LARGE SCALE MAPPING (1:5000 VECTOR AND RASTER) USING HIGH RESOLUTION SATELLITE IMAGE

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الملخص

صور الأقمار الصناعية عالية الدقة مرئيات الكويك بيرد توفر الكثير من الإمكانيات لعملية التخريط، وكذلكٍ في تطبيقات نظم المعلومات الجغرافية. صور الأقمار الصناعية عالية الدقة يجب معالجتها هندسيا باستعمال نقاط الضبط الأرضي لإنتاج خرائط دقيقة.

تم في هذه الدراسة اختيار الجزء الشمالي الغربي من ليبيا (في منطقة طرابلس) كمنطقة الدراسةٍ التي تمتاز بتضاريس مسطحة. منطقة الدراسة تم تغطيتها بصورة كويك بيرد مصححه عموديا دقة تميزها المكانية 60 سم وأيضا بخريطة طبوغرافية ذات مقياس رسم كبير منتجة من صور جوية ستيريو استخدمت كبيانات مرجعية حيث تم استخلاص نقاط الضبط الأرضي ونقاط التحقق منها. وتم التصحيح الهندسي للصورة باستخدامٍ طريقةٍ النموذج الرياضي متعدد الحدود من الدرجة الثانية. رقمنة الصورة المصححة تمت يدويا وبصرياً باستخدام الحاسب الآلي عن طريقٍ برنامج (Arc GIS). نتيجة مقدار متوسط الأخطاء التربيعية لنقاط التحقق تم تقييمها وفقا للمعايير الوطنية لدقة البيانات المكانية (NSSDA).

ABSTRACT

High resolution satellite images (HRSI) such as QuickBird supply a lot of opportunities in mapping, GIS and many other applications. HRSI have to be geometrically and precisely processed with GCPs to generate accurate map production.

In this study, the North-West part of LIBYA (in Tripoli Region) test field which has a flat topography is chosen as a test area. The test study area was covered with orthorectified QuickBird image 60 cm spatial resolution, large scale topography map produced from stereo aerial photo have been used as a reference data, ground control points (GCPs) and check points (CPs) were extracted. Geometric correction of the image is done based on mathematic model (2D-polynomial) approach. Vectorization of the rectified image was done manually and visually by the computer on the screen using Arc GIS software package. The NSSDA on the check points (CPs) is evaluated.

KEYWORDS: Satellite Images; High resolution; Orthorectified; Check Points; Control Points; Geometric correction; GIS

INTRODUCTION

Today earth observation satellites can monitor almost every corner of our planet; the collection of information for each location, especially if is difficult or impossible to reach, has been intensively carried out in recent years using satellite data, which in turn increasing our global knowledge of our planet. With satellite data it is possible to collect information of medium scale that cover many areas for which no maps were available before, or it has been possible to intensively update available mapped and un-mapped information over many areas. In recent years, since high resolution satellites have become operational available, the information that can be collected from space borne images has dramatically increased, since the improved geometrical resolution has enabled map developers the detection of natural and man-made features that were simply impossible to distinguish in the past with medium resolution satellite data.

Therefore it is now possible to produce accurate representations of a specific location of the earth using PC in very short time. Around our planet, several earth observation satellites are in operational 24hrs a day. These satellites observe the earth on several spectral bands, and with different geometrical resolution. As high resolution satellites can be marked those satellites that can collect information with a geometrical resolution equal or better than 2.5 meters. At the moment, data from the following high resolution satellites are available on a commercial basis:

- SPOT5 (panchromatic mode, 2.5 meters)
- EROS (panchromatic mode, 1.8 meters)
- IKONOS (panchromatic mode, 1 meter; multispectral mode 4 meters)
- QuickBird (panchromatic mode, from 0.61 meters; multispectral mode from 2.44 meters)

GeoEye-1 (panchromatic mode, from 0.41 meters; multispectral mode from 2 meters).
Still in a rollout phase there is also the Orbview satellite, with 1 meter resolution in panchromatic mode and 4 meters in multispectral mode. The choice of using data from one satellite instead of another depends on several factors. As a rule of thumb, it can be said that SPOT5 should be preferred when very large areas must be mapped with medium detail level, while Ikonos, QuickBird and GeoEye-1 are the right choice when more detailed information must be collected. Focusing on the extraction of information on a large scale, QuickBird offers the most powerful solution, since it combines the best geometrical performance (from 0.61 to 0.66 meters resolution for the standard collection angles in the range 0°-15°) with the largest image size (more the twice the size of an Ikonos frame). The difference between one meter and 60 centimeters is often critical when detailed info must be collected. Therefore QuickBird and GeoEye-1 can be considered a key instrument for high scale mapping from space. In this study it is used QuickBird data for flat terrain area to produce large scale maps after processing.

OBJECTIVE OF THE STUDY

This paper helps to study the ability of producing digital (raster& vector) large scale (1:5000) planimetric maps for a flat terrain area, through the using of high resolution satellite image (QuickBird satellite image with 60 cm spatial resolution) with acceptable accuracy.

STUDY AREA AND DATA SET

Study Area

The study area chosen in this investigation located at North-West part of Libya (in Tripoli Region), the total area is 15 km^2 considered to be flat terrain area, and bounded by the coordinate of:

point	E	N
Lower Left corner	219205.660	3633792.740
Upper Right corner	223405.060	3637277.540

Data Set
Satellite Image

For this study, panchromatic QuickBird image with 60 cm spatial resolution and multispectral with 2.44m resolution were used. The image was provided as orthorectified image as shown on Figure (1). Its radio metrically calibrated for sensor and platform – induced distortions, and map to a project system .This image was projected a Universal Transverse Mercator (UTM), zone 33N on the WGS84 ellipsoid.

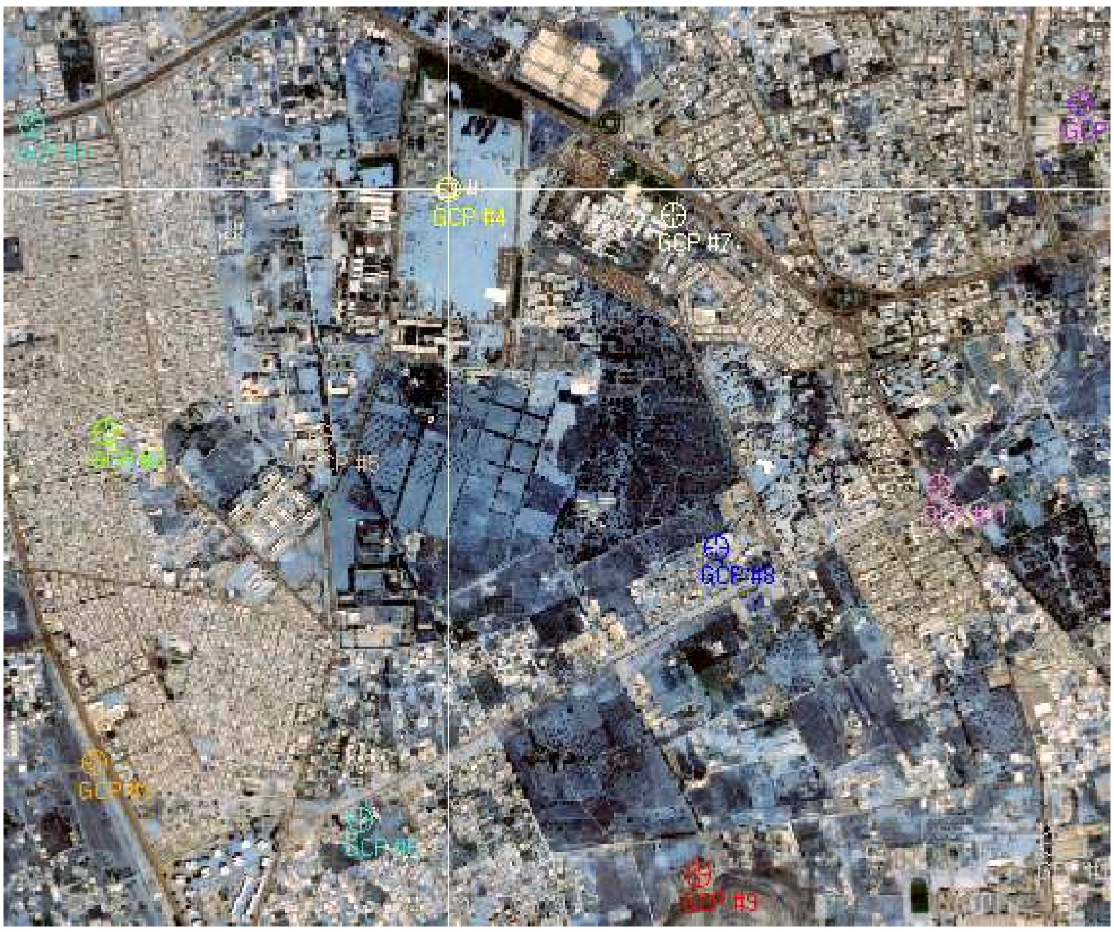

Figure 1: The study area.

Ground Control Points and Check Points

Geometric distortion introduced by sensor system attitude and altitude change can be corrected using GCPs and appropriate mathematical models [1]. A large number of ground control points (GCPs) and check points (CPs) were commonly chosen at sharp features and can be easily identified on the image, and on the reference map, distributed uniformly on the study area .The coordinates (x, y) of their points were measured based on Libyan Transverse Mercator (LTM2°) projection system. The total number of (GCPs) and (CPs) are 32 points which collected from large scale topographic map scale 1:1000 produced from stereo aerial photo.

METHODOLOGY

The methodology followed in this study involves three steps:

- Geometric correction of the image.
- Enhancement of the rectified image.
- Vectorization of the corrected image.

Geometric Correction

The 12 GCPs selected were input to the least-squares regression procedure to indentify:

- The coefficients of the coordinate transformation.
- The individual and total RMS error associated with the GCPs [2].

By using the ERDAS Imagine software package, third order polynomial transformation used, the total RMS error was computed as shown in Figure (2).

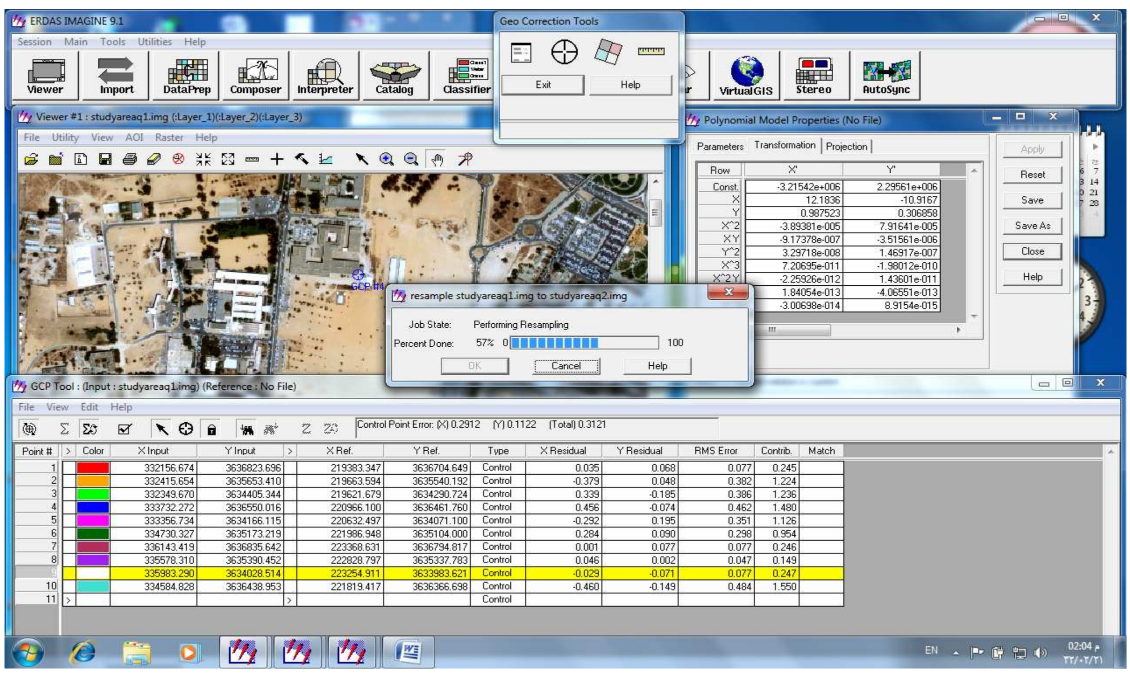

Figure 2: (Source: ERDAS Imagine Software Version 9.1 Print Screen)

The common strategy is to select many candidate GCP pixels distributed across the image, determine the map coordinates of these points, develop the rectification model based on all candidates GCP, and then reject those GCPs that contribute high model residual error. The process of adding candidate GCP pixels and rejecting GCPs with high model residual error is continued until an acceptable average model error (e. g., 1 pixel) is obtained and minimum numbers of GCPs are retained [3].
The (10) GCPs finally selected that produced an acceptable total RMS error (0.312 m) as shown in Table (1).

Table 1: 10 GCPs finally selected that produced an acceptable total RMS $_{error}$

Point #	Point ID	Easting input (UTM)	Northing inpt (UTM)	Easting ref. (LTM)	Northing ref.(LTM)	X Residual (m)	Y Residual (m)	RMS error (m)
1	GCP 1	332156.674	3636823.696	219383.347	3636704.649	0.035	0.068	0.077
2	GCP 2	332415.654	3635653.41	219663.594	3635540.192	-0.379	0.048	0.382
3	GCP 3	332349.67	3634405.344	219621.679	3634290.724	0.339	-0.185	0.386
4	GCP 4	333732.272	3636550.016	220966.1	3636461.76	0.456	-0.074	0.462
5	GCP 5	333237.844	3635623.897	220486.866	3635526.659	Deleted	Deleted	Deleted
6	GCP 6	333356.734	3634166.115	220632.497	3634071.1	-0.292	0.195	0.351
7	GCP 7	334585.445	3636438.725	221819.417	3636366.698	-0.46	-0.149	0.484
8	GCP 8	334730.327	3635173.219	221986.948	3635104.292	0.284	0.09	0.298
9	GCP 9	334636.289	3633879.921	221912.898	3633862.808	Deleted	Deleted	Deleted
10	GCP 10	336143.419	3636835.642	223368.631	3636794.817	0.001	0.077	0.077
11	GCP 11	335578.31	3635390.452	222828.797	3635337.783	0.046	0.002	0.047
12	GCP 12	335983.29	3634028.514	223254.911	3633983.621	-0.029	-0.071	0.077
					Control Point Error :(X) 0.2912, (Y) 0.1122 (Total RMS error) 0.3121			

Enhancement

Image enhancement techniques improve the quality of an image. These are a wide variety of techniques for improving image quality. The contrast stretch, density slicing, edge enhancement, and spatial filtering are more commonly used techniques [4].

Vectorization

This is the final stage after geometric correction process of satellite image. ArcGIS software package has been used for the production of the desired planimetric vector maps as shown on Figure (3).

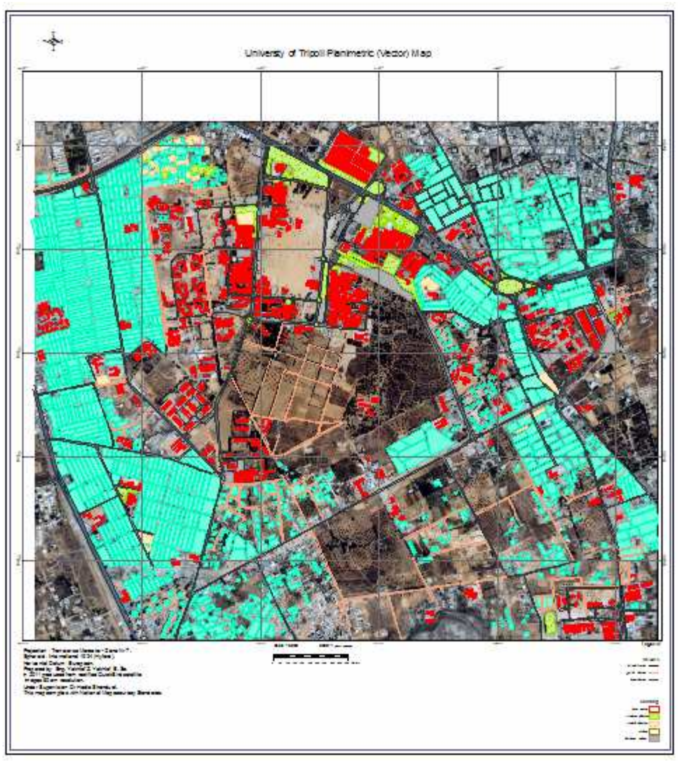

Figure3: Vectorization of the rectified image

Vectorization of the corrected image was done visually and manually on the computer screen [5]. Various layers have been created and stored on many layers (buildings, parking areas, green areas, and roads layers). Each layer was presented as a points or line or a polygon depends of feature type as shown on Figure (4), Figure (5).

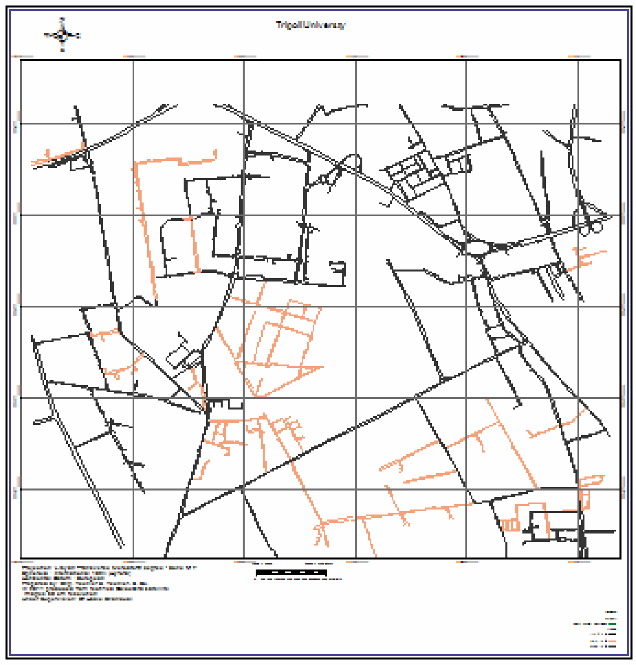

Figure 4: Roads layer. (Source: Arc Map Software Version 9.3 Print Screen)

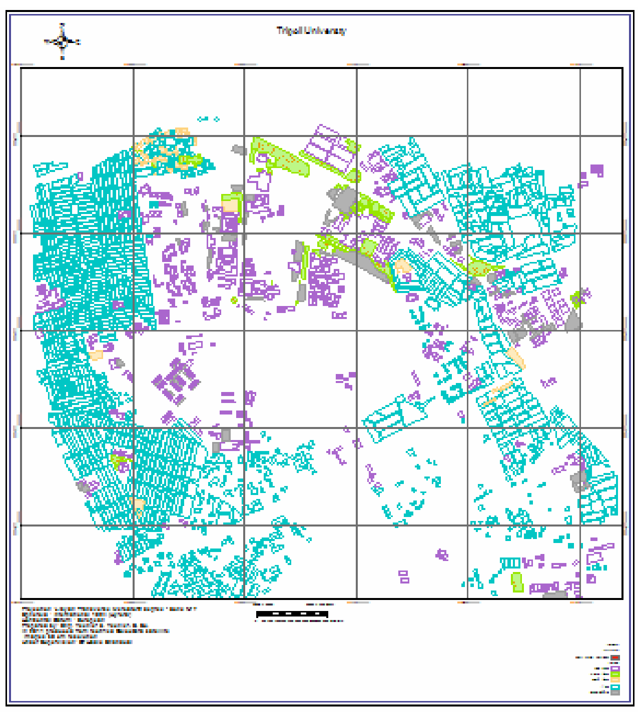

Figure 5: Buildings, parking, and green area layer. (Source: Arc Map Software Version 9.3 Print Screen)

ANALYSIS AND DISCUSSION OF RESULTS

For checking the planimetric accuracy of the produced map, the coordinates of check points were extracted from reference map, produced map, and tabulated in Table (2).

Table 2: Horizontal accuracy statistic worksheet

Point number	Point description	x (independent)	x (test)	diff in x	$(\text{diff in x})^2$	y (independent)	y (test)	diff in y	$(\text{diff in y})^2$	$(\text{diff in x})^2 + (\text{diff in y})^2$
1	CP1	220239.149	220239.72	-0.571	0.326041	3635951.95	3635951.17	0.778	0.605284	0.931325
2	CP2	219909.997	219909.876	0.121	0.014641	3634654.83	3634654.378	0.453	0.205209	0.21985
3	CP3	221457.631	221456.929	0.702	0.492804	3635773.55	3635774.051	-0.506	0.256036	0.74884
4	CP4	221432.609	221431.243	1.366	1.865956	3634714.97	3634715.738	-0.768	0.589824	2.45578
5	CP5	222738.608	222739.152	-0.544	0.295936	3635646.03	3635645.502	0.53	0.2809	0.576836
6	CP6	222510.33	222511.547	-1.217	1.481089	3634435.82	3634435.636	0.18	0.0324	1.513489
7	CP7	219363.089	219363.582	-0.493	0.243049	3635915.23	3635915.531	-0.302	0.091204	0.334253
8	CP8	220780.351	220779.483	0.868	0.753424	3636090.52	3636089.124	1.395	1.946025	2.699449
9	CP9	221833.298	221832.259	1.039	1.079521	3635954.81	3635954.54	0.27	0.0729	1.152421
10	CP10	223051.014	223053.579	-2.565	6.579225	3635735.43	3635735.078	0.348	0.121104	6.700329
11	CP11	220221.29	220221.445	-0.155	0.024025	3635175.43	3635175.597	-0.167	0.027889	0.051914
12	CP12	221505.074	221505.381	-0.307	0.094249	3635254.53	3635253.04	1.491	2.223081	2.31733
13	CP13	222732.068	222732.378	-0.31	0.0961	3635586.72	3635585.334	1.386	1.920996	2.017096001
14	CP14	220751.05	220751.172	-0.122	0.014884	3634813.48	3634813.16	0.324	0.104976	0.11986
15	CP15	220618.605	220616.687	1.918	3.678724	3634735.94	3634736.037	-0.098	0.009604	3.688328
16	CP16	223238.555	223242.036	-3.481	12.117361	3634519.02	3634518.32	0.697	0.485809	12.60317
17	CP17	222096.631	222094.906	1.725	2.975625	3636441.8	3636441.22	0.576	0.331776	3.307401
18	CP18	220088.849	220089.143	-0.294	0.086436	3636657.49	3636657.49	0	0	0.086436
19	CP19	220327.371	220328.689	-1.318	1.737124	3634242.73	3634244.064	-1.335	1.782225	3.519349
20	CP20	221362.659	221360.013	2.646	7.001316	3636576.7	3636578.021	-1.323	1.750329	8.751645001
									sum	53.795101
									average	2.68975505
									RMSE	1.640047271
									NSSDA	2.838593816

Sum = $\sum [(\text{diff in x})^2 + (\text{diff in y})^2]$

average = sum / number of points

RMSE = Root Mean Square Error = average $^{1/2}$

NSSDA = National Standard for Spatial Data Accuracy statistic = 1.7308 * RMSE

The horizontal root mean square value is the sum error squared in both the x and y directions divided by the number of control points. The RMSE calculated value was 1.64004m. This root mean square value multiplied by 1.7308 (NSSDA) gives a 2.838m horizontal accuracy at the 95 percent confidence level, and it is less than 4.572m which meets maps specification needed in producing scale of 1:5000, according to the National Standard for Spatial Data Accuracy (NSSDA).

CONCLUSIONS

From the present study it can be concluded that using orthorectified QuickBird images, using third order polynomial function, and ground control points extracted from topographic maps scale 1:1000 measurements as a reference are only valid for a geographic region with similar properties (flat terrain area), planimetric maps 1:5000 scale can be generated .

RECOMMENDATIONS

This study recommends recalculating the results using hilly terrain study area with different mathematical models, and DTM.

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