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The Effect of Densification and Distribution of Control Points in the Accuracy of Geometric Correction

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ABSTRACT

Geometric distortions are inevitable in aerial images due to many factors, such as the curvature and rotation of the earth and the motion of the scanning system. Ground control points (GCPs) are important features used in non-parametric approach for aerial image rectification. The most common approach for geometric corrections is the use of polynomials. . It depends on selection of several clearly discernible points, called Ground Control Points (GCPs), in the distorted image, and map them either to their true positions in ground coordinates (e.g. latitude, longitude) measured from a map, or to geo referenced image (corrected before), coordinates of corresponding points, through a mathematical transformation, that will convert the raw image coordinates into the desired coordinates. The rectification results are invested by using the total Root Mean Square Error (RMSE).

In this study two tests were carried out. Firstly, the distribution of three, six and ten control points were investigated .the second test examines the densification of control points and their effects in the accuracy of geometric correction. The bad location and bad distribution of the selected GCPs lead to an increase in the average RMS error value of correction of an image which should be taken into consideration; for example, the results obtain from the densified GCPs used to adjust the aerial when GCPs had been selected in one line we did not achieved an image. The results obtained from the densified GCPs used to adjust the aerial photographs showed approximately the same results those in the first case. Therefore, the use of the three GCPs is sufficiently enough to adjust the aerial image. The thing that preserve time and money.

Keywords: Geometric Correction, Liner Error, RMS, GCP

I. INTRODUCTION

Remote sensing can be defined as the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by device that not in contact with the object, area or phenomenon under in resignation "(likes, 1979). While the science of remote sensing provides the instrument and theory to understand how object and phenomenon can be detected, the art of remote sensing useful information. (Canada center for remote sensing tutorial)

II. METHODS AND MATERIAL

2. Geometric Distortion in Imagery

It would be wonderful if every remotely sensed image contained data that were already in their proper geometric x, y location. This would allow each image to be used as if it were map. Unfortunately, this is not the remotely sensed data and removes the geometric distortion so those individual picture elements (pixels) are in their proper plan metric (x, y) map location (Jensen, 2005).

Any remote sensing image, regardless of whether it is a acquired by a multispectral scanner on board a satellite, photographic system in an aircraft, or any other platform, sensor combination, will have various geometric distortion. (Levin, 1999)

This problem is inherent in remote sensing, as we attempt to accurately represent the three dimensional surface of the earth as a two dimensional image.
All remote sensing images are subject to some form of geometric distortion, depending on the manner in which the data are acquired. these errors may be due to a variety of factors in duding one or more of the following to name only a few :

- The perspective of the sensor potties.
- The motion of the scanning system.
- The motion and in stability.
- The platform, attitude, and velocity.
- The terrain relief, and
- The curvature and rotation of the earth.

3. Main Objectives of the Study

The main objective of this study is to evaluate the accuracy of geometric correction adjusting satellite image, in addition to study the effect of distribution and densification of control points used in geometric correction.
The study also investigates and compares the result obtained when increasing the number of control points, in addition to investigate the effect of the distribution of control points in the geometric correction.

4. Data and Method

This search had been oriented to evaluate the effect of Intensification and Distribution of Control points in the Accuracy of Geometric Correction and how to enhance the accuracy by best distribution of ground control points and reduce the number of ground control points when had been used in projects remote sensing which preserve time, effort and money. The general adopted in this study are summarized in the flow chart displayed in figure (1) bellow.

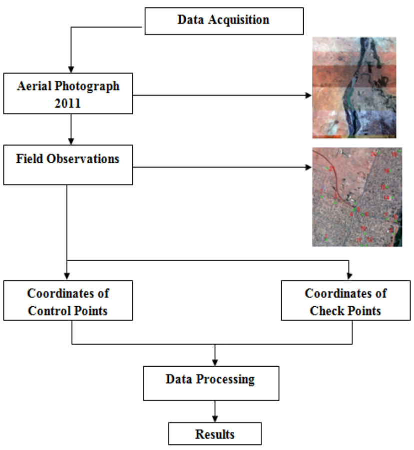

Figure 1 : The Study Flow Chart

4.1 ***Study Area***

The study area for this study is Sudan Khartoum State Karari Locality. Geographically, the study area is bounded by and approximately covering a total are 0f 8935158.99334 Surrounded between coordinates longitude ($32° 30' 10.0"$E& $32° 31' 45"$**E**) and latitude ($15° 42' 30"$ **N** & $15° 44' 10"$ **N**). Figures (2)and (3) below represents the study area within Sudan map and distribution of control points respectively.

Figure 2 : Study Area Within SUDAN Map

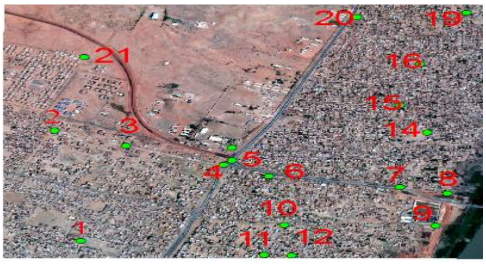

Figure 3 : Study Area and Distribution of Control Points

4.2 Data Acquired and Sources

In order to examine the effect of distribution and densification of control points in the geometric correction, the following data were acquired:

i. Aerial photograph had been used as a primary source of spatial data with the following specifications:

Produced by : Sudanese Survey Authority.
Date of Photography: 2011.
Resolution: 0.5m
Datum: WGS84.
Projection: UTM, Zone 36N.

i- Geodetic Coordinates of Ground Control Points (GCPs)

Datum: WGS1984.
Projection: UTM, zone 36.

ii. Reference Control point

Datum: WGS1984.

Projection: UTM, zone 36.
E: 447936.15
N: 1738151.661
H: 393.463 (Ellipsoid Height).
Description: concrete control point.
Location: Sudanese Survey Authority.
Source: Sudanese National Survey Corporation.

4.2 Hardware and Software Used

In general, different types of hardware and software used for this study:-

4.3.1 Hardware

- GPS receiver.
- Two Trimble 5800 GPS (reference and rover)

4.3.2 Software

- Trimble Geodetic office was used for coordinates processing
- Erdas Imagine software was used for geometric correction process.

5. Field Observations

The reference GPS were set at the control point. The twenty one control points were observed by rover to be used to calculate the accuracy of coordinate of digital image after geometric correction. table (1) and (2) shows the control points and check points respectively.

Table (1) Coordinates of Control Points

Pt No	Name	E(m)	N(m)
1	school	447018.871	1737063.056
2	N.W.ROWF	446846.766	1738355.916
3	S.E.ROWF	447300.528	1738193.287
4	S.W.ROWF	447887.601	1737962.136
6	MANARA	448196.581	1737816.926
7	BRIDGE	449009.692	1737696.920
8	BRIDGE0	449320.994	1737612.696
9	S.E.WATER	449238.299	1737239.127
12	S.W.EAST-11	448331.023	1736889.845
13	MANARA-MOSQUE	449184.004	1738340.344
14	DOCAN S.W.CORNER	449011.072	1738651.093
16	S.W.HOUSE	449426.047	1739737.399
17	N.W.HOUSE	448741.259	1739688.195
18	N.E.ASHLACK	447041.060	1739215.796

Table (2) coordinates of check points

Pt No	Name	E(m)	N(m)
5	CENTER	447961.504	1738002.610
10	N.E.CORNER	448289.977	1737248.815
11	SOUTH10	448170.163	1736897.210
15	N.W-MOSQUE	449134.438	1739134.217

6. Data processing

Aerial photograph of the study area had been opened on Erdas software as shown in figure (4) below

Figure 4 : Aerial photograph of study area

6.1 Geometric Correction

In order to examine the accuracy of geometric correction by using coordinates of control points, two tests were carried out.

6.1.1 First Test (Distribution)

In this step, geometric correction using three control point's distribution and three points clustered in order to examine the effect of distribution of control points in Geometric correction

6.1.1.1Three Distributed Control Points

Figure (5) below represents the distribution of the three control points in addition to check point in study area.

Figure 5 : Three Distributed Control Points and check point

6.1.1.2 Three Points Control Cluster

Figure (6) represents the clustered control points used in geometric correction

Figure 6 : Three clustered Control Points and Check Point

6.1.1.3 Six Control Points in Line

Six control points laying in straight line were used in the geometric correction figure (7)

Figure 7 : Six Control Points in Straight Line and Check Point

6.1.1.4 Six Distributed Control Points

Six control points were distributed also used to evaluate the geometric correction. Figure (8) represent the distribution of control points.

Figure 8 : Six Distributed Control Points

6.1.1.5 Ten Distributed Control Points

Ten control points were used in order to examine the effect of number of control points in the geometric correction .figure (9) represents the distribution of control points.

Figure 9 : Ten Distribution Control Points and Check Point

III. RESULTS AND DISCUSSION

The main objective of this study is directed towards examination of the effect of the distribution and densification of control points in the geometric correction .This section will present the result of the geometric correction using three, six and ten control points, and also examine test in term of root mean square (RMS) and linear errors.

A. Linear Errors

The differences between actual ground coordinates of the check points (from GPS) and their measured coordinates (from corrected aerial photograph) were computed. The linear errors for any points were computed using the following equation :

$$\text{Linear error} = \sqrt{\Delta E^2 + \Delta N^2} \qquad (1)$$

Where,

ΔE= measured coordinate –actual grand coordinate
ΔN=measured coordinate –actual grand coordinate

Tables (3) below illustrates the results of the geometric correction when three distributed control points were used, the resultant image represented in figure (10) below

Table (3) Difference in E and N Coordinates, and Linear Error Correction Using Three Control Points

Pt No	Name	E(m)	N(m)	ΔE	ΔN	Linear Error
5	Center	447926.24	1738048.61	35.264	-46	57.96162261
10	N.ECorner	448258.61	1737285.45	31.367	-36.635	48.22874572
11	South10	448126.17	1736940.95	43.993	-43.74	62.03685718
15	S.W corner	449022.32	1738647.26	-11.248	-145.09	145.5253435

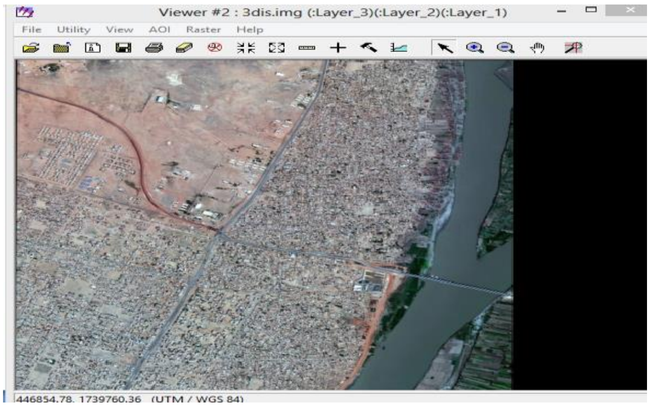

Figure 11 : Result of Geometric Correction Using Distributed Three Control Points

Table (4) below illustrates the results of the geometric correction using three clustered control points, and figure (12) below shows the resultant image Table(4) Difference in E and N Coordinate, and Linear Error Using Three Clustered GCPso

Pt No	name	E(m)	N(m)	ΔE	ΔN	Linear error
5	Center	447962.18	1738001.37	-0.676	1.24	1.412294587
10	N.E.Corner	448290.86	1737247.39	0.883	1.425	1.676399117
11	South10	448167.00	1736895.36	3.63	1.85	4.074236123
15	DocanS. Wcorner	449011.70	1738649.76	-0.628	1.333	1.473524007

Figure 12 : Result of Geometric Correction With Three Clustered Control Points

Table (5) below illustrates the results of the geometric correction using six distributed controls points and figure (13) represents the resultant image

Table (5) Difference in E and N Coordinate, and Linear Error Using Six Distributed GCPs

Pt No	Name	E(m)	N(m)	ΔE	ΔN	Linear Error
5	Center	447961.07	1738002.41	0.434	0.2	0.47786609
10	N.ECorner	448290.99	1737241.85	-1.013	6.965	7.038280614
11	South10	448166.96	1736884.67	3.203	12.54	12.94259669
15	S.Wcorner	449011.54	1738654.52	-0.468	-3.427	3.458808032

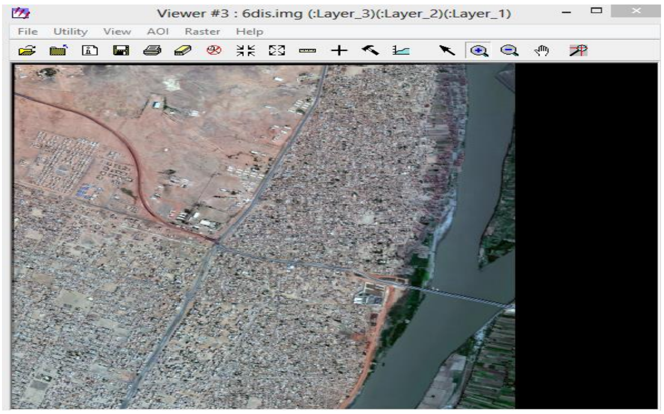

Figure 13 : Resultant Image of Geometric Correction Using Six Distributed Control Points

Tables (6) below illustrates the results of the ten distributed control points for geometric correction and Figure(14) Result of Geometric Correction With Ten Distributed Control Points

Table (6) Difference in E and N Coordinate, and Linear Error Using Ten Distributed GCPs

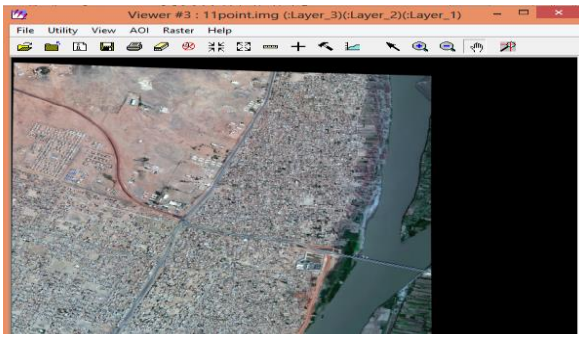

Figure 10 : Resultant image Using Ten Distributed Control Points

B. Accuracy Evaluation

Root mean square errors for Easting and Northing coordinates were calculated for each order in the two tests. The equations used to calculate root mean square error are as follows:

$$\text{Root mean square error in } \Delta E = \sqrt{\frac{\sum \Delta E^2}{n}} \quad (4)$$

$$\text{Root mean square error in } \Delta N = \sqrt{\frac{\sum \Delta N^2}{n}} \quad (5)$$

Where,

ΔE ≡ different between measured coordinate and actual grand coordinate in easting.

ΔN ≡ different between measured coordinate and actual grand coordinate in northing.

n ≡ number of points.

To evaluate the accuracy of each test carried out, the root mean square errors were computed for the three order of the polynomial equation as shown in table (7) and table (7) below.

Table(7) R.M.S in Easting &Northing for Four Images

Name	R.M.S.E in ΔE	R.M.S.E in ΔN
3clustered GCPs	4289.339938	26422.41893
3 distributed GCPs	14.807949	8.767614
6 distributed GCPs	11.6927.58	217.547154
10 distributed GCPs	7.666778	337.387414

Finally, the linear errors for the three order of polynomial equation were computed for the two satellite images as shown in table (8). The liner errors can be calculated using equation (7) below

Pt No	Name	E(m)	N(m)	ΔE	ΔN	Linear Error
5	Center	447961.07	1738002.41	0.434	0.2	0.47786609
10	N.ECorner	448290.99	1737241.85	-1.013	6.965	7.038280614
11	South 10	448166.96	1736884.67	3.203	12.54	12.94259669
15	S.Wcorner	449011.54	1738654.52	-0.468	-3.427	3.458808032

$$\text{Linear error} = \sqrt{\text{R.M.S.E in } \Delta E^2 + \text{R.M.S.E in } \Delta N^2}$$

Table (8) Linear Error for the Three Images

Images	Linear Error
3clustered GCPs	175.2477072
3 distributed GCPs	5.164983253
6 distributed GCPs	5.722635657
10 distributed GCPs	5.600764493

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