Bulgarian Academy of Sciences. Space Research Institute.
Aerospace Research in Bulgaria. 18. 2003. Sofia

ANALYSIS OF THE PRECISION OF GEORECTIFICATION OF SATELLITE IMAGERY USING DISTRIBUTORY DATA VS. GROUND-BASED GPS MEASUREMENTS

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Abstract

The present work makes a comparative analysis of the precision of geometric rectification (georectification) of satellite imagery using in parallel distributor data - coordinates of the central and corner pixels and high precision ground-based GPS measurements.

This work is further step in the research of rectification problems that has been made so far on satellite imagery by defining ground control points of (GCP) with GPS measurements [2, 3, 4, 7].

1. Introduction and purpose of the research

Satellite data occupy an important place in various spheres of theory, practice, and military activities. The modern state of satellite imagery provides real possibility for large-scale mapping, upgrading of available maps, monitoring of the earth cover and other practical and research objectives where it is necessary to determine with high precision the mutual location among different discrete points or contours in a given region [1,2,3,4,5,6,7].

To accomplish these objectives it is necessary to perform coordinate rectification of the images of the identified ground control points (GCP) on satellite imagery using GPS measurements. The distributor of the American-Israeli Group IAI/Core of the "EROS" satellite shares the same opinion. At the conference organized by the Ministry of Defense in October 2001, when discussing these issues he confirmed that defining the coordinates of the GP using GPS measurements improves precision 3 to 4 times which in reality corresponds to the resolution of the space imagery.

Various companies and corporations provide program support for solving this problem. Here, it is of crucial importance to know the geometric characteristics of the different types of space imagery (scenes). Users have to bear in mind these facts when choosing program packages for processing different types of scenes.

These issues are addressed in greater detail in [2,5,6,7], and on the basis of the performed research and analysis the following conclusion has been reached: many users know that the bigger part of the available program products for imagery processing are not able to handle geometric configurations.

Most often the worked out and classified satellite imagery is not a final product. Raster aero and satellite imagery must be combined with other information sources, either spatial (topographic and soil maps, vegetation, roads, numeric models of the relief and others) or non-spatial (temperature, moisture of air and soil) information or database. In a number of applications, the numeric analysis of satellite raster imagery is accomplished using supplementing information taken from the vector data, on which GIS are based.

Aero and satellite imagery play an important role in monitoring the changes of the land cover as a result of human activities or biophysical processes. In this case, the time analysis requires using imageries received from different sources at different periods of time.

From the above stated it can be concluded that a combination of different imagery and maps from different sources and periods of time requires precise geometric rectification and this is a process that has to be performed prior to integrating data for mutual processing.

The present work makes a comparative analysis of the precision of geometric rectification (georectification) of satellite imagery using in parallel distributor data – coordinates of the central and corner pixels and high precision ground-based GPS measurements.

This work is further step in the research of rectification problems that has been made so far on satellite imagery by defining ground control points of (GCP) with GPS measurements [2, 3, 4, 7].

2. Selection of analysis area and data

The area where the measurements were conducted lies in the north-east of Plovdiv; it is presented on map list **К-9-47-Б** (RAKOVSKI), scale **1:50 000,** 3d edition, 1993, covering territory **20 x 20 км**. I was chosen because the satellite picture was analyzed as a scene from **SPOT 2** with the following parameters given by the distributor – **SPOT-IMAGE**, Toulouse, 22/03/1994. The GCP coordinates were measured by a differential GPS, supplied by section "Laboratory for Communication and Navigation Instrumentation". The equipment precision, using basic transmitter ad accumulation time of 10 min for every measurement is (0.5±0.2) m. This precision was completely sufficient for our purposes having in mind:

- The resolution of scanner HVR 2 in the spectral channels – pixel 20 x 20 m
- The scale of the used map list – 1:50 000

3. Methodology

3.1. Coordinate rectification of satellite imagery using distributor data

The georectification of the above-presented SPOT scene was made using the program product ENVI, version 3.5, from October 2001. Three different rectification methods: RST, Polynomial and Triangular were applied. The standard parameters from the rectification of these points are presented on Table 1. The comparison of the results from the three methods did not reveal any deviation in the coordinates of the chosen control points (Fig. 1).

Table 1. Rectification of the analyzed scene by distributor data

	Map X	Map Y	Image X	Image Y	Predict X	Predict Y	Error X	Error Y	RMS
#1	326984	4676608	1577.50	1502.50	1577.4466	1501.8068	-0.0534	-0.6931	0.6852
#2	306436	4712489	155.50	1.50	155.5141	1.6828	0.0141	0.1828	0.1834
#3	364902	4698272	3163.50	1.50	3163.5126	1.6640	0.0126	0.1640	0.1645
#4	289259	4654854	1.50	3003.50	1.5127	3003.6650	0.0127	0.1650	0.1655
#5	347727	4640642	3010.00	3004.00	3010.0140	3004.1814	0.0140	0.1814	0.1819

Fig 1. Fragment from satellite imagery after rectification using three different methods - RST, Polynomial and Triangular.

3.2. Coordinate rectification of satellite imagery using ground-based GPS measurements

Having in mind the similar results obtained when applying each of the geometric correction methods, the polynomial method was selected for rectification. Five of a total of ten measured GCPs were used (Fig. 2).

Fig. 2. Selection of GPS measured GP

On Table 2, the standard parameters from the rectification of the measured ground control points are presented.

Table 2. Rectification on the analyzed scene based on GCPs from GPS measurement

	Map X	Map Y	Image X	Image Y	Predict X	Predict Y	Error X	Error Y	RMS
#1	319550	4676716	1218.00	1580.89	1217.0451	1580.7490	-0.9549	-0.1410	0.9652
#2	318651	4674863	1195.89	1691.56	1195.9719	1681.5721	0.0819	0.0121	0.0828
#3	334736	4676472	1955.75	1416.50	1955.6258	1416.4817	-0.1242	-0.0183	0.1255
#4	321852	4673171	1370.25	1725.00	1370.6529	1725.0595	0.4029	0.0595	0.4073
#5	321287	4679324	1269.57	1434.57	1270.1642	1434.6577	0.5942	0.0877	0.6007

3.3. Results assessment

To control the obtained results, a digitalized map list with scale 1:50000 was used. The digitalizing of the map list was done on scanner A4. Before mosaicing of the four images, geometric correction of the knots of the coordinate net was performed. This was done to avoid paper deformations or deformations that might appear during the scanning process.

The raster imagery of the digitalized map was mosaiced to the coordinates of the measured GCPs in the geographic projection of the rectified satellite image.

- The coincidence of the GCPs of the two imageries was controlled. The difference in the positions of the GCPs from the two imageries was less than 2 pixels.
- The coincidence of the selected triangulatory points from the map with the respective satellite images was analyzed. The results are graphically presented below.

3.3.1. Deviation of the GCP vs. their real coordinates on the rectified satellite imagery by distributor data (geographical projection: UTM, WGS-84, Zone 35, Pixel 10 m)

Table 3. GCP measurement and deviation from the real situation following rectification by distributor data.

GCP	Географска ширина	Географска дължина	Грешка в поз. , m
The bridge after Shishmanci	42.2229515N	24.9975207E	90
Manolsko konare	42.2121323N	24.9510037E	110
Trangular point «Bokludga»	42.2495707N	24.9559323E	120
Dink	42.3194826N	24.7993665E	95
Skutare	42.1904148N	24.8425216E	100
Rakovski	42.2990631N	24.9735579E	105
Voevodino	42.2049088N	24.8032604E	95
Trangular point «Domuztepe»	42.2785440N	24.8751930E	120
The bridge after Kalekovetc	42.2456617N	24.8337894E	115
Kalekovetc (173.7/52г.)	42.2217887N	24.8137240E	110

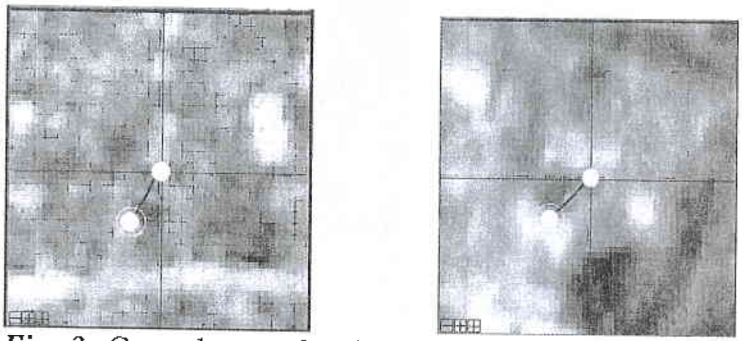
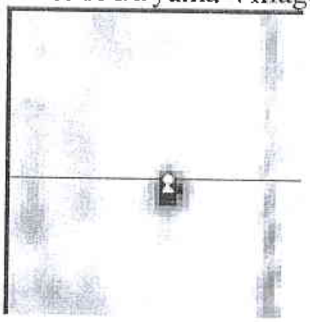


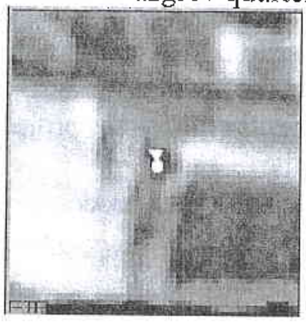
Fig. 3. Ground control points: Skutare village and Kalekovetc village (level 173.7 / 2yrs.), accordingly. The circles identify the points with coordinates equal to the coordinates of the GCPs. The beginning of the coordinate system points to the real location of these points on the imagery following rectification by distributor data.

3.3.2. The deviation of the GCPs location defined using GPS vs. their real location on the rectified satellite imagery is less than 1 pixel (Fig. 4, a, b, c, d). The imagery is in projection: UTM, WGS-84, Zone 35, Pixel 10 m.

a) GCP "Pereseto", 176.0
West of Stryama Village



b) TT "Mezartepe"
North of Izgrev quarter



c) TT "Ploska Mogila"
East of Gen. Nikolaevo Village

d) TT 154.0
East of Sadovo village

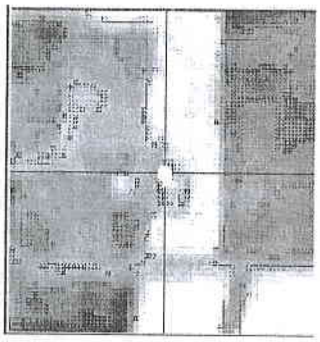


Fig. 4. Rectification of satellite imagery by 5 GCP, GPS measured on the ground. The circle (0) marks the location of the selected triangulatory point on GPS measurement and the triangle (Δ) marks the location of the triangulatory point on the ground.

4. Conclusion

We would like to mention here that due the fact that satellite imagery with resolution of 1 m (from the type "IKONOS", "EROS - A and B" "Quick Bird") was not available, we were forced to experiment with scene from SPOT -2.
In spite of this the results of the GPS measured GCPs feature 4 times higher precision compared with the results submitted by the distributor.

Apart from these requirements, in our opinion, it is necessary to take into consideration the following:

- The changes in the scale coefficient and the relief in the various directions of the scene when rectifying the imagery;
- Using the earth (referent) ellipsoid as projection plane;
- The ellipsoid's heights;
- Applying strict methods for data processing and of result assessment.

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АНАЛИЗ НА ТОЧНОСТТА НА ГЕОМЕТРИЧНОТО ПРИВЪРЗВАНЕ НА КОСМИЧЕСКИТЕ ИЗОБРАЖЕНИЯ ПО ДАННИ ОТ ДОСТАВЧИКА СПРЯМО GPS ИЗМЕРВАНИЯ

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Резюме

Сегашното състояние на космическите изображения дава реална възможност за едромащабно картографиране, обновление на съществуващи карти, мониторинг на земното покритие и други практически и изследователски цели, при които е необходимо да се постигат високи точности при определяне взаимното разположение между отделни дискретни точки или контури в определен регион[1,2,3,4,5,6,7].

Целта на настоящата работа бе да сравни точността на геометричното привързване (геоupdatedректификацията) на сателитните изображения с използваните, от една страна на данни от дист-рибутора, а от друга, на високоточни GPS измервания върху терена.

Независимо от това, че бяхме принудени експериментите да проведем със сцена от SPOT — 2, получените резултати, след като се извършиха GPS измервания на идентифицираните ОТ от терена, са с 3 - 4 пъти по-големи точност, в сравнение с предоставените резултати от доставчика.