Partial Distortion Correction of Remote Sensing Image Rectification Error

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Abstract

At present, geometric rectification of remote sensing image mainly uses the method of digital rectification in which control points is very important to image rectification quality. In actual work, accuracy of control points always is affected by many factors that cause partial distortion in rectified remote sensing image. Partial distortion error existing in rectified remote sensing images is not paid much attention to, and many remote sensing processing software lacks ability to deal this problem.

This paper presents a method to check and display partial distortion error by overlaying remote sensing image and digital raster graphics (DRG) or digital line graphics (DLG) with the support of image roaming and scaling, which visually shows whether partial distortion exists or not in rectified image. To solve the problem of partial distortion, triangle transformation algorithm, a scheme of disassembling polygon into multi-triangles, the principle of triangle geometric distortion are introduced.

In the experimental research, this paper selects aerial image and 1:10,000 topographical map to match and to be rectified. In the first, digital raster graphics (DRG) is generated from 1:10,000 topographical map rectified by ERDAS remote sensing image processing software, then 16 points are selected separately from aerial image and DRG, image rectified by polynomial equation in ERDAS with the reported mean error of 3.3887 pixels, image distortion error is checked by overlaying DRG with rectified image. In flat area, distortion can not be observed, and in mountain area distortion is obvious. With the software developed under Windows using simplified algorithm paper presented, partial distortion is corrected in two steps with different quad size. Partial distortion rectification is done in the environment of image overlaying, so it guarantees correctness of partial distortion.

Partial distortion rectification is very fast because rectification area is small, calculation amount is also small. Results show that algorithm paper presented is feasible. Further research will be focused on overlaying image with image having different time phase, different remote sensing source and distortion rectification inside arbitrary polygon.

Keywords remote sensing image, rectification, error, partial distortion

1 Problem

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In the processing of information extraction from remote sensing, extracted information always be projected into a certain mapping system in order to make geometric measurement, comparison, fusion, analysis and so on. In remote sensing image processing and application, it is an important step to project remote sensing image into a mapping system correctly without distortion of geometric position, shape, length, direction of objects on image[1].

At present, geometric rectification of remote sensing image mainly uses the method of digital rectification. In this method, a number of corresponding points are selected separately from remote sensing image and projection reference system, a strict mathematical equation is established between remote sensing image and projection reference system using selected points as control points, then image can be rectified pixel by pixel using this mathematical equation. However, in actual work, accuracy of control points always is affected by many factors, such as irregular image distortion introduced by topographical undulation, earth rotation and etc, scanned map, as an usual mapping system, can be distorted by factors of paper distortion and scan machine. The error in control points will make inaccurate mathematical equation that will generate errors in rectified image.

This paper presents a new approach of partial distortion correction of remote sensing image rectification error after analysis of rectified error. This approach can be used as a quality checking method of rectified image, and also be a supplement of current image rectification software.

2 Visualization of rectification error of remote sensing image

The rectification accuracy of remote sensing image can be reflected by a value calculated by several checking points, such as mean error. If partial distortion is too big or checking points are not well distributed, the value calculated by checking points can not well reflect quality of image rectification. With the further development of digital photogrammetry and digital earth, remote sensing image rectification using digital raster graphics (DRG) and digital line graphics (DLG) is extensively applied [2]. Image rectification quality can be visually checked by overlaying DRG or DLG with rectified image with the support of image roaming and scaling. Figure 1a, 1b visually show whether distortion exists or not in rectified image.

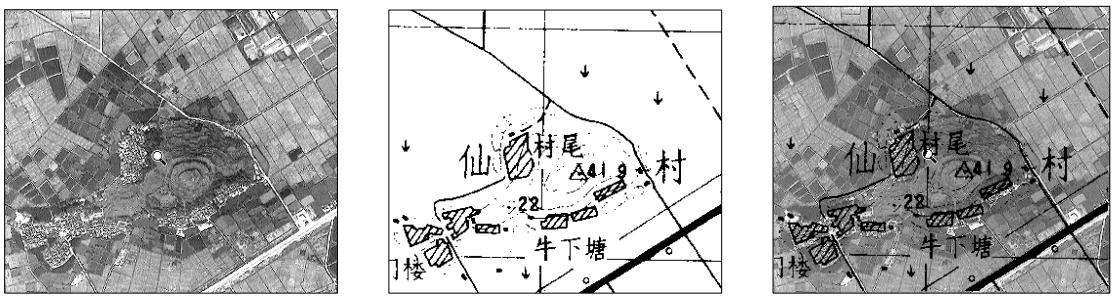

Figure 1a Overlaying DRG with rectified image（no partial distortion）

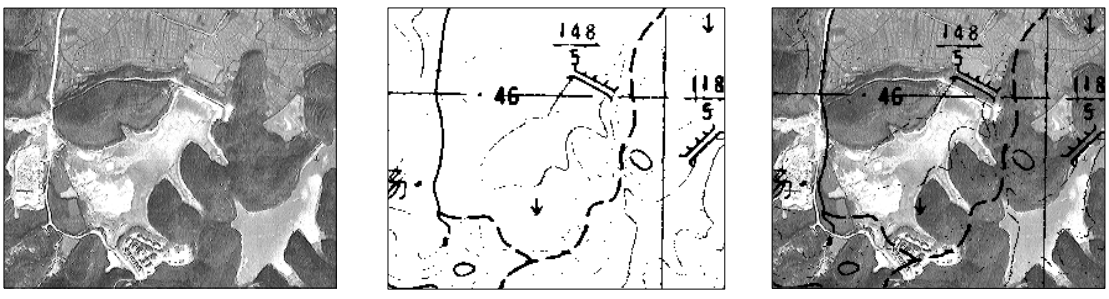

Figure 1b　Overlaying DRG with rectified image（partial distortion）

3　Partial distortion algorithm based on triangle transformation

3.1　Partial area triangle-disassembling

The errors in rectified image are from many factors，and their distribution is not regular. To correct errors, image distortion should be in a small area or a region. In figure 2a, point 6 should move to 6', and distortion should happen in the polygon made by points 1,2,3,4,5. The principle of partial distortion is that distortion should happen in the interior of polygon, angular points of polygon should not be changed. To implement the principle, this paper disassemble polygon into several triangles (shown in figure 2b). Partial distortion rectification can be solved if triangle can transform to triangle continuously (such as triangle 1,2,6 to triangle 1,2,6').

3.2　Triangle transformation

This paper presents the following algorithm for geometrical transformation of triangle (1,2,3) and triangle (1,2,3') in figure3:

1) Calculate transformation in X direction, Dx and Y direction, Dy between point 3 and point 3'. Dx and Dy for point 1 and 2 are set to zero.
2) Calculate intersection point 4a and 4b along horizontal line of rectified point 4
3) Calculate Dx and Dy for point 4a and point 4b linearly according to Dx and Dy of points 1,2,3 along line of 1,3 and line 2,3.
4) Calculate Dx and Dy for point 4 linearly along the line of 4a, 4b according to Dx and Dy of point 4a and point 4b.
5) The new position of 4 in new triangle (1,2,3') should be: X=X+Dx and Y=Y+Dy

According to the same algorithm, triangle can be transformed inversely. Base on geometrical transformation above and image re-sampling, partial distortion of triangle can be realized.

4　Implementation and analysis of partial distortion rectification

4.1 Implementation of partial distortion rectification

To realize algorithm above, this paper simplifies distortion algorithm in the experimentation. The simplified method is dividing image into grid, this means polygon in figure 2 is simplified as quad, and distortion is only within quad every time, four triangle is formed with one distortion point and four quad angular points shown in figure 4. The size of quad can be adjusted according to actual partial distortion.

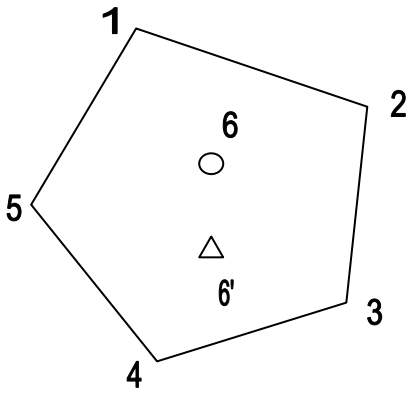

Figure 2a. Partial distortion

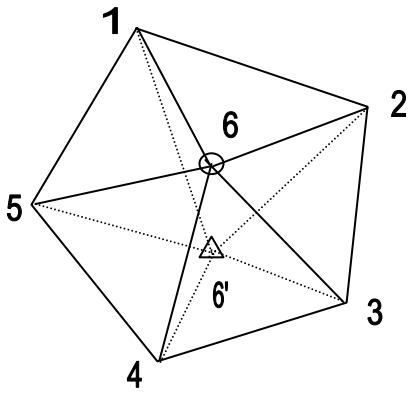

Figure 2b. Partial area triangle-dissolving

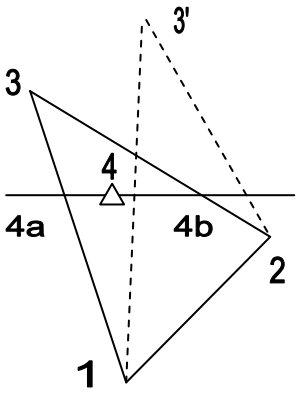

Figure 3. Triangle transformation

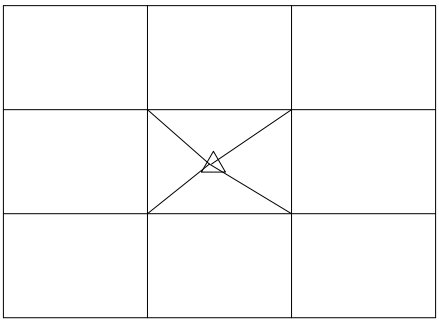

Figure 4. Simplified distortion algorithm

4.2 Example and analysis

In actual research, this paper selects aerial image and 1:10,000 topographical map to match and rectify. First, digital raster graphics (DRG) is generated from 1:10,000 topographical map rectified by ERDAS remote sensing image processing software, then 16 points are selected separately from aerial image and DRG, image rectified by polynomial equation in ERDAS. The mean error is reported as 3.3887 pixels, image distortion error is checked by overlaying DRG with rectified image. In flat area, distortion can not be observed (shown in figure 1a), and in mountain area distortion is obvious (shown in figure 1b).

In the experiment, distortion rectification software is developed under Windows and is used to rectify partial distortion in figure 1b in two steps. In the first step, a large quad is used, and dam is moved and matched (shown in figure 5a), in the second step, a small quad is used, the edge of reservoir is adjusted (shown in figure 5b). In figure 5, white crosses in ellipse are angular points of quad. After two step rectification, match in this area is good. Partial distortion rectification is done in the environment of image overlaying, so it guarantees correctness of partial distortion. Partial distortion rectification is very fast because rectification area is very small, calculation amount is also small.

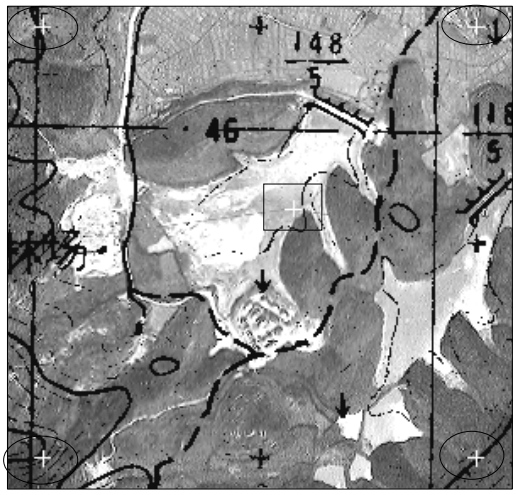

Figure 5a The first step of partial distortion

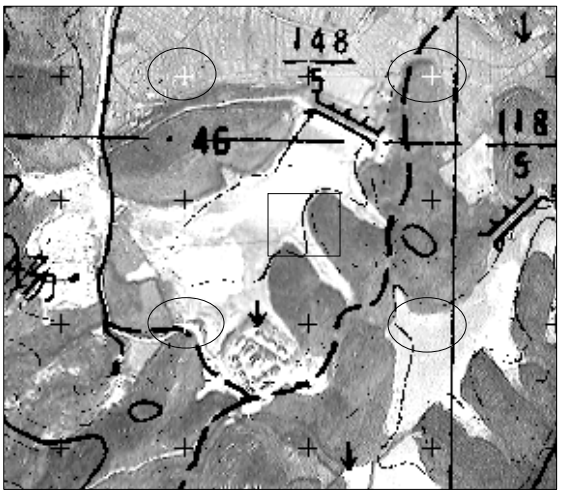

Figure 5b The second step of partial distortion

5 Conclusion

Rectification error existing in rectified image is a common problem. Rectification error, existing in partial area, distributes irregularly. At present, remote sensing image processing software, both in China and abroad, all focus on rectification of image using mathematical equation generated from control points, and ignores partial distortion. This paper have done preliminary research on partial distortion rectification based on overlaying digital raster graphics and remote sensing image to discover distortion error visually. In preliminary research, this paper obtains good results using simplified algorithm. Further research will be focused on overlaying image with image having different time phase, different remote sensing source and distortion rectification inside arbitrary polygon.

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