GEOMETRIC ACCURACY OF A CARTOGRAPHIC PRODUCT AT 1:50,000 SCALE UPDATED BY DIGITAL HRV-SPOT IMAGES AT LEVEL 1B

Oscar Ricardo Vergara[1], Júlio César Lima d'Alge[1],
Kevin Theodore Fitgibbon[2], Guaraci José Erthal[1]

Instituto Nacional de Pesquisas Espaciais - INPE[1]
Departamento de Sensoriamento Remoto e Meteorologia Espacial-DSM
Av. dos Astronautas, 1758 - C.P. 515 - Jardim da Granja
12201-970 São José dos Campos, SP - Brasil
Fax: +55 123 21 8743. E-mail: richard@dpi.inpe.br
Instituto Tecnológico de Aeronáutica (ITA)[2]

Abstract

The lack of updated topographic maps shows the need to develop methodologies to update such documents, reducing time and resources expenditures. Taking into account the advantages derived from the use of Remote Sensing data for cartographic purposes, the aim of this work is to improve the geometric accuracy of digital HRV-SPOT images at level 1B, in the frame of a methodology for cartographic updating, using GIS techniques. The results show that digital HRV-SPOT images (level 1B) geometricly corrected by image/map registration, allow to achieve the geometric accuracy of class A topographic maps, at 1:50,000 scale.

1 Introduction

There is a need to develop methodologies for updating topographic maps with reduced time and resources expenditures. Since the early times of data acquisition from the LANDSAT satellite series, Remote Sensing images became an important source of information for cartographic applications. The development of image processing systems as well as of Geographic Information Systems allowed the accomplishment of methodologies to update topographic maps using digital images. Taking into account the specifications for geometric accuracy established for topographic maps, it is convenient to emphasize that the products of different sensor systems are submitted to corrections at different levels that allow the improvement of their geometric quality.

HRV-SPOT images are products from a sensor system that was designed specifically for cartographic applications. These images present levels of processing that allow their use for both thematic cartography as well as for updating topographic maps. Several studies indicate that the geometric quality of these products can be compatible with the accuracy required for topographic maps at 1:50,000 [4, 6], even at level 1B [1]. Based on the results of these studies, the aim of this work is to improve the geometric accuracy of digital HRV-SPOT images at level 1B by a polinomial registration procedure. So, it is expected to attain the geometric accuracy that meet the specifications required to update topographic maps at 1:50,000 scale, in the frame of a methodology using image processing and GIS techniques.

The area under study is a module of the topographic map "São José dos Campos" (São Paulo State, Brazil) at 1:50,000, that is a city located on a region with both flat and hilly terrain, presenting altimetry varying from 550 m to 800 m. The geographic coordinates of the map mentioned above are: S 23°00'00" to S 23°15'00" and WGr 45°45'00" to WGr 46°00'00" while the coordinates of the area under study are S 23°07'35" to S 23°14'06" and WGr 45°52'07" to WGr 45°59'06".

This work was performed with the following materials:

- Topographic map "São José dos Campos", (sheet SF-23-YD-II-1), scale 1:50,000, edition 1973 (IBGE), UTM projection;
- Digital HRV-SPOT images at both panchromatic and multispectral modes, with geometric correction (level 1B). Taking into account the requirements of geometric accuracy for this study, images looking nearly vertical were selected (Table 1):

K/J	MODE	DATE	INCLINATION
717/396	P	14.03.90	+2.0°
717/396	XS	18.08.89	+2.0°

Table 1: Image identification

These images were afterwards used to generate a third product, based on data fusion techniques. This product was also used for the cartographic updating. Image processing was made at SITIM (Integrate System for Image Analysis), developed at INPE.

2 Methodology

The updating of a topographic map is a procedure that adds new information to the old map and deletes information that no longer exist. In this study, the cartographic updating was made using a GIS, merging digital images (updating information) and the digitized information layers of the old map. In order to accomplish this method, described at Figure 1 [8, p. 63] the SGI (GIS developed by INPE) was used. This system is available at the SITIM environment and allows storage, analysis and combination of geocoded Remote Sensing data and of those originated from other sources.

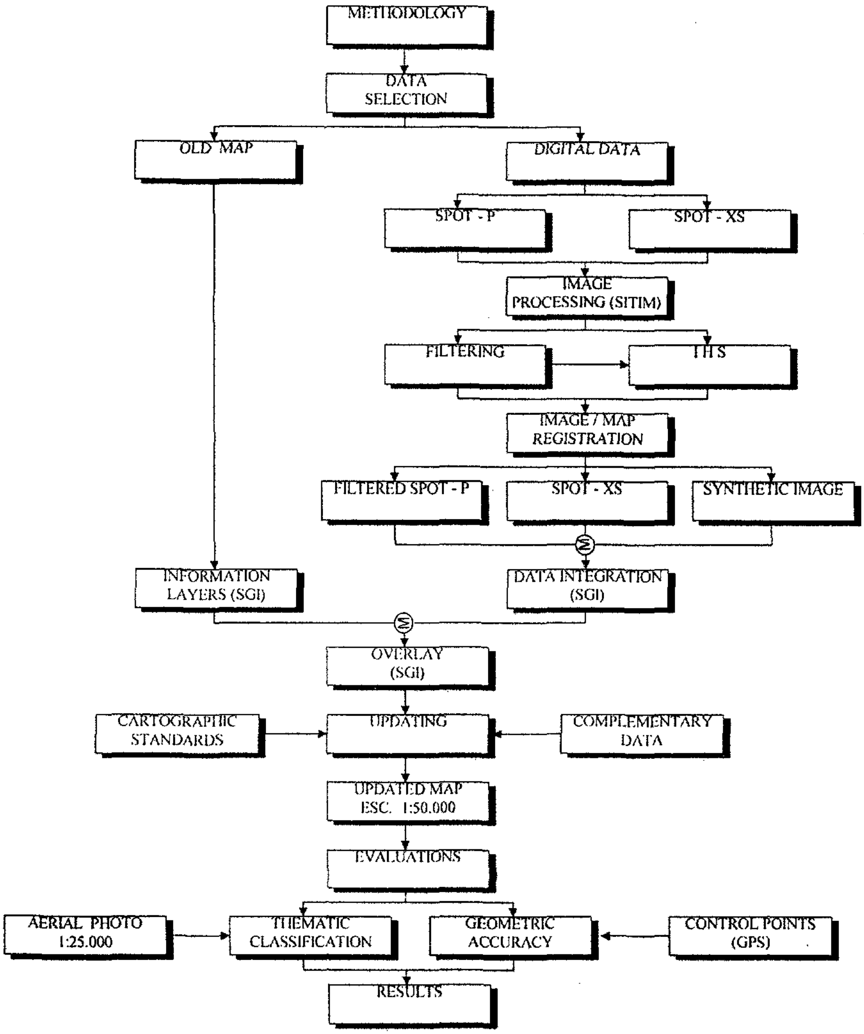

Figure 1: Updating methodology

Within this procedure, the image/map registration task is considered as of fundamental importance to guarantee the geometric accuracy of the updated document. In this study, the registration of the three images used was performed with an error below 1 pixel.

After the procedure of updating was concluded, the new information layers were plotted to obtain the updated cartographic document at the scale of interest (1:50,000). Afterwards a similarity transformation was applied, to evaluate the geometric accuracy of this product. This mathematical model is used at independent evaluations of final products and it offers four degrees of freedom (a scale factor, a rotation and two translations)[3, 5]:

$$X'_i = a.X_i + b.Y_i + X'_0$$
$$Y'_i = -b.X_i + a.Y_i + Y'_0$$

The control points needed to accomplish this evaluation were obtained by GPS, with the following equipment from Project PNUD/ICAO BRA-92/006: TRIMBLE receptors, models RL 4000 (stationary receiver) and DL 4000 (movable receiver), L_1 using code C/A. By a differential measurement, the coordinates of the points were obtained with error below 10 m. As control points, were used clearly identifiable features, such as road crossings, bridges, etc., considering the criterion of uniform spatial distribution [7] . Nine control points were used to evaluate the geometry of the updated map.

3 Results

As for the analysis of results, accuracy requirements for topographic maps, according to Brazilian Laws, were taken into account. The Decree Nr. 89.817 from June 20, 1984, states that "90% of those points well defined on a map, when tested in the field, should not have an error above planimetric PEC (Standard for Cartographic Accuracy) established" [2]. The same rules indicate the value of planimetric PEC as of 0,5 mm at the scale of the map. Consequently, the standard of planimetric accuracy for class A maps, at 1:50,000 scale, is defined by a maximum error value of 25 m. The results presented on Table 2 show that the root mean square error, as well as most individual errors are below this tolerance. Of the control points set, only point 3 has an error that is just a few centimeters above the same tolerance.

CP	1	2	3	4	5	6	7	8	9
ΔP(m)	18.17	22.14	25.61	17.85	11.86	12.89	21.15	6.36	5.1
RMS (m) = 18.083									

Table 2: Results of the geometric evaluation of the output cartographic document

4 Conclusions

The objective of this study was to improve the geometry of HRV-SPOT data at level 1B, by a polinomial registration procedure. The results show that, using a module that is much smaller than the map (10 km x 10 km) and within an environment such as that one of SITIM/SGI systems, it is possible to obtain the geometric accuracy needed to update topographic maps at 1:50,000 scale.

However, it is important to further extend this study with new experiences, because its results depend on factors such as the characteristics of the area under study (intensity of relief) and of the images used (inclination, distance of the area under study from the center of the image), as well as the quantity, quality and spatial distribution of the control points used to register and to evaluate the geometric accuracy of the output product.

References

[1] Andrade, L.A. de. Possibilidades de obtenção de produtos cartográficos com utilização de imagens do satélite SPOT. In: *Simpósio Brasileiro de Sensoriamento Remoto, 5.*, Natal, 11-15 out. 1988. Anais. São José dos Campos, INPE/SELPER, 1988, v. 1, p. 245-252.

[2] Brasil. Ministério da Ciência e Tecnologia. Comissão de Cartografia. *Cartografia e Aerolevantamento Legislação.* Brasília, 1986. Cap. II, p. 26-27.

[3] D'Alge, J.C.L. Qualidade geométrica das imagens TM do Landsat 5. In: *Congresso Brasileiro de Cartografia*, 13. Anais: 44-59. Brasília, 1987.

[4] Gugan, D.J.; Dowman, I.J. Topographic mapping from SPOT imagery. *Photogrammetric Engineering and Remote Sensing, 54*(10):1409-1414, oct. 1988.

[5] Machado e Silva, A.J.F. *Modelos de correção geométrica para imagens HRV-SPOT.* (Msc. Dissertation in Applied Computation). São José dos Campos, INPE, 1989. (INPE-5001-TDL/395).

[6] Toutin, T.; Carbonneau, Y. La multi-stéréoscopie pour les corrections d'images SPOT-HRV. *Canadian Journal of Remote Sensing, 15*(2):110-119, sep. 1989.

[7] Vergara, O.R.; Frery, A.C.; d'Alge, J.C.L. Spatial distribution of control points. ISPRS Congress, Commission III, 27., Washington, D.C., 1992. *International Archives of Photogrammetry and Remote Sensing.* Washington, D.C., ASPRS, v.29, pt. B3, p. 109-112. São José dos Campos, INPE, 1992. (INPE-5413-PRE/1760).

[8] Vergara, O.R. *Avaliação de produtos de sensoriamento remoto para fins de atualização cartográfica.* (Msc. Dissertation in Remote Sensing). São José dos Campos, INPE, 1994. 155 p. (INPE-5584-TDI/546).

Acknowledgments

The authors acknowledge FAPESP (Foundation for Research of São Paulo State) for funding this study.