

ORTHORECTIFICATION AND ASSESSMENT OF QUICKBIRD IMAGERY USING D-GPS MEASUREMENTS OVER PAROS URBAN AREA

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ABSTRACT:

The present paper focus on the rectification of QuickBird imagery (Standard PSM True Color image) in order to update the urban planning of Parikia (Paros island, Greece). Although the spatial resolution is sufficient for such application and the radiometric information is often better than the case of existing aerial photos, an accurate geometrical calibration is needed. The methods applied in this study are a linear polynomial correction using 3D GCPs, a RPC correction without refinement and RPC correction with linear refinement using 3D GCPs. The ground control points (GCPs) were collected by means of GPS differential observations (D-GPS). Investigation of the results was performed by examining the RMS error of three additional GPS points for each of the above methods.

1. INTRODUCTION

In the frame of urban development planning and monitoring of building shell expansion the use of very high spatial resolution satellite imagery is shown to be of great advantage due to the limited ground resolution of existing aerial photographs and the absence of up-to-date catalogues.

QuickBird, launched on 18 October 2001, is the highest resolution commercial earth observation satellite now operating producing imagery from 60 cm of resolution. Due to its high resolution has quickly become the best choice for large scale mapping using high-resolution satellite images. The satellite collects multi-spectral and panchromatic imagery and pansharpned data are produced in natural or false colors.

As any other satellite image geometric distortions are presented in the QuickBird basic images related to distortions caused by platform and its elliptic movement around the Earth, distortions due to the imaging sensor (parameters like focal length and the instantaneous field of view, the panoramic view and the oblique viewing system in some cases), distortions due to the Earth (earth rotation, curvature and topographic relief). An additional deformation could be arise during the georeferencing processing. The geometric corrections for the very high resolution satellite images require high accuracy in-door work and precise collection of ancillary data. during field work.

Several published papers confirm quite good results using different methods and techniques for geometric correction and georeferencing of very high resolution images (Zhou, G. and R. Li, 2000, Cheng et al, 2001, Grodecki, J., and G. Dial, 2001, Toutin et al, 2002, Toutin and Cheng, 2002, Cheng et al, 2003, Vassilopoulou 2003, Grodecki J. and Dial G., 2003, Toutin, 2003, Volpe and Rossi, 2003).

The present paper concerns the assessment of different orthorectifying techniques in order to improve the accuracy of an already georeferenced QuickBird standard product image. The

image covers Parikia, the main urban center of Paros island (Cyclades).

2. GEOGRAPHICAL SETTINGS – DATA USED

Paros island belongs to Cyclades island complex located in the southern part of the Aegean sea. Parikia is the biggest and most populated urban center over the island (Figure 1). Parikia hosts the main harbor of the island, used by a high number of tourists mainly during the summer period.



Figure 1 Location of study area (ENVISAT-MERIS image, Source: ESA).

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The area covered by the image presents low relief in the build up zone and in the surroundings as well, with a maximum elevation of 100 meters. The coast is characterized by sand and rock beaches and harbor infrastructures. The latter provided us the capability to collect a high number of accurate GCP's.

The QuickBird imaging system simultaneously collects 67-72cm resolution stereo panchromatic and 2.44-2.88m multi-spectral images. Using different processing levels, DigitalGlobe provides three types of QuickBird products for the same scene including basic, standard, and orthorectified image products. A Standard Sharpened True Color type QuickBird image dated 29 July 2003, 7° off-nadir acquisition covering around 71km², was used. Standard imagery are radiometrically calibrated, corrected for systematic sensor and platform-induced distortions as well as resampled into a cartographic projection (UTM, WGS'84). Standard imagery together with the supplied attitude, ephemeris, and camera model information (RPCs), allows improvements of the orthorectification process. Their positional accuracy is about 23m (Circular Error with 90% level of confidence), excluding any topographic displacement. In areas of low relief an absolute spatial accuracy of up to 14m RMSEr may be achieved (Eurimage 2004).

3. METHODOLOGY AND PROCESSING

Two main categories of rectification methods are usually used for the geometric correction of high-resolution satellite imagery, parametric and non-parametric methods.

Parametric approaches are based on complex mathematical models that use viewing geometry of the sensor, while non-parametric approaches built a correlation between pixels in the image and its ground locations, based on two cubic polynomials. The coefficients of the polynomials accompanied the image (RPCs), are generated by the image provider (DigitalGlobe Inc.), based on the position of the satellite at the time of image capture.

For the purpose of the present paper non-parametric methods were applied for the rectification of the acquired Standard type imagery, i) Simple linear polynomial correction using 3D GCPs, ii) RPC correction without refinement, iii) RPC correction with linear refinement using 3D GCPs.



Figure 2 Distribution of the collected GCPs (yellow) and check points (red) during field campaign.

The image rectified using RPCs has georeference information obtained from the image provider, however small errors in the satellite parameters can translate into large errors in the image georeferencing. The use of additional 3D GCPs for the refinement of the model allows a more accurate georeferencing. Such a process will ensure that accurate geographic extents are computed for the image.

The collection of GCPs was made by means of GPS differential measurements (D-GPS) through field campaign carried out using geodetic receivers of WILD type (SR299 & SR399). A total number of 15 GCPs, well distributed within the building shell as well as the perimetric region, were measured (Figure 2). A coordinate accuracy of 0,2-0,4 cm in the horizontal and 0,6-0,8 cm in the vertical was obtained.

Twelve of the collected GCPs were applied for the rectification process, while the remaining three were used as a reference coordinates (check points) for the evaluation of the produced results.

4. EVALUATION AND DISCUSSION

The evaluation of the georeferenced images produced by the fore mentioned methodologies was made by calculating the RMS error, based on three reference GPS check points, the coordinates of which are known with high accuracy. The coordinates of the corresponding pixels in the georeferenced images represent the input coordinates. The RMS error is expressed as distance (m) in the source coordinate system. The calculated RMS for its method are summarized in the following tables (Tables 1, 2 & 3).

	XR _i	YR _i	R _i	R _x	R _y	T
1	0,447	-0,073	0,453	0,500	0,626	0,801
2	0,559	-0,959	1,110			
3	-0,485	-0,501	0,698			

Table 1 Calculated RMS error for the simple linear polynomial method using 3D GCPs. Where i: number of GCP, XR_i & YR_i: the X & Y residual for GCP_i, R_i: the RMS error for GCP_i, R_x & R_y: the X & Y RMS error and T: the total RMS error.

	XR _i	YR _i	R _i	R _x	R _y	T
1	1,528	-6,313	6,496	1,411	6,222	6,380
2	1,906	-7,099	7,351			
3	0,015	-5,089	5,089			

Figure 2 Calculated RMS error for the RPC model without refinement.

	XR _i	YR _i	R _i	R _x	R _y	T
1	0,454	0,382	0,593	0,503	0,764	0,915
2	0,634	-1,101	1,270			
3	-0,390	-0,628	0,739			

Figure 3 Calculated RMS error for the RPC model with linear refinement by 3D GCPs.

The lower accuracy (RMSEr = 6,380m) was obtained by following the RPC model without any refinement made. The incorporation in the processing of first order polynomial refinement with adequate 3D GCPs, produced higher accuracy (RMSEr = 0,915m).

Even higher accuracy (RMSEr = 0,801m) was obtained using the simple linear polynomial correction. Although distortions induced by sensor's viewing geometry are not taken into consideration, it seems that the polynomial functions perform better.

Differences in the rectification results among various methods are graphically represented by a digitized road segment in the Standard product and then superimposed on the rectified products (Figure 3 & 4).



Figure 3 Standard Sharpened True Color type QuickBird image (left) and rectified image using simple linear polynomials with 3D GCPs (right). See overlapped a road segment before (red) and after (blue) the rectification.



Figure 4 Rectified QuickBird image using the RPC model linearly refined by 3D GCPs (left) and without refinement made (right). In the second case both the rectified (blue) and the non-rectified (red) vectors coincide.

Our research study was conducted using ERDAS IMAGINE 8.7 software. The above software does not support parametric rectification. Due to this limitation, in order to efficiently eliminate the geometric distortions of the images, while achieving accurate georeferencing, a combined use of the methods mentioned above could be applied

Though a further investigation could be suggested following two stages. The first concerns a geometric correction using the RPC model, followed by a post-processing step involving a polynomial correction with the suitable number of accurate

GCPs (on the image produced by the first step) in order to improve the georeferencing.

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