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Evaluation of the Cartographic Accuracy of the DEM Generated by a Stereo pair of Images Ikonos

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Abstract

The purpose of this paper is to present the results of the assessment of Digital Elevation Model (DEM) generated from the IKONOS images stereo pair. The DEM was generated by an automated photogrammetric process in the software ERDAS LPS ATE. The methodology is based on rational function polynomial using the Rational Polynomial Coefficient (RPC) as the main information on triangulation and DEM extraction. The DEM is a cartographic product key for study and analysis of altitude. So evaluate the accuracy of even become indispensable for these product is reliable source of information for project about environmental management and territorial planning. Were used to evaluate the parameters required by Padrão de Exatidão Cartográfica (PEC). The study area was the city of Luís Alves, situated in the northern state of Santa Catarina.

Keywords: Rational Polynomial Coefficient, Process photogrammetric rational function polynomial

1. Introduction

Many cities and rural communities are settled in natural sites subject to natural phenomena that present a danger to the population, such as floods, landslides, high winds, and earthquakes, among others. The generation of these hazardous phenomena with high frequency and/or magnitude can cause since many disasters accidents, damages, including loss of life. The development of many regions and countries could be affected by the occurrence of such disasters, because economic resources are lost at the time of occurrence of the event and also spent on reconstruction, which leads to a vicious circle, since the economic resource is spent in emergencies and reconstruction rather than on prevention.

In this sense this search discloses the cartography as a fundamental instrument for planning, management and monitoring of areas considered at risk. For this case study were chosen the scenarios susceptible to risk of slipping on the Sub-basin of Luís Alves river, Santa Catarina, region which was greatly affected by the rains of November 2008.

The methodological referential of the survey was to create a computational procedure of spatial modeling, based mainly on the assessment of the potential of stereoscopic image pair of IKONOS II. By means of digital photogrammetry was possible to view 3D terrain surface and the generation of a digital elevation model

(DEM), which resulted in the orthorectification of the image and subsequently in the making of the Cartographic base.

An essential tool in this process are the satellite positioning systems that is becoming increasingly popular today, by collecting accurate coordinates on field, you can assess a greater degree of precision and accuracy when the orthorectification of satellite imagery.

These coordinates have been corrected already passed on to a Microsoft Excel spreadsheet, which were later transformed into a shape file to be used as control points in ERDAS/LPS software. This software aims to extract the DEM and the IKONOS II Satellite image of orthorectification, for the purpose of generating a Cartographic base for further studies, such as the determination of risk scenarios. In this way this article describes the phases of GPS data collection and processing, as well as the stages of image orthorectification.

2. Theoretical Reference

2.1. Satellite image IKONOS II

The stereoscopic pair of images used in this article was obtained by IKONOS II Satellite sensor. This sensor gets images with spatial resolutions of 1 meter in pan, and 4 meters in multispectral. It also has 11-bit radiometric resolution, related to the largest number of gray levels, which allows for greater differentiation and contrast of objects. The IKONOS II Satellite images are well-regarded in the market, providing high resolution images and still allow viewing of quality and accuracy in three dimensions. A stereoscopic pair IKONOS II consists of two scenes acquired for the same geographical location of Earth, obtained in two different perspectives during the same passage of the satellite.

Currently the satellite has been used for national security, military mapping, air and sea transport and by regional and local governments, and is being available for commercial sales. Finally, the satellite has a special feature, presents the stereoscopic pair, which allows the viewing of the image in three dimensions, thereby facilitating interpretation of certain features, such as roads, buildings, necessary for the planning and survey of control points, as well as allowing the interpretation of geomorphology of the terrain, water splitters, mains drainage, required to parse the areas susceptible to flooding, floods and mass movements.

2.2. Orthorectification

The orthorectification and based on a mathematical basis, reflecting the geometrical and geometry of the Earth's surface captured by the sensor. This takes into account the distortions that occur in the formation of these image distortions and for platform, sensor, the Earth and the map projection (Okida, 2003). An image is not ortho cannot be taken as a source of information secure metric, since it has mistakes due to rotation of the sensor and displacements due to the mountainous terrain of the Conic perspective. Already the image in orthographic projection can be taken as a cartographic document (Brito, 2002). The orthorectification is a reduction of distortions caused by terrain, i.e. vertically adjusts the image to the relief of the terrain, with the goal of obtaining images with high quality internal accurately geometric better than twice the spatial resolution.

3. Methodology

3.1. Use of ERDAS for the orthorectification of satellite image IKONOS II

For the orthorectification of satellite image IKONOS II, it was used the Leica Photogrammetry Suite software (LPS). This is full digital photogrammetry software developed and marketed by ERDAS Imagine. There is more than one model of LPS to achieve different functions. For this research license has been used LPS ATE, which allowed the automatic extraction of the DEM. In obtaining image IKONOS II were also provided the Rational Polynomial Coefficients (Rational Polynomial Coefficient-RPC) to each band (Figure 6). The RPC expresses the relationship between the object and the space-image; these come separately in a txt format file. This file is the data about the geometric representation between the ground and the image. This file has the photogrammetric process through image processing packages of LPS (Figure 7), without the need to have access to the physical model of the satellite camera (Lutes, 2004).

Figure 6: Data from PRC

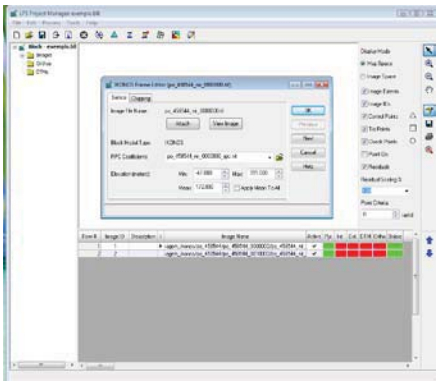

Figure 7 – Application data from rpc

After insertion of the outdoor and indoor guidance via RPC, the next step was to add the control points (GCPs) that were tracked in the field by GNSS Receiver, as shown in Figure 8.

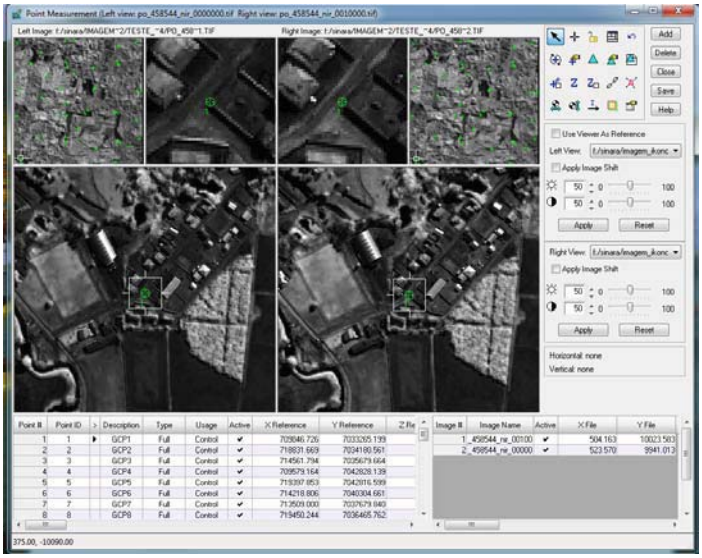

Figure 8: Currently LPS window add the GCPs (control points).

Using a Microsoft Excel spreadsheet, developed with the processed, were added the coordinates (X, Y, Z) of each point collected in the field. Then identified these points both in the image on the left and the right (figure above). To improve the process, were added 35 tie points (points of adjustment that assist in securing image), which were distributed proportionally.

The next stage of the project was to extract the image pair DEM. The LPS allows five types of output files; DEM, TIN, 3D Shape, ASCII, LTF. The type chosen was DEM (Digital Elevation Model). Even adding these files outside of the final DEM presented the minimum elevation as negative, indicating that there were holes in the model in two distinct areas of the image. In the floodplain and at the peak of the highest hill. It is believed that the negative value is due to the minimum and maximum values shown in the RPC. The same features as the minimum altitude -24 meters and the maximum value as 528 meters. According to the IBGE topographic quotas for this region range from 10 to 580 meters. As not obtained good results, sought an alternative to improve the template. SRTM used the as an external DEM to improve product quality.

On the EPAGRI/SC website is available for download the SRTM (Shuttle Radar Topography Mission) refers to the State of Santa Catarina. So it was done downloading the file for the Itajai-Açú River watershed with a spatial resolution of 30 meters. Then was cutted just the area of interest, represented by the limits of the image IKONOS II, so as to take an ideal representation of altimetric data information, aiming at the junction the data area. You can see an improvement with the insertion of SRTM, since the minimum elevation reached 0 and the maximum value to be 524 meters. As the study area is very close to sea level this value is acceptable. Thus, you can generate a regular grid with DEM and level curves with equidistance of 10 meters, which was used for the orthorectification of the image.

From the generation of the DEM was executed the orthorectification satellite image IKONOS II, using parameters stipulated by the software, obtaining as result the image shown in Figure 9. The process of orthorectification of high resolution images in commercial software like ERDAS/LPS becomes restricted, because the user does not have access to the processing parameters of template used. The only data used were the ortho image, the file containing the polynomial coefficients, the Digital Elevation Model and the interpolation method. If used the cubic convolution interpolation method. In this method the 16 pixels (4 x 4 windows) are taken into consideration and the cubic polynomial interpolation and held to each column fitting, then interpolate a new cubic polynomial to these results. The image produced by cubic convolution presents a better visual representation and also a better spatial accuracy.

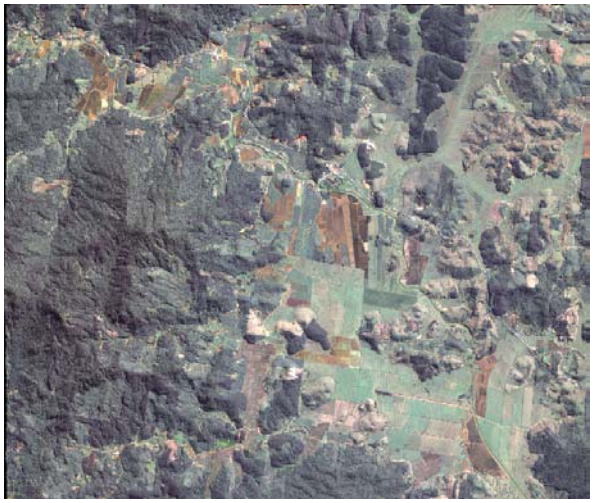

Figure 9: Ortho image IKONOS II

By not having access to the adjustment procedure as well as too not for the parameters of the transformation, the only way available to statistically evaluate the precision and accuracy of the DEM and ortho image, was the comparison of coordinates (X, Y, Z) raised in the field and in the image. For the evaluation of precision and accuracy of the ortho image was used the second GPS survey already described earlier. After comparing the data were assessed by applying the statistical analysis.

4. Findings and conclusions

During the preparation of this work were found difficulties obtaining manuals that describe the steps of DEM generation and ortho image. But have been developed and perfected methods using cutting-edge software on the market, ERDAS/LPS 2010 that has specific functions for handling spatial data. After you prepared this study can conclude how important it is to follow the steps, since the screening phase using a GNSS geodetic receiver to get precision points, obeying the rules for its use. As well as post-processing in the LGO software, for ensure that the control points were fixed and ready to be used as an aid to the orthorectification

of the image, given the millimeter precision required. Thus, with the use of the ERDAS/LPS software to the objectives defined at the beginning of the survey, the ortho image IKONOS II can generate DEM products in scale of 1: 25,000 altimetric data and 1:10.000 planimetric data. Considering the reviews, taking into account both considerations the Cartographic Accuracy standard – (*Padrão de Exatidão Cartográfica*) - PEC – in class A.

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