RECTIFICATION OF HIGH-RESOLUTION SATELLITE IMAGES USING AN APPROACH OF IMAGE SERIES

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ABSTRACT:

In some circumstances, it is difficult to obtain highly accurate control data or suitable reference images for rectifying high-resolution satellite images. And using the rectified low-resolution images to rectify high-resolution images cannot get high accuracy of the results. To solve these problems, an approach of image series is proposed. Through analysis and experiment, it is proved that the approach of image series can guarantee the high accuracy of rectified high-resolution images, and it can act as a generalized method for rectifying high-resolution satellite images. It has practical significance in the task of rectifying a large amount of high-resolution satellite in the area that it is hard to obtain high accuracy control data.

1. INTRODUCTION

One of the important requirements of rectifying satellite images is the highly accurate control data, especially for rectifying high-resolution satellite images. There are some traditional methods to obtain the control data, such as selecting control points from the proper scale cartographic maps, or, getting high accuracy control data by field survey. In practice, many factors limit the use of these methods. For instance, it is difficult to acquire suitable maps, or those maps are out of date, remote areas are inaccessible for filed survey and so on. With the abundance of image data available, it is now common that high-resolution satellite images are rectified using the close resolution rectified images. But in reality, it is very difficult to find the close or higher resolution rectified images. On the other hand, the low-resolution images are getting easier to be obtained; therefore they are commonly chosen to rectify high-resolution satellite images. Obviously, the method will bring problems that the matching of control points would include larger errors, and the accuracy of rectified images will be affected due to the differences of resolutions. For example, large residuals will be found when an IKONOS image with 1m resolution is rectified using a TM image with 30m resolution. To address this problem, the method of high accuracy image matching techniques has studied. Tit is expected to obtain high accuracy of control data by performing image matching to sub-pixel accuracy, and good results have been achieved. But this technique is more complex to be used in practice and in the environment of volume-production.

At present, with the continuing launch of the remote sensing satellites, satellite images of diversified resolutions are available, and it is easy to form an image series for covered project areas. This paper designs a recursive rectification approach using the image series. The idea of the proposed approach is very simple: lower resolution satellite images are used to rectify high resolution images, then the rectified high resolution images are used to rectify higher resolution satellite images. The rectification processing component in this approach could be carried by any utilizing existing commercial software. Thus, it is practical and feasible, especially for mass production tasks.

2. THE PROCESSING FLOW CHART OF THE PROPOSED APPROACH

The processing flow chart of the proposed approach is shown in figure 1.

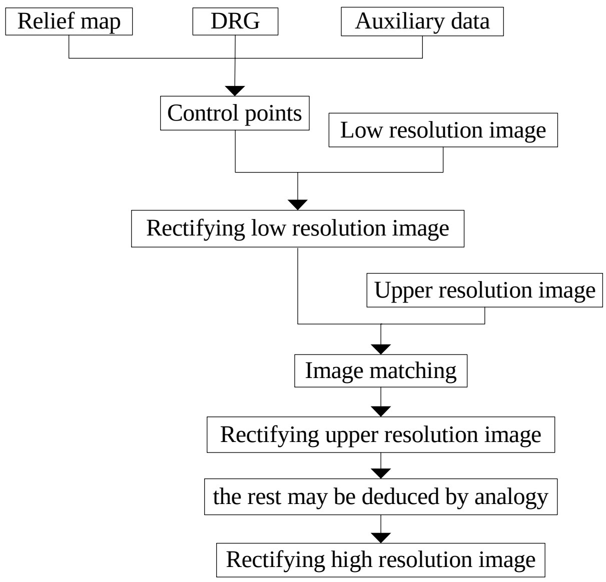

Figure 1 technique workflow

The pivotal processing includes as following:

(1) Rectifying low remote sensing images

Control points are collected from the cartographic map with a proper scale or digital raster graph (DRG). Because the low-resolution rectified images will be the base images for rectifying higher resolution images, it must pay great attention to the accuracy of control points. It would be preferred to using a rigorous rectification model for the low-resolution images.

(2) Matching of low-resolution satellite images with upper resolution

Features can be selected by extraction of edges and interest points. Features of lines and points selected would be considered as control data. Highly accurate matching of low-resolution satellite image with upper resolution image would be achieved using these features.

(3) Quality control

Because rectification of high-resolution remote sensing images with low-resolution images by the approach of image series is a repeat and indirect processing, so the final accuracy of rectification results will be influenced by the accuracy of each rectification processing. Therefore the quality control plays an essential role during whole processing. The quality control involves the accuracy check of the control data extraction, image matching, fitting model accuracy and the training of operators.

3. ANALYSIS AND EXPERIMENTS T

With above workflow, we can see that the proposed rectification approach has a few repeat rectification processing for different resolution images. As a consequence, the accuracy of final rectification results would be an integrated accuracy of the whole processing, not a simple linear combination. If the whole rectification processing includes *n* times rectifications, while $n = i$. Assuming the accuracy of rectification *i* is $\sigma_i(i, i+1)$, then the final accuracy σ is an implicit function of $\sigma_i(i, i+1)$. It could be shown as:

$$\sigma = f(\sigma_i)\ ,\ i = 1, 2, ..., n$$

According to the error propagation rule, the final accuracy σ is:

$$\sigma^2 = (\frac{\partial f}{\partial \sigma_1}\sigma_1)^2 + (\frac{\partial f}{\partial \sigma_2}\sigma_2)^2 + \cdots + (\frac{\partial f}{\partial \sigma_n}\sigma_n)^2$$

In order to check the final error rectification and analyze influencing factors, we establish two image series. The first image series is composed of a TM image (30m) and an IKONOS image (1m). The second image series is composed of a TM image (30m), a SPOT image (10m) and an IKONOS image (1m). For the first image series, we rectified the IKONOS image using the TM image directly (the TM image was first rectified using a relief map). For the second image series, according to the workflow shown in Figure 1, we completed two rectifications: the SPOT image which has been rectified using the TM image, then the IKONOS image was rectified using the SPOT image. Forty-seven control points were selected on the three images. Among them, 20 control points were used as the control points and the rest 27 points were used as the check points. We completed the rectification using the commercial software ERDAS for each single rectification (quadratic polynomial was chosen as the fitting model). The accuracy of the rectification is shown in Table 1:

Table 1 Comparisons of the rectification residuals (unit: meter)

Image Series	RMS of control points	RMS of check points
TM-IKONOS	5.760	7.925
TM-SPOT-IKONOS	2.128	3.117

Table 1 shows that the accuracy of high-resolution satellite image rectification based on the approach of image series is higher than the accuracy of the rectification using low-resolution satellite image directly. It shows that resultant accuracy is influenced by several factors and it is difficult to be shown as an explicit linear function. plain and application of quadratic polynomial are two of them. But the most important reason is that image could be regarded as having a crisp shape. The geometrical relation of the crisp shape is kept well. Although the accuracy of rectification is influenced by error spreading, the accumulated error is weaken after adjustment. On the other hand, the image rectification accuracy is improved by using the proposed approach of image series.

4. CONCLUSIONS

Analysis and experiments show that accuracy of image rectification is improved by using an image series instead of using the low-resolution satellite image directly. It provides a simple and practical solution to the condition that control data and image-rectified with suitable resolution are difficult to be obtained. To the different situations of getting data resource, similar problems would be resolved using this approach with appropriate modification. For example, the low-resolution orthographic aerial photos can be selected to rectify the low-resolution satellite images, then the higher resolution satellite images can be used to rectify higher resolution aerial photos.

The disadvantage of this approach of image series is due to the quality control in the rectification processing and workload increased. In the other hand, the final accuracy of rectification result must be checked and evaluated carefully through the course. Control of the influence of the factors will guarantee the implement of high-resolution satellite image rectification.

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