ACCURACY ANALYSIS OF DIGITAL ORTHOPHOTOS

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ABSTRACT:

Digital orthophotos are used by many professionals in land management and fields such as planners, foresters, soil scientists and zoning administrations. As the field of photogrammetry moves to the digital domain, the increasing numbers of digital photogrammetric systems (DPS) appear in the commercial market. DPS can produce digital orthophoto product with greater speed, lower cost, and an effective interface to geographic information systems (GIS). However, a significant segment of the user community is still cautious about product accuracy of these new systems. The goal of this research is to theoretically analyze the main influential factors in the planimetric accuracy of digital orthophotos according to the production process of digital orthophotos in order for us to take some measures to control the quality of them ,and enhance user's belief for them.

1. INTRODUCTION

With the current growth in demand for digital spatial information, people pay more and more attention to digital products. The digital orthophotos, one of the digital products, become very popular because of its diversity of use. They can be integrated directly into GIS database, this is extremely useful for providing a base for a new data set or for updating an existing one. They are also a more accurate and a more readily usable data source for all kinds of applications than conventional data sources.

Digital orthophotos can be produced through digital orthorectification process based on interior and exterior orientation elements of air photograph and DEM. Digital orthorectification is a process that employs digital images processing and digital photogrammetric techniques. After digital orthorectification, the central perspective image is transformed into an orthogonal projection. It often implement on softcopy photogrammetry workstation. The softcopy techniques rely on film-based aerial images that are converted to digital form using high accuracy photogrammetric scanners. These softcopy images are the primary input to the digital differential rectification process. Other inputs include the camera calibration information and measured fiducial coordinate for the determination of the interior orientation; ground control information and measured image coordinates for the determination of the exterior orientation parameters of each image; a corresponding digital elevation model for the determination of the elevation of each elevation of each elemental area to be orthorectified in the image. Production of digital orthophoto map (DOM) involves many production steps, each of which exists errors that are propagated into the final product. If care is taken to limit the magnitude of error of each production procedure, the resulting digital product can constitute a highly accurate geometric reference.

At present, although digital photogrammetric system (DPS) can efficiently produce digital orthophotos, its accuracy is doubted by the most users. In order to make digital photogrammetric products accepted widely, it is necessary to analyze the accuracy of them.

There exist many factors that affect digital orthophoto accuracy. In this paper, we mainly discuss several important factors as follows: scanning resolution, the accuracy of relative orientation and absolute orientation, the accuracy of the ground control, the accuracy of image matching and the accuracy of DEM used in the orthorectification process.

2. SCANNING RESOLUTION

Because the digital photogrammetric workstation(DPW) relies on scanned aerial photographs for its input data, the accuracy of digital photogrammetric products is contingent on the ability to convert an analogue aerial image into digital image. It is important to select the correct scanning resolution so that the original image quality can be preserved. Scanning high resolution images down to the granularity of the film emulsion would require a pixel sizes less than 1 micrometres. It is neither possible due to limitation of scanner optics nor feasible due to the extremely large digital files. Therefore, there is a need to balance the requirement to preserve original image quality and storage.

Trinder (1987) discusses the issue of reducing pixel sizes so as to do justice to original analogue image resolving power, and he found that deterioration in image quality become more significant as the scanning aperture size increases beyond 25 micrometres. Thus the selection of the scanning aperture size is critical to ensuring good image quality and limiting image file sizes. In practical work, scanning resolution uses 25 micrometers.

3. INTERIOR ORIENTATION

Interior orientation is a process that establish relationship between scanning coordinate system and image coordinate system and rectify the probably error exsited in digital image. The interior orientations are based on the measurement of the photo fiducials, so measurement accuracy of photo fiducials determines the accuracy of interior orientation. As to the most digital photogrammetric systems, an accuracy report of interior orientation is real time offered.

4. RELATIVE AND ABSOLUTE ORIENTATION

In order to establish a model similar with real terrain surface, orientation of stereo pairs must be done. Determination of orientation of stereo pairs can be completed in two steps: relative orientation and absolute orientation. The purpose of relative orientation is to determine the relative positional relationship between two images of stereopair. Relative orientation includes three steps. First, search for conjugate points through image matching; second, use conjugate points to compute relative orientation elements (b_y,b_z, ϕ , ω , κ); third, compute the three-dimension coordinates of the conjugate points. After completing relative orientation, we can do absolute orientation. The aim of absolute orientation is to relate image space to object space. This process can be completed through a transformation of coordinates using ground control points.

From above discussion, we know that the accuracy of orientation is determined mainly by accuracy of image matching and accuracy of ground control points.

5. ACUURACY OF IMAGE MATCHING

Image matching is the basis of photogrammetric automation. The basis of image matching is the determination of the location of a point in conjugate image by matching gray-scale values in the two images. To do this, the x-parallax between the conjugate points within the stereo overlap of a photogrammetric model can be determinated. Since the different in parallax magnitude is a function of the height defference. The x-parallax different are used to determine the elevation of points relative to one another.

The accuracy of image matching is determined by image quality and the matching techniques employed. Image quality is related to the source image quality and the resolution of scanned image. Good source image quality and high resolution may help for improving accuracy of image matching. At the same time, we must consider storage space. Using high resolution to scan image can increase volume of data and thus need large storage space to store image, and increase labor.

If aerial photography has a good quality, image matching can be more precise than stereoscopic measurement in an analytical plotter (Ackermann, 1994). The practical precision of image matching by least squares correlation is in the order of 0.1 to 0.2 pixels. Although image matching has an advantage over conventional manual stereo measurement, the ultimate success of image matching depends largely on the quality of the scanned image and on image texture. Because image matching by correlation is based on matching gray-scale values in corresponding images, matching algorithms can become confounded if the image are lacking in radiometric quality, tonal differences. In addition, image matching can be further impeded by occlusions and height discontinuities caused by obstacles such as tall buildings, bridges or trees.

6. ACCURACY OF GROUND CONTROL POINTS

Ground control points also have effect on planimetric accuracy of digital orthophotos. The role of ground control is to determine the exterior orientation elements of each photograph. The accuracy of ground control points affects that of exterior orientation elements and then affects accuracy of digital orthophotos. The accuracy of the ground control affects the accuracy of the digital orthophoto. Relative accuracy in an orthophoto is directly related to photo scale, but its absolute accuracy depends largely upon the quality of the ground control information used to orient the image to the ground space . Moffitt and Mihail (1980) suggested that, for large scale photogrammetric products, ground control accuracy to at least second order specification is required. In order to assess orthophoto accuracy, the uncertainty of the ground control information must be of a lower magnitude than the measurement noise in the image.

With the developing of Global Positioning System (GPS), it is widely used for ground control. Because GPS signals are affected by the ionosphere, one must guard against the ionosphere delay that GPS signals encounter. By Simard (1990) testing, the use of single frequency data would be adequate to achieve the relative accuracy of ± 3 centimetres. Other issues to consider include the number and the distribution of GPS control point.

7. DEM GENERATION

The effect of DEM on planimetric accuracy of digital orthophotos is in detail discussed. The role of the DEM is to eliminate terrain induced displacement so as to transform a central perspective to an orthogonal projection. DEM quality is a very important element of the orthorectification process as it can greatly influence the accuracy of planimetry in orthophotos. The quality of photogrammetrically generated DEMs depends on a number of factors including the accuracy of elevations making up the DEM, the density or spacing of the elevation points in the DEM, and the accuracy of image matching.

The density and distribution of terrain points in a manual collection process are judged by the instrument operator according to terrain roughness, and required point density is in practice selected on the basis of sampling theory. In DEMs that are produced automatically by image matching, the grid spacing is not dependent on an interpolation scheme. This is because the grid elevation are not determined from just a few surrounding points using an interpolation algorithm but from numerous and densely distributed elevation observation automatically with the vicinity of the grid point. The result is that the accuracy of an automatically generated DEM is generally much better than that of a DEM produced using conventional methods. For photogrammetrically generated DEMs, their accuracy is a function of both DEM point density and the scale of the image used to generated DEMs.

8. ORTHOPHOTO GENERATION

The process of orthorectification differentially transform, on a pixel-by-pixel basis, a central perspective image to an orthogonal projection. This approach is a rigorous rectification in that it takes into account directly the ground surface elevation variation by incorporating into the solution a gridded DEM. In order to assess the accuracy of orthophoto, the image coordinates of control points within digital orthophotos produced can be measured and compared to their actual ground surveyed values. Computing the control point coordinate differences between the measured value in the orhtophotos and the actual ground surveyed values, and then use root mean squared error to indicate the accuracy of orthophotos.

9. CONCLUSION

Production of digital orthophotos deals with many steps and each step imports some errors which can propagate to digital orthophotos. The motive of this paper is to investigate the accuracy of digital orthophotos using DPS. Some main factors that affect digital orthophoto accuracy involve scanning resolution, relative orientation and absolute orientation, the ground control, image matching and DEM used in the orthorectification process and their effect is simply discussed. Because accuracy assessment of digital orthophotos is a complicated issue, The method of combining theory with practice is a suitable one.

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