THE GIS TECHNOLOGY TO UPDATE TOPOGRAPHIC MAPS

Maria Isabel Castreghini de Freitas Viadana [1]
Jorge Pimentel Cintra [2]
1 Universidade Estadual Paulista "Júlio de Mesquita Filho"- UNESP/ IGCE
Departamento de Cartografia e Análise da Informação Geográfica - C.P.178
13.506-900 - Rio Claro (SP) - Brasil
2 Escola Politécnica da Universidade de São Paulo
Departamento de Engenharia de Transportes - C. P. 61.548
05424-970 - São Paulo (SP) - Brasil

Abstract

The main aim of this work is to present a updating alternative to topographic maps. This work intends to attend a tipical regional planning user whose best scale of work is 1: 50,000 and that isn't well off to sophisticated hardware and software acquisitions. This paper describes a metodology using satellite images SPOT and Landsat-TM to topographic map updating with the Geographic Information System (GIS) IDRISI 4.1. Considerations about the partial results are presented where is detached the superiority of information content resultant of merged image when compared with SPOT pancromatic image.

1. Introduction

Actually, the GIS technology presents countless resources involving cartografic techniques. There are sophisticated systems that offer unlimited resources and high cost, but there are also simple systems with low cost, academics in general. These last ones provide an easy and cheap implementation, more compatible with the user reality in development countries.

The advantage of mapping using orbital images consists in the periodicity and repetitition associated with the low cost when compared with the topographic and photogrammetric proceedings. The limitations consist of the resolution of the available images and their contents. In reality, there are many works showing that orbital images perform geometric requisites for any scale but a few ones perform the information requisites.

1.1. Objectives

The main aim of this work is to test the IDRISI 4.1. system in updated tasks involving linear features of topographic maps in scale 1:50,000 using SPOT pancromatic and merged orbital images Landsat-TM and SPOT. This work intends to attend a tipical regional planning user (agricultural, forest , land use, ...) whose best scale is 1: 50.000 and that isn't well off of more sophisticated hardware and software acquisitions. Also, it doesn't need high cartographic precision but updated informative content in order to develop his work in a Geographic Information System (GIS).

1.2. The necessity of updated maps

The publication [5] alerts to the importance of updated maps for the development of any country. It presents the statistic of United Nations from 1987 that indicates that only 56% of the world territory is covered with 1:50,000 maps, increasing this area in 2% per year. That situation changes according to the Earth region. Unfortunately, when they are disponible, the maps in Brazil are in unsatisfactory scales or not up-to-date. It's important to note that maps in useful scale for planning are about 30 years old. All that salients the necessity and importance to develop quick and cheap updated methodologies offering an acceptable precision. The situation of sistematic mapping in Brazil is presented in Table 1, adapted from [1].

Sistematic Mapping of Brazil	Percentage Existent (%)	Percentage to Execute (%)	Number of Foreseen Maps
1:25,000	1.6	98.4	47,712
1:50,000	13.1	86.9	11,928
1:100,000	65.9	34.1	3,049
1:250,000	66.2	33.8	556
1:500,000	42.8	57.2	159
1:1,000,000	100	0	46

Table 1: Situation of sistematic mapping in Brazil.

1.3. Area of Study

The area of study is a sector of topographic map from IBGE (Instituto Brasileiro de Geografia e Estatística), Brasilian Institute of Geography and Statistics, SF-22-R-IV-3, named Botucatu, scale 1:50,000 edited in 1969 and based in aerial photographs from 1965. This is a map in Universal Transverse of Mercator Projection (UTM), fuse 22. The area of study corresponds to 8,520m x 8,440m, with latitudes 22°52'S and 23°00'S and longitudes 48°22'W and 48°30'W.

2. Same updated methodologies and the software IDRISI

The work [6] presents a software developed to compilation and revision of digital maps resulting from satellites images and orbital photographs. This study detaches the importance of informative content in cartographics aplications using orbital images. A multiresolution composite image was produced in [7] for mapping at 1:50,000 scale using Landsat TM and SPOT P, improving the interpretation of the TM multispectral images.

The software IDRISI is a raster geographic information system developed and improved since 1987 by the Graduate School of Geography at Clark University, projected to provide professional-level geographic research tools on a low-cost non-profit basis, according to [3]. The version 4.1 [4], launched in 1993, is used in this work.

3. Methodology

3.1. Data Acquisition

The Higher Resolution Visible (HRV) imaging system in SPOT satellite, colleted the pancromatic data on May 21, 1991 (K712 - J396), with 10 m resolution. The Thematic Mapper (TM) imaging system in Landsat-5 colleted the data from six espectral bands with 30 m resolution on October 14, 1991 (Orbit 226 - Point 76A). Topographic maps from IBGE in 1:50,000 scale, of 1969 and from IGC (Geographic and Cartographic Institute) in 1:10,000, 1978, projection Universal Transverse Mercator (UTM). The original data from IBGE topographic map were digitilized using AutoCAD R.10, edited and exported to IDRISI using the DXF format. The features were distributed in layers corresponding to existent information.

3.3. Image Processing

In Image Processing stage was necessary to make the image geometric registration followed of the merging and enhancement of the data. Two images were tested: the SPOT pancromatic with enhancement and the SPOT and TM merged image using IHS transformation. This proceedings intend to improve the quality of the images to visual interpretation of interest features.

3.3.1. Geometric Registration

The geometric registration was made using 31 control points with perfect identification in SPOT and TM images and in topographic maps 1:10,000. The first degree polynomial was adopted in IDRISI's resampling algorithm. Because the two sets of data presented different spatial resolutions, the TM data were resampled using a expantion factor of 3 times, resulting spatial resolution of 10 m.

3.3.2. Enhancement and merging SPOT-P and TM data

The first test involved only the SPOT pancromatic (P) image, with low contrast in histogram, that was enhanced with simple linear stretch using cut-values inferior and superior of 15 and 76 gray levels. The method used to integrate the two data sets was the IHS Transformation. In IHS space the colours are defined by intensity, hue and saturation attributes. Before doing the transformation the manual histogram equalization was applied to the images involved in the research, searching a higher balance among the associated colours in RGB space. The process involved the transformation of each chosen TM band from RGB (red, green and blue) space into IHS colour space and the replacement of the intensity component with the SPOT pancromatic data. Then, the inverse transformation of I (SPOT-P), H (TM) and S (TM) was realized using simple linear stretch, resulting a RGB merged image. This procedure intends to combine the higher spacial resolution of SPOT-P with the best spectral resolution from TM bands, according with [2, 7]. To choose the best merged image to the linear features detection considerated in this study, the IHS transformation was applied to TM-RGB compositions: TM-321, TM-432, TM-543, TM-743, TM-435 and TM-437. Control features were analysed with respect to elements of interpretation: shape, pattern, colour, texture and association. In mean, the results are good. Through visual analyses of control features, the best image to those updated objectives resulted from TM-437composition.

3.4. Screen Digitalization and Edition

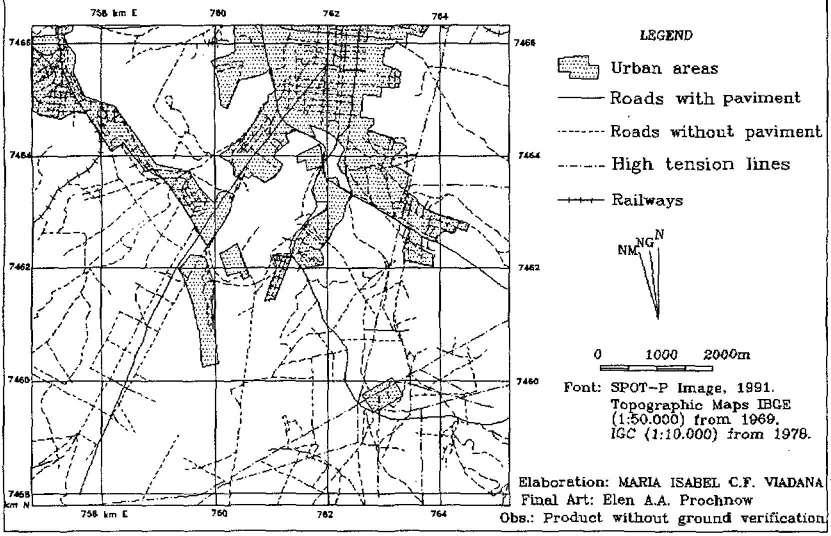
The screen digitalization was made with the IDRISI's digitalization mode. The new linear features were registered by observation of image and original map on the screen. Features no detected were detached for future ground verification. Files with the updated maps were generated in vectorial format, transformed in DXF and exported to AutoCAD R.10. The edition involved basically closing polygons and intersections and that was made in AutoCAD R.10. Then, for each image tested, the features were distributed in layers: new roads with paviment, new roads without paviment, new railways, new high tension, new urban area, repeated features and no detected old features.

4. Results

4.1. Updated Topographic Maps

The figure 1 presents the updated map resulting from SPOT pancromatic image and the updated map from merged image resulting from IHS transformation. This results are preliminars and were obtained without ground verification.

TOPOGRAPHIC MAP UPDATED WITH SPOT-P IMAGE
SECTOR OF BOTUCATU (SP), BRAZIL



TOPOGRAPHIC MAP UPDATED WITH MERGED IMAGE (SPOT-P AND LANDSAT-TM)
SECTOR OF BOTUCATU (SP), BRASIL

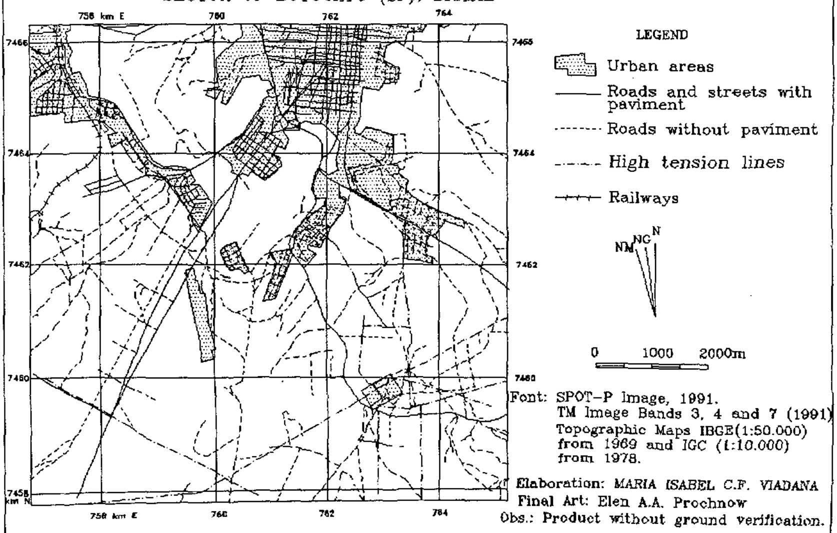


Figure 1: Updated maps from SPOT-P above and Merged Image below.

4.2. Information Content

The measure of information content was made through AutoCAD R.10 using functions concerning to polylines lengths and areas. The final result is presented in Table 2 where appears the total length and area corresponding to the features from original map and from updated maps.
The RMS analyses using verification points in generated products will be performed in the next stage. The Table 2 shows both resultant maps adding large quantity of information in the original map.There are between SPOT-P and merged image products little differences in urban areas and high tension values. The great discrepancy in roads with paviment is function of arrangement of street detection in merged image what doesn't occur in SPOT-P image. The arrangement of streets appears like roads without paviment in original map. In general, there are difficulties in the identification of railways and high tension lines due to a loss of continuity of this features on the images.

Length and area of features	Original Map (1969)	Updated Map from SPOT-P (1991)	Updated Map from Merged Image (1991)
Urban Areas (m^2)	2,901,750	11,575,730	11,568,290
Roads with paviment (m)	20,750	30,540	116,730
Roads without Paviment (m)	136,160	268,070	203,180
Railways (m)	5,370	5,970	4,830
High Tension (m)	24,840	30,270	29,180

Table 2: Length and area of features from original map and updated maps.

5. Conclusions

These preliminary results demostrated the potential of a alternative methodology with low cost to updated topographic maps at 1:50,000 scale, according to the need of regional planning users. The comparision of informative content performed shows that merged image product is superior at SPOT-P image when are considered roads and streets with paviment. The combination IDRISI and AutoCAD to develop the research was very productive, although limitations imposed mainly by digitalization and image processing from IDRISI. The softwares had satisfactory performance. In continuity of this work there will be ground verifications and the quantitative analyses of geometric precision of generated products, very important for the conclusion of this research.

References

[1] BRASIL, 1991. Ministério da Economia, Fazenda e Planejamento. Fundação Instituto Brasileiro de Geografia e Estatística. **Mapeamento Geral do Brasil**. s.l. Escalas diversas. 9 mapas.

[2] Chavez, P.S.; Bowell, J.A., 1988. Comparison of the spectral information content of Landsat Thematic Mapper and SPOT for three different sites in the Phoenix, Arizona region. **Photogrammetric Engineering and Remote Sensing**, 54(12), p. 1699-1708.

[3] Eastman, J.R., 1992. **IDRISI 4.0**. User Guide. Wiscosin, Clark University. 178p.

[4] Eastman, J.R., 1993. **IDRISI 4.1**. Updated Manual. Wiscosin, Clark University. 211p.

[5] Jacobsen, K., 1992. Advantages and disadvantages of different space images for mapping. In: CONGRESS INTERNATIONAL SOCIETY FOR PHOTOGRAMMETRY AND REMOTE SENSING. **Proceedings**. Washington, ISPRS, Commission II, p. 162-168.

[6] Meneguette, A.A.C., 1988. Exatidão cartográfica e conteúdo informativo de imagens de satélite para compilação e revisão de mapas digitais. In: SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO, V. **Anais**. São José dos Campos, INPE, p. 232-235.

[7] Sanchez, R.D., 1987. Image mapping of the Viedma area, Argentina at 1:50,000-scale using merged LANDSAT TM and SPOT P data. **Revista Cartográfica**. v.51/52, p.123-131.