Use of Quick Bird Panchromatic Image and GPS Navigation

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Key words: Cadastre, Quick Bird Image, GPS Navigation Receiver.

SUMMARY

The concept of a Multi-Purpose Technical Cadastre, which initially emerged in European Community countries, foresees the effective use of property data for local and regional strategic planning and registry. The European cadastre model is generally based on the precise determination of property positioning and its physical description as well as use characteristics. This permits the implementation of public policies to put the property's social function into effect. The cadastral systems at Brazilian city halls have been practically abandoned, with many errors and without any maintenance policy. Cartography is the main instrument of support for the cadastral systems. Only in recent years has it been considered as an important means to supply graphic information to the planning activity, becoming useful in the decision making process. With the promulgation of Law 10257/2001 (Statute of the City), several public policy instruments were created to guide urban policies, mainly with the objective of ensuring the social function of the property and the city as a whole, thus helping with social justice. In order to apply these important public policy instruments, it is necessary to know the place's reality to permit necessary analysis from precise and appropriate diagnostics. With the objective of permitting access to these intervention instruments, especially for small and mid-sized city halls, this study introduces the development of a cadastral survey methodology by integrating the Quick Bird panchromatic image and the Garmin GPS 12XL navigation receiver.
This study introduces the validation of the coordinates for the support points, determined with observable points gathered from the GPS navigation and image orthorectification, starting with the support points determined with the low cost receiver. Some properties from a test area were also registered (with special attention to the properties characterized by irregular polygons) determining the vertice coordinates from the orthorectified image and compared to those obtained from the survey using the GPS navigation receiver, whose observable points are collected and then post-processed used the relative positioning method. The results obtained point to a very promising solution from a field survey cost point of view, since the system used (GPS navigation receiver, topographic antennae and tripod) is comprised of a set of low cost equipment when compared to a geodetic receiver. It is thus hoped that small companies or even city halls can implement this methodology, which proposes the use of low cost equipment, materials and procedures with greater frequency.

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1. INTRODUCTION

The current situation of national Cartography is concerning, above all from the view point of information updating. Many locations, especially in the Northern and Northeastern regions of the country, have never even been mapped in medium and large scales, whether due to the lack of economical and strategic interest in the region or lack of resources for the investments in this purpose. In Brazil, the current mapping indexes in the different scales prove that the lack of topographic maps is more severe for the larger scales: 76.54% (1:250.000), 75.39% (1:100.000), 13.9% (1:50.000), 1.01% (1:25.000) (SIERRA and HUARAJO, 2001 apud VERGARA, 2002).

Upon handling urban mapping, the matter is more delicate, for the cities obey a dynamic growth system, suffering significant alterations in a relatively short period and the ground layouts need representation in large scale, which increases the problem of updating, since precision and cost are closely related to scale.

The usage of ground layouts is intense, or should be, by the different sectors and secretariats that compose the planning area of a municipal administration, since from these information can be gotten and action can be planned for multiple purposes. Being this way, the cadastral updating should be periodic for it to be possible to always work with current data, consonant with reality.

According to Carneiro and Loch (2000), the information contained in the cartographic base, of Brazilian municipal districts, is impaired in many aspects, such as the lack of updating, lack of geodetic control and nonexistence of municipal cadastral reference network.

This reality does not belong just to the Brazilian scenario. According to the IDB (International Database) 72% of the municipal districts in Latin America do not have maps of their jurisdiction on paper or in digital means (COHEN, 2000).

With the purpose of gradually turning this situation around, the cartographic community has been directing forces in the search for alternative methodology of cartographic and cadastral updating, quicker and more economical than the conventional classic methodologies.

Allied with the urban cartographic bases, the Multipurpose Technical Cadastre (MTC) is an important tool for elaborating a precise diagnosis of the municipal district, allowing for analysis that may point out efficient solutions. The multipurpose cadastral system generate a complex database which contains the most varied information, not just referring to the real estate matter, but also cense information, infrastructure information such as highways, avenues, roads, etc.

In this work, the Quick Bird images and the GPS navigation receiver are used for cadastral survey, mainly of real estate characterized physically by irregular polygons, which are difficult to be measured using simple topographic methods such as tape-measure measurement. In this method, the GPS navigation is used for the survey of control and check points, which will be used in the process of image orthoretification and quality control. This way, the image is orthoretified to obtain the coordinated of the vertices of the real estate of interest.

Generally, the real estate with this format is not surveyed in the urban registration missions due to the difficulty and cost of survey using topographic methods, therefore generating a registration that does not contemplate the so called empty urban areas.

The use of the GPS navigation as the main instrument for carrying out the support field, was based upon the methodology studied by Camargo et al. (2003), in which it is possible to carry out the absolute positioning, relative or differential, and improve the accuracy of the positioning for the post-processing of the observations.

It is believed that this methodology makes both the registration and updating process more agile, with reduced costs and time, providing better conditions for carrying out more frequent periodic updating.

2. BIBLIOGRAPHIC REVIEW

2.1 GPS Navigation Receiver and register of Observables

With the modernization of the GPS system, and the turn off *Selective Availability* (SA), which took place in 2000, the usage of handheld or GPS navigation receivers is becoming more and more popular. These receivers estimate and store the positions, but do not register observables (pseudorange and L_1 carrier phase), which makes the post-processing of data not viable.

This way the Institute of Engineering Surveying and Space Geodesy (IESSG), at the University of Nottingham, developed a commercial program known as GRINGO *(GPS Rinex Generato*r), with the purpose of registering observables and make possible the post-processing of data to remove the SA effect and other errors, without having to invest in equipment to receive DGPS corrections or a more expensive GPS receiver (CAMARGO et al., 2003).

Also, available on the internet are programs that register brute data received from navigation receivers, the observables: pseudorange and and L_1 carrier phase, and transform them in RINEX format. Such software was developed at the Polytechnic University of Madrid, in Spain, are is designated as ASYNC and GAR2RNX (*Garmin to Rinex*) (GALAN, 2002).

In the ASYNC program, as well as in GRINGO, the decoded data from the Garmin navigation receivers is transmitted to the computer, laptop or data collector (for example, Psion), through a serial port, in real time.

However, in combination with a simple data collector or laptop, the program make the GPS receiver low cost users (handheld or navigation receivers) capable of carrying out a variety of activities and applications such as, for example, associated to a attribute collection program, it can collection data for the Geographic Information System (SIG).

The GPS system, by itself only, cannot provide any alteration detection tool. However, in this case, a combination of methods can be adopted using, for example, the detection of alterations by field surveying, systematized intercommunication among real estate registration institutions and organs, or also though aerial images.

2.2 Cartographic and cadastral updating

When handling updating, one of the purposes of this work, again we come across the difficulty of detecting the alterations which occurred in the object space, for the determination of the position goes through its detection step and its classification as an interest object for updating. In Photogrammetry using the high space resolution orbital images can be useful both in detecting alterations and extracting interest features.

In the case of alteration detecting by differences observed in images, orbital or photographic sensors, at a first moment only the semantic aspects of the images are considered, but on the other hand, it can be observed that currently, using digital image processing resources, the geometric aspects come to exert an important role in this activity.

Due to the constant changes that occur in space, as well as the dynamism of its phenomenon, it is necessary to update the cartographic data. However the mapping is not always match reality, seeing that it cannot accompanying the changes occurred in a short period of time.

In the urban area, the problem found in updating data is even more expressive, due to being an environment where there are changes at every moment, such as new constructions, new subdivisions, channeling of water course, among others. All these alterations should be contained in the ground layouts.

Through ground layouts, many sectors that compose the Municipal Administration can extract information and make decisions supported in data identified from space. From there comes the need to have constantly updated data, for it to be possible to work with data that reflects reality.

2.3 Use of high resolution images in cadastral surveying

According to Passos et al. (2001) the ground layout consists of an instrument that aides several private and publics sectors, being that the use of this tool contributes to the municipal planning and management.

Even if ground layouts are available, it become inevitable the need for the disposition of this information in digital means, with wide-ranging details that make it possible to update with greater dynamism, with reliable measurement of the rural and urban areas and urban expression. This makes it possible for greater agility in access to cadastral bulletins and, also, an efficient access for the visualization of the researches real estates.

Currently there is the possibility of having a source of visual information where roads, houses and details can be identified for a physical updating of the cadastral reality, both in urban and rural areas. A means for overcoming such needs is the acquisition of high resolution satellite images, which offer large coverage and a smaller cost when compared to a aerophotogrammetric surveying.

In the physical registration measurements should be done that have good precision and accuracy. The geometric correction of the images becomes necessary, through the orthoretification process, in which geometry marking errors and displacement due to relief are corrected. Taking into consideration the distortions related to the platform, sensor, Earth, and cartographic projection.

According to Costa and Magalhães (2003) orthoretification needs a specific procedure which comprehends steps as a definition of a projection system, generation of a Digital Elevation Model (DEM), acquisition of control points, adjusting and analysis of residues and finally orthoretification.

3. DEVELOPMENT

The first step for the generation of orthoimage was the determination of control point in the field. For such, 6 well defined control points were used and distributed spatially and determined by satellite tracking with post-processing of observables, using the Garmin GPS 12XL receiver and a Work About collector with Windows CE, as shown in Figure 3-1.

Figure 3-1: Low cost GPS data collection system.

The next procedure was carrying out the geometric correction of the image using the Rational Function Model, a digital model of the terrain and the referred control points, using Leica Photogrammetric Suite (LPS) software.

Two experiments were done to test the model to be used in the geometric correction. In the first, one parameter translation and other information about the geometric correction was used, being that the root mean square error (RMS) obtained was 0.213 pixels. In the second experiment, similar transformation parameters and other information referring to the geometric correction were used, being that the RMS obtained was 0.240 pixels.

From the values obtained it can be verified that, using only translations, the RMS was lesser than in the experiment with similar transformation. It can be said that this happens because the errors associated to the image are small, allowing a more simple modeling to be used.

According to Tao et al. (2000), the generalized model most commonly used is based on the rational 3D polynomials, which in literature are known as Rational Function Model (RFM), Rational Polynomial Coefficient (RPC) and Rational Function Coefficient (RFC).

The Rational Function Model (RFM), defined by 80 coefficients or less, called Rational Polynomial Coefficients (RPCs), is an alternative model adopted and distributed by Space Imaging and Digital Globe in its products, allowing processing such as orthoretification and the reconstruction of stereo pairs, affirms Xu (2004).

The RPC model is represented by ratio of two cubic polynomials of the coordinates in the object space. Two different ratios of cubic functions are used to indicate/represent the relation of the object space for the line and object space for the column. The coordinates in the image space and object space are normalized between –1 and +1 to improve the accuracy and avoid excess memory.

The Rational Function Coefficients, according to Xu (2004), are generally third order polynomials. The arrangement of the polynomial terms, or number of terms, are diversified. However, NIMA's (*National Imagery and Mapping Agency*) definition, an American mapping agency, is that both the numerator as well as the denominator have 20 cubic terms, being adopted by Space Imaging and Digital Globe, as the ideal number of terms becoming a standard.

The ratios of the first order terms represent the distortions caused by the optic projection, as to the correction of the Earth's curvature, atmospheric refraction and lenses distortions, can be shaped by the second order terms.

Other more complex, unknown distortions with superior order components can be observed in third degree terms. The polynomial coefficients are also called RPC (Rational Polynomial Coefficients).

The term RPC model, frequently refers to the specific case of RFM, in the direct form with third order polynomials, and are usually solved with the independent approach of the terrain, where the physical model is vital, for the determination of transformation coefficients. First, a bi-dimensional point grid is generated over the entire extension of the image, following, the tri-dimensional coordinates are calculated, through a physical model, forming a tri-dimensional grid and having as limits, the extension of the image and the amplitude of the terrain's salience.

The tri-dimensional grid is intercepted through layers with points at the same height. The Rational Function Model relates two sets of coordinates being estimated the respective coefficients, through an adjustment. (HU *et al*, 2004).

To generate the orthoimage, the bilinear interpolator was used for the re-sampling of the original image. The final result of the orthoimage generation is a corrected image of the distortions due to relief, inclinations at the moment of the scene taking, among others.

4. EXPERIMENTS AND RESULTS

The experiments were carried out in a test area, located near the condominium Damha 2, belonging to the urban perimeter of Presidente Prudente – SP, which has real estate with the characteristics proposed in this work, or in other words, real estate formed by irregular polygons and located in the so called urban empty areas or in the urban expansion area, as shown in Figure 4-1.

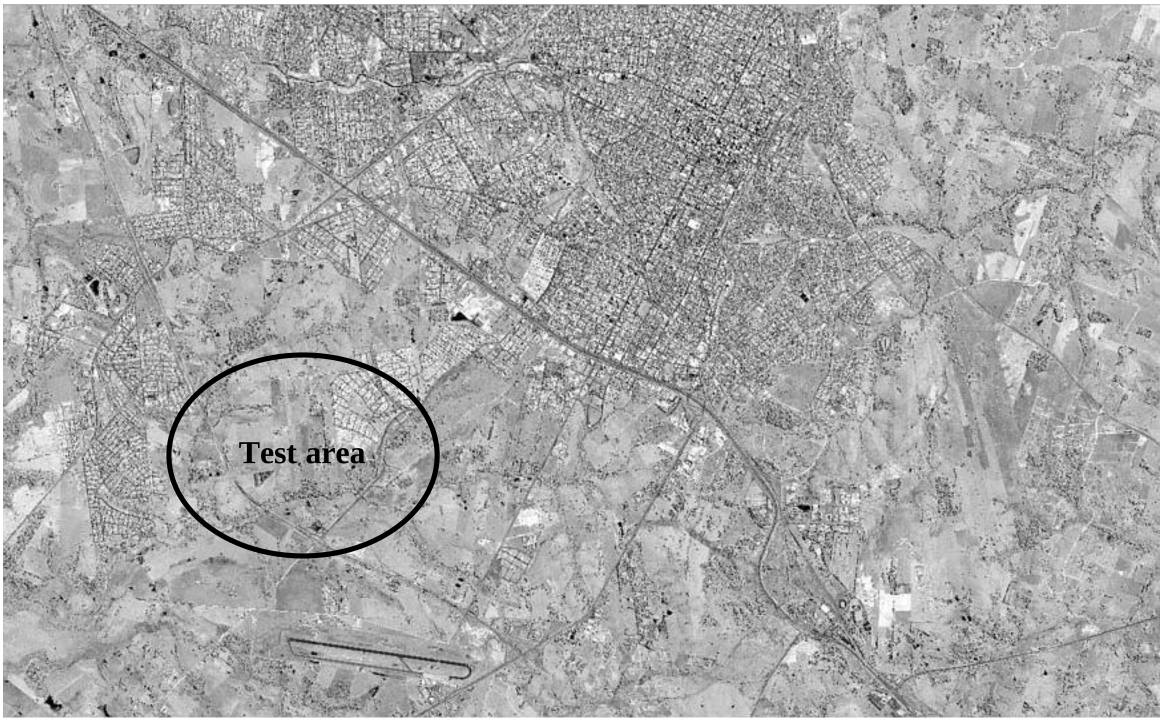

Figure 4-2 shows the generated orthoimage, in which some properties with rural characteristics were surveyed, in their majority, some being used as country recreation areas or residences.

Figure 4-2: Orthoimage of test area.

Table 4-1 shows the discrepancies of the coordinates determined through a GPS navigation receiver and those determined from the orthoimage.

Table 4-1: Discrepancies, of the coordinates.

Point	**ΔE(m)**	**ΔN(m)**
P1	0.305	-0.089
P2	0.047	1.117
P3	0.776	0.562
P4	-0.277	-1.174
P5	0.034	-0.623
P6	0.270	-0.002
P7	-0.868	0.383
P8	-0.551	-0.705
P9	-0.131	0.335
P10	0.285	-0.549
P12	-0.619	-0.517
P13	0.432	-0.534
P14	0.554	-0.593
P15	0.601	0.587
P16	0.040	-0.498
P17	-0.045	-0.620
P18	-0.211	-0.581
P19	-0.546	-0.047
P20	-0.286	-0.537
P22	0.543	0.543
P24	-0.571	-0.580
P25	-0.602	0.525
Average	-0.021	-0.163
Standart desviation	0.486	0.586

From Table 4-1 it can be observed that the discrepancies at coordinate E are not over -0.868 m and at N of -1.174 m. Despite the average being low, the standard deviation is close to the value of 1 pixel of the image (0.60 meters).

A more detailed analysis was done from the results obtained with views to the association of the Brazilian Civil Code, which in its Article 500 § 1º establishes the maximum of one twentieth of area in the total area of the real estate to be commercialized, or in other words, 5%.

Being this way, 2 real estates were chosen (glebes characterized by irregular polygons) for surveying. All the vertices of these real estates were surveyed through geodetic GPS receiver Trimble 4600LS and navigation Garmin GPS 12XL with post-processing of observables.

The coordinates of the vertices from the same real estates (PR8 and PR7) were determined also through a series of three vertice measurements, giving origin to three areas, as shown in Table 4-2.

Table 4-2: Area and perimeter: discrepancies for the PR8 and PR7 properties, with relation of data obtained with the GPS navigation receiver
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		Property PR8	Property PR7
Points/GPS Garmin 12XL post-processing	Area	70526.133 m^2	72382.804 m^2
	Perimeter	1335.654 m	1355.416 m
QuickBird Image Orthorectified	Area	A1=70734.416 A2=70739.728 A3=70460.769 $A_{average}$ = 70644.971 m^2	A1=72461.565 A2=72520.170 A3=72475.464 $A_{average}$ = 72485.733 m^2
	Perimeter	P1=1339.037 P2=1337.504 P3= 1337.850 $P_{average}$ = 1338.13 m	P1=1355.673 P2=1354.104 P3=1356.062 $P_{average}$ =1355.279m
Discrepancy	Area	D =118.838 m^2	D =102.929 m^2
	Perimeter	D = 2.476 m	D = 0.137 m

Observing Table 4-2, it can be observed that the discrepancies found between the areas obtained through GPS navigation and through orthoimage were around 100 m^2 for the real estates PR8 and PR7, representing just 0.16% and 0.14% of the areas, respectively. In relation to the perimeter the error was better than 2.476 m, and represents a difference around 0.18%.

In table 3 the experiments with geodetic receiver and the orthoretified image are presented.

Table 4-3: Area and perimeter: discrepancies for the PR8 and PR7 properties, with relation of data obtained with the GPS Geodetic receiver.

		Property PR8	Property PR7
Points/GPS Trimble 4600LS	Area	70878.054 m^2	72261.3022 m^2
	Perimeter	1336.824m	1354.904m
QuickBird Image Orthorectified	Area	$A_{average}$ = 70644.971 m^2	$A_{average}$ = 72485.733 m^2
	Perimeter	$P_{average}$ = 1338.13 m	$P_{average}$ = 1355.279m
Discrepancy	Area	D = 233.083 m^2	D = 244.431 m^2
	Perimeter	D = 1.314m	D = 0.375m

Observing Table 4-3, it can be observed that the discrepancies found between the areas obtained through GPS geodetic and the same ones through orthoimage were around 240 m^2 for the PR8 and PR7 properties, representing a difference of approximately 0.33% and 0.34%, respectively. As to the perimeter the difference was better than 1.314 m, which corresponds to an error around 0.098%.

Considering that the coordinates obtained through the GPS geodetic has a lower positional error than the error found in the determinations with the GPS navigation with the post-processed observables, these results are more significant.

Even so, comparing the values obtained (0.34%) with that established in the Brazilian Civil Code, it can be observed that these procedures perfectly serve the Brazilian legislation in terms of area precision.

5 CONCLUSIONS

It can be observed that this methodology allows for a significant improvement of quality of cadastral surveying of real estate with specific physical characteristics such as irregular polygons existing in the known urban empty areas and the urban expansion areas (Urban Glebes).

It should be pointed out that the Brazilian Civil Code, in its Article 500 § 1^{o}, established the maximum of one twentieth in the total area of the real estate to be commercialized, or in other words, 5% in an era that the topographic surveying methods did not have the resources that are available today.

Analyzing the results obtained in this work, the need to review these values can be observed, since the technological advance in the last years was significant, allowing for the determination of the area of real estate with much greater precision than the precision expected at the time of the promulgation of the referred to code.

The conditions in which the images are found, practically nadiral, with just 3^{o} of inclination, as well as the relief is not predominant steep in the study areas, contributed significantly to the positive results obtained in this work, due to the favorable conditions that cannot always be achieved.

However, it is recommended to carry out future studies in less favorable conditions for the comparison of these results with those obtained until now.

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