m و 0.2115m والخطا الكلي هو 0.3982 m. هذه الدراسة تظهر القدرة على اعطاء دقة عالية لنظام الاحداثيات الجغرافية من الصورة (Quick Bird), بينما صورة (Land sat) اعطت دقة واطئة.

1- Introduction

Bruce Sharp, Kelly,and MacDonald,[1**].** Accuracy is the degree to which information on a map or in a digital database matches Actual/ True or Accepted values. The discrepancy between the encoded and the actual value of a particular attribute for a given entity is defined as an “error”. Accuracy is an issue pertaining the quality of data and the number of errors contained in a data set or map. The level of accuracy required for particular applications varies greatly. Highly accurate data can be very difficult and costly to produce and compile. Accuracy is always a relative measure, since it is always measured according to the specifications. To judge fitness-for-use, one must judge the data according to the specification, and also consider the limitations of the specification itself. The requirements for planimetric accuracy of satellite image correction are discussed in the context of base mapping accuracy standards. Measurements are presented for SPOT and the Landsat Thematic Mapper. Lawrence, Bon, and Ramesh, [2]. The positional accuracy of a GIS layer can be separated into absolute and relative components. Accepted standards for estimating horizontal accuracy in cartographic data quantify absolute positional accuracy only. This paper presents a technique for quantify absolute and relative positional accuracy estimated through error propagation from a covariance matrix for affine transformation parameters. Albert K.Chong, [3].They are suggested a technique for spatial sampling and error reporting for image base maps. The technique is based on the coverage of an image map base, the initial estimated accuracy, and the principle of error propagation to determine a number of check points. The location of these check points is randomly generated to obtain a non-biased evaluation of the overall image map base. Ramirez, and Ali, 2003, [4]. They have been developed metrics for positional accuracy of linear features. Linear features are more complex than cartographic points and are major components of spatial databases. R.J.Ackermann, 1996, [5]. In this paper have been described a quality control system which can be applied to photogrammetric feature extraction. There are two sources of errors for GPS mapping projects – errors inherent in the GPS positions and errors due to interpretation and definition of features. Interpretive errors indicate how well the operator can determine features on the ground and they are introduced when the field operator neglects significant details or fails to gather enough information to adequately define a certain feature. For example, an edge of a curved car park pavement requires enough positions to define the shape of the arc. The required accuracy of the points and physical placement of the GPS antenna centre or mounting pole must be adequate to represent the feature at a suitable map scale. Delineation and interpretation of some features requires more operator skill than others. For example, estimating a road centre line and locating an exact ground location from an image pixel requires significant operator skill. Conversely, indicating that a sign post is accurate to 1m,when the operator is casually standing adjacent to the sign by several meters during data capture misrepresents accuracy due to poor feature interpretation [6].

These boundaries, the UTM zone and the ellipsoid are established on each newly-created empty file. Geometric rectification of the imagery resamples or changes the pixel grid to fit that of a map projection or another reference image. This becomes especially important when scene to scene comparisons of individual pixels in applications such as change detection are being sought [7].

2- Description of studied area

We are choose AL-Kut city in our study which is localized at the east of Iraq at the left bank of the Tigris river about 160 kilometers (99 miles) south east of Baghdad at the coordinates (32°30′20″N 45°49′29″E) and Its area about (17012 km^2) which constitute 4% of total area of Iraq that is about (441000 km^2).

3- Available data

We make use of the following data in our work
1- Quick Bird satellite image in 2006 as demonstrated in figure (1).
2- Land sat satellite image as illustrated in figure (2).
3-ERDAS Imagine, Arc GIS and GPS.

Figure (1): Quick Bird satellite image for AL Kut city in high resolution.

Figure (2): Land sat satellite image for AL Kut city in low resolution.

4 - Garmin GNSS 72 GNSS Device

The Garmin GNSS 72 is a device for land or marine navigation designed to provide precise GNSS positioning by using correction data that obtained from the Wide Area Augmentation System (WAAS) as shown in figure (3). This device can provide position accuracy to less than three meters, while being rugged, water-resistant, and unsinkable--making it perfect for fishing outings, whether you are boating or hiking.

Figure (3): Garmin GNSS 72 GNSS Device.

5 - Geometric Correction

Digital images collected from airborne or space-born often contain systematic and non-systematic errors that arise from the earth curvature, platform motion, relief displacement, non-linarites in scanning motion, and the earth rotation. Some of these errors can be corrected by using ephemeris of the platform and precisely known internal sensor distortion characteristics. Other errors can only be corrected by matching image coordinates of physical features recorded on the image to the geographic coordinate of the same feature collected from a map [6].

In this research geometric correction have been carried out for Quick Bird and Landsat satellite images which their resolutions about (61cm) and (30 m) respectively using GPS to collect GCPs and analysing the errors.

6- Results and discussions

The following first-order polynomial transformation equation can be used to determine the required coefficients to transform pixel coordinate to the corresponding other coordinate value.

$$X_0=a_1 +a_2 X +a_3Y \qquad (1)$$
$$Y_0= b_1 + b_2X + b_3Y \qquad (2)$$

Where X and Y are the input pixel coordinates while X_0 and Y_0 are the output (geographic) coordinates.

The order of the polynomial used in this process is the order of the transformation. Polynomial equations are used to convert the source coordinate to rectify the coordinate. The pixel coordinate system has an X coordinate (column) and Y coordinate (row).

The relationship between the pixel coordinate system and the geographic coordinate system can be defined by polynomial transformation. The best order of transformation can be obtained using a trial and error process.

Initially, a few (at least three for first-order polynomial) ground control point (GCPs) are required to determine six transform each set of row (X) and column (Y) pixel coordinate to output (Geographic) coordinates. In this work, second-order transformation equation (where at least 6 numbers of GCPs are required to determine 12 transformation coefficients) for X and Y are:-

$$X_0= a_1 + a_2X + a_3Y + a_4X^2 + a_5XY + a_6Y^2 \qquad (3)$$
$$Y_0= b_1+ b_2X + b_3Y + b_4X^2+ b_5XY + b_6Y^2 \qquad (4)$$

The GCPs were measured by using GNSS for the geometrical correction process in the present study. High resolution Quick Bird is used to establish a geodetic relationship between the image coordinate system (input X, Y) and the geographic coordinate system GCPs (reference X_0, Y_0). There is one of the factors that contribute to this result which is the different number of GCPs that have been used. Table (1) and figure (4) summarizes the results of the geometric correction of the data.

The result of the satisfactory experiment for the imagery rectification (for 10 points gave a few close and errors in both directions) shows that the $RMSE_E$ (y)and $RMSE_N$ (x) are 0.3374 m and 0.2115 m respectively, while the total RMSE is 0.3982 m.An evaluation of the accuracy of the check points in table (2), which is identified the residual errors such as $RMSE_N$, $RMSE_E$ and total

RMSE which are 0.6979 m, 0.1495 m and 0.7137 m respectively. These results are showing high accuracy.

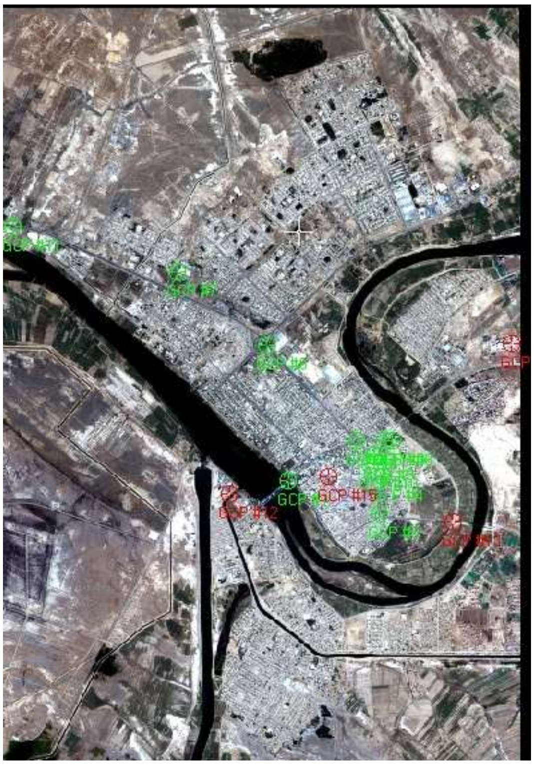

Figure (4): The location of GCPs &check points for high resolution

Table (1): The coordinates of 11 GCPs, with their residual errors for high resolution satellite image

Point id	X input	Y input	X ref.	Y ref.	X residual	Y residual	RMS	CONTRIB
GCP1	577003.864	3506163.721	577005	3596164	0.651	0.143	0.667	1.674
GCP2	577918.799	3596695.304	577191	3596696	0.186	0.584	0.614	1.541
GCP3	578280.5	3596700.137	578280	3596700	0.405	0.245	0.474	1.189
GCP4	578264.139	3596223.018	578264	3596223	0.225	0.14	0.265	0.666
GCP5	578209.255	3595720.037	578209	3595720	0.538	0.174	0.566	1.42
GCP6	576733.753	3597965.939	576734	3597966	0.346	0.027	0.347	0.872
GCP7	575543.003	3598943.895	575543	35989.44	0.1	0.033	0.105	0.265
GCP8	578391.934	3596694.873	578392	3596695	0.193	0.02	0.194	0.478
GCP9	578153.899	3596479.892	578154	3596498	0.084	0.007	0.085	0.212
GCP10	578097.98	3596375.987	578098	3596376	0.059	0.106	0.121	0.305
GCP11	573351.002	3599547.005	573351	3599547	0.333	0.082	0.343	0.862
Total RMSE for control points in X direction					0.3374			
Total RMSE for control points in Y direction					0.2115			
Total RMSE for control points					0.3982			

Table (2): The coordinates with residual for check points at high resolution image.

Point id	X input	Y input	X ref.	Y ref.	X residual	Y residual	RMS	CONTRIB
GCP1	576224.021	3595984.103	576224	3595984	0.807	0.252	0.845	1.184
GCP2	579191.969	3595605.989	579192	3595606	0.004	0.118	0.118	0.165
GCP3	579980.978	3597989.977	579981	3597990	1.104	0.032	1.104	1.548
GCP4	577537.973	3596211.975	577538	3596212	0.28	0.105	0.299	0.419

Total RMSE for control points in X direction	0.6979
Total RMSE for control points in Y direction	0.1495
Total RMSE for control points	0.7137

For low resolution Land sat image**,** the corresponding one dimensional values of residual (using 10 points gave the biggest errors in the x and y axes) for both direction $RMSE_E$ and $RMSE_N$ are equal 0.9951 m,and 1.2036 m respectively, and the total RMSE is about 1.5617 m as illustrated in table (3) and figure (5).
Table (4) shows the comparison of check points and RMSE for coordinates x and y which are 0.8282 and +-1.299m respectively. The results show that the value of RMSE is equal 1.5406m and the low RMSE indicates smaller accuracy.
In low resolution satellite image, when using greater number of GCPs will lead to more errors, it is difficult to identify the location of these points beyond to overlap the features in this image.

Figure (5): The location of GCPs &check points for low resolution image.

Table (3): The 10 GCPs &their residual errors of low resolution satellite image.

Point id	X input	Y input	X ref.	Y ref.	X residual	Y residual	RMS	CONTRIB
GCP1	577004.571	3596162.427	577005	3596164	0.127	0.285	0.312	0.2
GCP2	577918.803	3596695.1	577919	3596696	0.21	0.313	0.377	0.241
GCP3	578281.474	3596698.878	578280	3596700	1.326	0.053	1.327	0.849
GCP4	578391.031	3596695.1	578391	3596695	0.159	1.1264	1.274	0.816
GCP5	578262.585	3596222.872	578264	3596223	1.581	1.032	1.888	1.209
GCP6	578209.696	3595720.422	578209	3595720	0.526	1.57	1.656	1.06
GCP7	576732.568	3597964.448	576734	3597966	0.942	0.171	0.957	0.613
GCP8	578153.028	3596494.875	578154	3596498	1.083	1.943	2.225	1.425
GCP9	578088.805	3596381.541	578087	3596385	1.714	2.275	2.848	1.824
GCP10	575542.554	3598942.903	575543	3598944	0.537	0.443	0.696	0.446

Total RMSE for control points in X direction	0.9951
Total RMSE for control points in Y direction	1.2036
Total RMSE for control points	1.5617

Table (4): The coordinates of check points with their residual for low resolution satellite image.

Point id	X input	Y input	X ref.	Y ref.	X residual	Y residual	RMS	CONTRIB
GCP1	573350.624	3599546.783	573351	3599547	1.456	1.456	2.141	1.39
GCP2	579192.382	3595606.178	579192	3595606	0.161	1.22	1.231	0.739
GCP3	576223.683	3595983.82	576224	3595984	0.269	1.182	1.212	0.787
GCP4	579980.997	3597990.135	579981	3597990	0.726	1.182	1.387	0.9

Total RMSE for control points in X direction	0.8282
Total RMSE for control points in Y direction	1.299
Total RMSE for control points	1.5406

In general, this device gives results with high accuracy (a low RMSE) for high resolution satellite image (Quick Bird), while the results that have been obtained from low resolution satellite image (Landsat) have low accuracy (large RMSE).Therefore, It is not necessary to get very expensive device for these applications.

7-Conclusion

1- The high resolution satellite image (Quick Bird) gives relatively high accuracy as the number of GCPs is increasing up to 11 GCPs, and that is due to distribution of GCPs over the studied area and entirely covered. But contrariwise in case of using low resolution satellite image, as 11GCPs give high error rate (RMSE),because the features of low resolution satellite image have been overlapped.
   clear GCPs as (Sadat Alkut) and (Alzahra education hospital) and others clear features in the image give low RMAE, because the features are not clear in low resolution satellite image and that increase RMSE because it's cannot be accurately selected.

2- RMSE depends on the type and resolution of the satellite image which want to be corrected geometrically. The total RMSE of control points which have been obtained from the high resolution satellite image (Quick Bird) with resolution 60cm is less than 0.5. While the low resolution satellite image (Landsat TM) at 30m resolution which has been give high RMSE value greater than 1 and represents high ratio in comparison with high resolution satellite image. This is due to the overlapping of the features and unavailability of accurately selected the features.
3- RMSE also depends on the type of GNSS device, Garmins72 GNSS device shows relatively high RMSE value, and that means the achievement of geometrical correction does not need expensive GNSS devices.

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