Check of Geometric Quality of Some Orthophoto maps the Metropolitan Region of Recife (PE) – Brazil.

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Key words: photogrammetry, orthophoto maps, geometric accuracy

SUMMARY

Since ancient times the man has sought to meet increasingly the environment in which they live. The pursuit of natural knowledge comes from the necessity of living beings to relate to the environment that surrounds it. From prehistoric times until today, it is observed that this relationship has been necessary not only for the survival of civilization, but also for the development of the planet. With increasing population and the great scientific advances, the quality of geometric information has become something primordial. Large urban centers, such as the city of Recife, widely taken root the geometric relationship of its cartographic concepts as a way to meet the needs of natural and historical: housing, travel, housing, registration, urbanization, sanitation, etc. In this case, it is important to have an updated mapping and in the appropriate scale. One of the problems in the construction of these maps is geometric in its margin of error, so that it does not present operational risks, or miscalculations that may distort the results of a particular project. For this reason, it is of fundamental importance to the quality of geometric accuracy of a orthophoto maps, within acceptable specifications.

The absence in the quality of geometric accuracy can permanently impair an entire project, for example, engineering, and even the planning of maintenance and development. The aim of this work is to use methodologies that allow for checking the geometric precision of some orthophoto maps the Metropolitan Region of Recife. As a result, you can analyze the orthophoto maps without the problem of disability in geometric precision, for applications in the area of control and urban monitoring. New technologies like Digital Photogrammetry and Remote Sensing were added to the search for knowledge mapping, enabling great revolutions in the quality of production and processing of spatial data. In the specific case of Recife cartography, digital mapping can be produced from existing cartographic documents (conversion from analog to digital) or be performed directly in digital form through technologies mentioned at the beginning of the paragraph. It is of interest in this work present some tools that were developed concurrently with the technological advancement, and how such tools can be applied in digital mapping and verification of the geometric quality of existing orthophoto maps.

RESUMO

Desde tempos remotos o homem tem procurado conhecer cada vez mais o ambiente em que vive. A busca natural desse conhecimento vem da necessidade dos seres vivos de se relacionarem com o meio que o cerca. Do período pré-histórico até os dias atuais, observa-se que essa relação tem sido necessária não apenas para a sobrevivência das civilizações, mas também para o desenvolvimento do planeta. Com o aumento populacional e o grande avanço

científico, a qualidade das informações geométricas se tornou algo primordial. Grandes centros urbanos, como por exemplo, a cidade de Recife, arraigaram de forma ampla a relação geométrica de seus conceitos cartográficos como forma de atender as necessidades naturais e históricas de: habitação, deslocamento, moradia, cadastramento, urbanização, saneamento, etc. Nesse caso, é importante que se tenha um mapeamento atualizado e na escala adequada. Um dos problemas na construção desses mapas está na sua margem geométrica de erro, para que o mesmo não apresente riscos operacionais, ou erros de cálculos que possam distorcer os resultados de um determinado projeto. Por essa razão, é de fundamental importância a qualidade da precisão geométrica de uma ortofotocarta, dentro das especificações aceitáveis.

A ausência na qualidade da precisão geométrica pode comprometer de forma definitiva todo um projeto, por exemplo, de engenharia, e até o planejamento de sua manutenção e desenvolvimento. O objetivo desse trabalho é utilizar metodologias que permitam a verificação da precisão geométrica de algumas ortofotocartas da Região Metropolitana do Recife. Com o resultado, será possível analisar as ortofotocartas sem o problema de deficiência na precisão geométrica, para aplicações na área de controle e monitoramento urbano. Novas tecnologias como Fotogrametria Digital e Sensoriamento Remoto foram agregadas a busca pelo conhecimento cartográfico, possibilitando grandes revoluções na qualidade de obtenção e processamento de dados espaciais. No caso específico da cartografia em Recife, o mapeamento digital pode ser produzido a partir de documentos cartográficos existentes (conversão do analógico para o digital) ou ser realizado diretamente na forma digital através de tecnologias citadas no início do parágrafo. É de interesse deste trabalho apresentar algumas ferramentas que foram desenvolvidas concomitantemente com o avanço tecnológico, e como tais ferramentas podem ser aplicadas no mapeamento digital e na verificação da qualidade geométrica de ortofotocartas já existentes.

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1. INTRODUCTION

With the scientific and technological development associated with populational growth, major centers, such as the city of Recife, capital of Pernambuco, Brazil, began to show a need for comprehensive and efficient geometric relationship between their cartographic concepts as a way to meet the immediate needs of, for example, urbanization. In this case the quality of the data obtained and processed is essential.

With the goal of eliminating errors that allow distortion of a particular project, it is relevant the condition of geometric precision in a orthophoto map. The neglect of such precision can mean, among other problems, serious flaws in designs and consequential damages.

Both in Digital Photogrammetry as in the Remote Sensing it is possible to find the possibility of major breakthroughs in the quality of production and processing of spatial data.

2. OBJECTIVES

2.1 General Objective

To use methodologies that allow verification of the geometric precision of orthophoto maps of the Metropolitan Region of Recife, in the years 1974 and 1988.

2.2 Specific Objective

2.2.1 To highlight the importance of the geometric quality of orthophoto maps in the years of 1974 and 1988.

2.2.2 Present and use tools that enable the verification of the geometric quality of these orthophoto maps.

2.2.3 Analyze the results obtained indicating the geometric accuracy of the existing orthophoto maps.

3. THEORETICAL FOUNDATIONS

According CORSO (2002), in recent decades, the development of information technologies has enabled the registration of geographic information in digital form, making them available for use in the analysis and decision making of various levels of government, business, academy, among other organizations.

According NERO (2005) it is important to study the technologies available in the market. Furthermore, it is also important to know how errors are propagated step by step in the application of such technologies to obtain the final products. Monitoring gradual

propagation of errors in the producing of an orthophoto map with their respective records, is striking in its geometric quality checking.

In the quest for knowledge of new technologies and their applications, according to Nero (2005), Geodetic Networks are the starting point and the cornerstone of any project that uses mapping, once a basic network of points with known coordinates is essential for geometrical quality of any mapping. Thus, the first checking of geometrical quality of a orthophoto map is whether the level of accuracy is sufficient for developing a program and / or design.

Besides Geodesy, Photogrammetry is other technology widely used in cartographic projects. It is an important science in the search for geometric quality, and that has been receiving continuous improvement in the art of obtaining photographs and draws of the same shapes, sizes, and positions of the objects contained in them (qualitative and quantitative information).

Currently, the increasing search for a geometric accuracy, the acquisition of spatial data is an activity that has used the digital photogrammetry, and consequently has been an important source of motivation for its development.

Photogrammetry is the set of techniques aimed to obtain quantitative and reliable information of photographs (FITZ, 2000). It is important to highlight that the photograph shows a two-dimensional image of a three-dimensional system, so itself does not allow the reconstruction of three-dimensional objects contained therein.

According DELMAR (1977), the length of an airport runway, a street, the position of a road, tracing contours, determining the elevation of a waterfall, the relative position of two cars after a collision, are some examples of an almost unlimited application of photogrammetry. With these examples we may have a slight idea of the importance of geometric precision in orthophoto maps, otherwise, a plane could land off the runway, or the height of a relief could be given in error, or even the position of an accident could be imprecisely determined.

It is important to remember that photointerpretation is different of photogrammetry in relation to the processing. Photogrammetry is related with the positional accuracy and geometry of the objects, quantitative aspect; while the photointerpretation is related to the significance of the object, the qualitative aspect.

The orthophoto maps are achieved through a set of aerial images, taken, for example, from an airplane or satellites, which have been corrected digitally for represent a vertical projection, whereby it is possible to perform accurate measurements.

With the resources presented previously, and using mathematical models applied concomitantly with computer technologies, we have in the geoprocessing a tool for checking the quality of orthophoto maps of Recife city. According to Silva (2003), geoprocessing represents any kind processing of georeferenced data.

To improve the quality of photogrammetric activities and consequently the geometric quality of orthophoto maps, SATO (2003) proposed a model of control of processing of Digital Aerial Photography called quality control system of the processes (QCP), that has as its basic philosophy to identify systematic problems in the process of production by reducing or eliminating errors.

Nero (2005) reports that the QCP is based on the guidelines of specifications of ISO 9004-1 (1994), and is divided into two parts: the first corresponds to the Module description

of Procedures, responsible for the description of the rules, regulations, work instructions, corrective actions and documentation of procedures performed, whereas the second part corresponds to the quality control of photogrammetric processes which is presented by SATO (2003), where are incorporated sets of methods, techniques and quality parameters, which help in monitoring and verification of the quality of each photogrammetric process used in the production of spatial data.

When we do the checking of the geometric quality in the orthophoto maps at each stage of its production, with respective records of its evolution, the geometric quality of the final product, according SATO (2003), becomes much better. It turns out that for the purpose of checking the quality, it is necessary to compare the material measured with a source considered as standard of comparison. The values of this standard of comparison can only be obtained in three ways: field survey, a product more accurate or a reference model that serves as a parameter.

NERO (2005) presents in his work a mathematical model, shown in equation (1), which may indicate the geometric precision of a orthophoto map according to the records of the errors in the various stages of its production, assuming there is no correlation between them.

$$\sum product = \left(\sum \text{sup}^2 + \sum photo^2 + \sum aerot^2 + \sum orientation^2 + \sum collection^2 \right)^{1/2}$$

Where:

$\sum product$ = expected error of the final product

$\sum \text{sup}$ = Error process of support photogrammetric

$\sum photo$ = Error in photos

$\sum aerot$ = Error in the aerotriangulation

$\sum orientation$ = Error guidance process

$\sum collection$ = Error process collection of spatial data

With the mathematical model above, we can check the geometric quality of an orthophoto map, and in function of this quality take decisions to locate the possible errors in acceptable parameters of safety and quality. As highlighted by MERCHANT (1982), the positional accuracy of the values considered as standard, must be at least three times better than the expected error or standard error permissible, which is 0.3 mm.

According GEMAEL (1994), the errors, as in many other cases, have the behavior of a normal distribution function, characterized by a curve of GAUSS. To obtain the probability corresponding to an interval, integration of this function can be performed between the points defining the break, consulting appropriate tables or using specific software.

When working, for example, with a two-dimensional system which may be associated with an area, a front, a boulevard, etc. the total error is obtained using equation (2):

$$et = [(\Delta N)^2 + (\Delta E)^2]^{1/2} \quad (2)$$

Where:

et = total error in position

ΔN = error in coordinated N

ΔE = error in coordinated E

This equation allows finding the metric difference between the position in mapping

and the "real" one or of comparison.

Through statistical calculations and probability we can work in a composite function of two normal distributions of dimensions x and y, which determine the probability of the confidence intervals of the region of interest and their respective standard deviations. Taking into account that it is a two-dimensional approach, the standard error being considered is given by equation (3).

$$\sigma_c = [(\sigma x^2 + \sigma y^2)]^{1/2} \quad (3)$$

The isolated examination of coordinates has the advantage of enabling the detection and elimination of systematic errors in the geometric accuracy of one or two planimetric components.

In the three-dimensional approach, coupled with the idea of volume and / or space, it is also possible to work a normal function of distribution, and apply statistical calculations and probability in the detection of geometric intervals trusted with their respective standard deviations. In this case, it is still possible to detect errors in their geometric variables, but the models become much more complex.

In the case of checking the geometric quality of a orthophoto map, in a region like the Metropolitan Region of Recife, in Brazil, don't forget that we work with a lot of orthophoto maps, and each one, or some, may correspond to a different cropping of aerophotogrammetric models. In this case, NERO (2005) proposes a control methodology and systematic mapping as a whole, considering a continuous mapping and not each leaf as an autonomous and isolated unit.

In his thesis, NERO (2005) reports that in the case of control through field survey it is recommended the achievement of the prior recognition and planning to avoid the displacement of a point theoretically good, when chosen in the office, but its location in field is, for example, difficult to access. And finally, in the case of the GPS survey, one must maintain a continuous reception from the satellite during the survey.

4. METHODOLOGY OF THE RESEARCH

This project will be based on literature review, which will provide important information about the disability in orthophoto map accuracy of the Metropolitan Region of Recife in 1974 and 1988, and how to resolve such difficulties with mathematical tools and accessories that also work as mathematical models.

The verification of geometrical quality of the orthophoto map will be valued taking into consideration that the good quality of the final product depends on the method of mapping production and of the care taken in the different steps. The geometric quality should follow well-defined standards, regardless of the technology used in the cartographic production. This may be the aerial photography, supported with direct survey in field by conventional surveying and / or using the GPS, but always observing the care needed at each stage, making their records, and following well-defined standards of geometric verification.

In Brazil, the decree No. 89817 of 20 June 1984 establishes the Regulatory Institutions of Technical Standards of the National Cartography in BRAZIL (1984), dealing with topics such as: control of the process and the final product, with its classification, the required elements of a charter, the Brazilian Geodetic System and others. The records of errors at each stage of cartographic production will be faced with the benchmark, and the results will be of

great importance in checking their geometric quality.

Some procedures in controlling geometry of orthophoto maps will be observed in order to preserve its quality. Initially this will be done by overlapping vectors to raster files obtained from the photolithography, and the four corners of the sheet must coincide with the coordinates numerically entered in the system. That is, the corners of the vector files on the sheet that perfectly overlaps the corners of the raster files.

Another procedure of control of this quality that also will be observed is associated with the topology, consistency of information levels, colors and other details set in IBGE (2001), which presents methodologies for validation of the scanning process. As for the management geometry, in BRAZIL (1984) has control standards that ensure optimal parameters and the minimum checking of the geometric quality of orthophoto maps.

The purpose of this methodology is to validate the geometric quality of orthophoto maps verified. In this case, it is recommended and required the generation of vectorial files having as input material the photolithographs of cartographic documents, because they are more dimensionally stable. As regards the vectoring parameters, NERO (2005) recommends that the distance between the vertices of an element in excerpts of sharp curve not exceed half of error chart of topographical, as shown in Table 1. Having the vector file within the control parameters is very important for the quality of the geometric accuracy of orthophoto maps.

Table 1 - Maximum distances tolerated to the spacing between vertices of lines or vector polylines.

SCALES	**TOLERANCES (m)**
1:25000	2,5
1:50000	5,0
1:100000	10,0
1:250000	25,0

Source: Adapted from IBGE (2001)

If the vector file is failing in its geometric quality, the same shall be subjected to a process of correction and subsequently subjected to further analysis as the standard described above. If approved, its geometric verification can be converted successfully to the Brazilian Geodetic System existing.

During the literature review will be identified whether or not of problems as the geometric precision of orthophoto maps by manipulating of the appropriate equipment, and application of mathematical models using appropriate software such as ArcGIS. These problems, when identified, will be studied in the light of its mathematical models that enable its evaluation in order of obtain the geometric quality of the material.

To better direct the work it will depart from the simplest situations as the identification of simple benchmark, which involves simple equipment and the use of models already available, to situations of greater complexity where is required differential equations, with actual analysis applications, or Rn, used concomitantly with software available on the market.

After highlighting some models applied in the solution of geometric deficiency of orthophoto maps in study, comparisons will be made using these methods of statistical tools. Then will have an overview of the problems associated with geometric accuracy of orthophoto maps.

5. EXPECTED RESULTS AND IMPACTS

The expected results are:

5.1 To indicate the geometric quality of orthophoto maps in the Metropolitan Region of Recife in the years of 1974 and 1988.
5.2 Show that the best method checks the geometric quality of these orthophoto maps.
5.3 With the result, it will be possible to analyze orthophoto maps without the problem of disability in geometric precision, for applications in the area of urban control and monitoring.

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