The Study of the Generalized Stereopair Matching Method

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Abstract— Traditional matching images method is required that remote sensing images must be obtained from same sensor in different times. If the region can't be covered by field view from one satellite sensor, images stereopair can't be acquired. It is necessary to match images from different satellites for getting the same overlap region. This method is called the generalized matching stereo pair. In this article, two images were selected for studying the generalized stereopair matching method, one was a QuickBird image, and other was a Spot image. Twenty six control points in same area in two images were selected for verifying the experimental results. The rate of success matching points was 88.5%. The result showed the generalized stereopair matching method was feasible and reliable.

1. INTRODUCE

The corresponding relationship between two or more points in the images is called image matching. The points set can be obtained from digitized images, maps, or GIS data et al.. Image matching method is widely used in the many fields, including navigation, aerial survey, satellite remote sensing, generation of DEM, three dimensional reconstruction, and military field et al. [1, 2].

The traditional method of images matching in the remote sensing field is researched for remote sensing images of the same sensor in different times. Although satellites can provide a lot of images on its flight path, the images in the region that sensor view angle can't be covered cannot be got. The images in some areas can't be got from satellite operator because of secrecy reasons. However the area without images may be interested, which is closely related national defense, economy, science and government major decisions and so on.

It is necessary to match images from different satellites for getting the same overlap region. This method is called the generalized matching stereo pair. This method has many advantages, such as enlarging the selection range of stereopair images, making full use of the existing data resources, saving costs, saving human and material resources.

2. CONSTRUCTION AND PROCESSING OF GENERALIZED STEREOPAIR

In photogrammetry and remote sensing, the stereopair is a pair of overlapping images taken from different stations. The stereo image points, lines and polygons constructed from any two images with overlapping areas is called generalized stereopair.

In this paper generalized stereopair was constructed from the multi-source images covering in the same area. The left and right images came from different sensors that their mechanisms were different. Therefore the spatial resolutions, colors and sizes of images were different. The left and right images should be normalized to facilitate automatic algorithm for matching the points with same position.

2.1. The Normalization of Spatial Resolutions

Before image automatic matching, left and right images spatial resolutions must be normalized. According to the spatial resolutions of the left and right images, the image resolution of high spatial resolution was lowered to low spatial resolution.

2.2. The Normalization of Colors

In this article, left image was a panchromatic image and right image was a color image, so left and right images should be unified into the same color space for matching images. The color image was transformed into gray image. The process of color image to gray image was calculated by each pixel by using the following formula:

$$Y = 0.3 * \text{Red} + 0.59 * \text{Green} + 0.11 * \text{Blue} \tag{1}$$

The standardized processing of image size was the last process. According to the small image size, the large image was subseted, the left and right images are coincident in size. Figure 1 was the standard image after processing.

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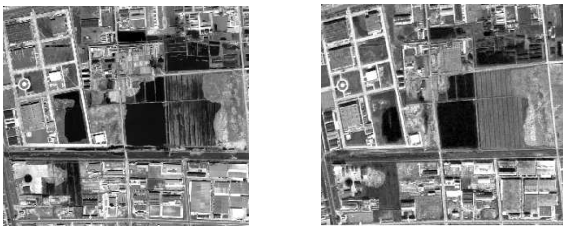


(a) (b)

Figure 1: Generalized stereopair. (a) Left image. (b) Right Image.

3. MATCHING METHOD

3.1. Gray Scale Match

The correlation coefficient and the least squares matching algorithms are most often used. The least squares algorithm can make full use of information within the image window for adjustment calculation. Its image matching can achieve high accuracy in theory and practice. Correlation coefficient can reach one pixel precision, and even reach sub pixel level after simulation of correlation coefficient.

3.2. Determining Layers of Pyramid

Top image matching can be carried out smoothly if the levels of pyramid are reasonable. The number of pyramid levels should be small and image distortion is small. Pyramid levels were determined according to the image size, the change in disparity, the size of matching window and other factors [3–5]. In this article pyramid levels were determined by the priori parallax. Several points were measured by artificial, then the parallaxes of these points were calculated and the maximum parallax $P_{\max}$ was estimated. If S pixels were searched on the top level matching, the pyramid levels N can be determined according to next formula:

$$p_{\max}/L^{N-1} = S * \Delta \tag{2}$$

Remark: The Δ in the formula is the size of pixel.

3.3. Theories of Correlation Coefficient and Least Squares Matching Algorithm

The commonly matching algorithms basing on gray scale are correlation function, covariance function, correlation coefficient, the absolute value sum and the mean variance of gray scale and so on. Among them correlation coefficient is the highest reliability, so this article adopted the correlation coefficient.

The correlation coefficient is defined as:

$$\rho(r,c) = \frac{\sigma(x,y)}{\sigma(x,x)\sigma(y,y)} = \max \geq T \tag{3}$$

In the formula, $\sigma(x,y)$ represents the covariance function of the target pixel gray and search area pixel gray, $\sigma(x,x)$ represents variance of pixel gray in the target area, ρ represents correlation coefficient. When ρ gets the maximum and (r, c) is the location of the same name point or the offset numerical, the threshold T is generally in the range of 0.6 to 0.8.

The correlation coefficient has good properties and can effectively eliminate the adverse effects of radiation on the matching results.

The geometric transformation parameters and radiation transformation parameters are introduced in the least Squares matching scheme. Geometric transformation parameters are used to compensate for the geometric difference between the two windows, and radiant transformation parameters are used to compensate radiate difference of pixel gray scale between the two windows.

Let the left and right images as f_1, f_2, g_1, g_2 is respectively corresponding to the matching window. For the size of the image matching window is very small, so higher distortion is ignored and linear distortion is left, the formula is followed:

$$\begin{cases} x_2 = a_0 + a_1 x_1 + a_2 y_1 \\ y_2 = b_0 + b_1 x_1 + b_2 y_1 \end{cases} \tag{4}$$

When taking the linear gray scale distortion into account between the right of the image and on the left image, the general model is followed:

$$g_1(x,y) + n_1(x,y) = h_0 + h_1 g_2(a_0 + a_1 x + a_2 y, b_0 + b_1 x + b_2 y) + n_2(x,y) \tag{5}$$

The error equation individually is established, its matrix is followed:

$$V = AX - L \tag{6}$$

Method of least squares:

$$X = (A^T A)^{-1} AL \tag{7}$$

The purpose of matching is to get the homonymy points, and the central of the window is usually taken as the point to be matched. However, in the relevant high precision image, the center of the window must be taken into account whether it is the best matching point. The accuracy of matching theory LS shows that matching accuracy depends on the window gray gradient $g_x'^2$, $g_y'^2$. The square of the gradient can be taken as weight, and the sum of weighted average coordinates can be got in the left window:

$$\begin{cases} x_t = \sum x g_x'^2 / \sum g_x'^2 \\ y_t = \sum y g_y'^2 / \sum g_y'^2 \end{cases} \tag{8}$$

Taking it as the target point coordinates, coordinates of its homonymy point can be obtained by the geometric deformation parameters, which can be got from the least squares image matching algorithm:

$$\begin{cases} x_s = a_0 + a_1 x_t + a_2 y_t \\ y_s = b_0 + b_1 x_t + b_2 y_t \end{cases} \tag{9}$$

4. EXPERIMENTS AND ANALYSIS

In this article, the experimental data were a QuickBird image and a Spot image from same region. After standard processing, the spatial resolution of QuickBird image was transformed into 2.5 meters and the size was 800×716 pixels, and the spot image spatial resolution was transformed into 2.5 meters and the size was 907×789 pixels.

The technical route of this article was followed. First, left and right images in the selected experimental area were unified into the same standard. Then the image of the pyramid was built, the reasonable initial matching points of the top pyramid image were selected.

The least squares method was adopted in the bottom pyramid, and the correlation coefficient method was adopted in the others. Matching flowchart was showed in Figure 2.

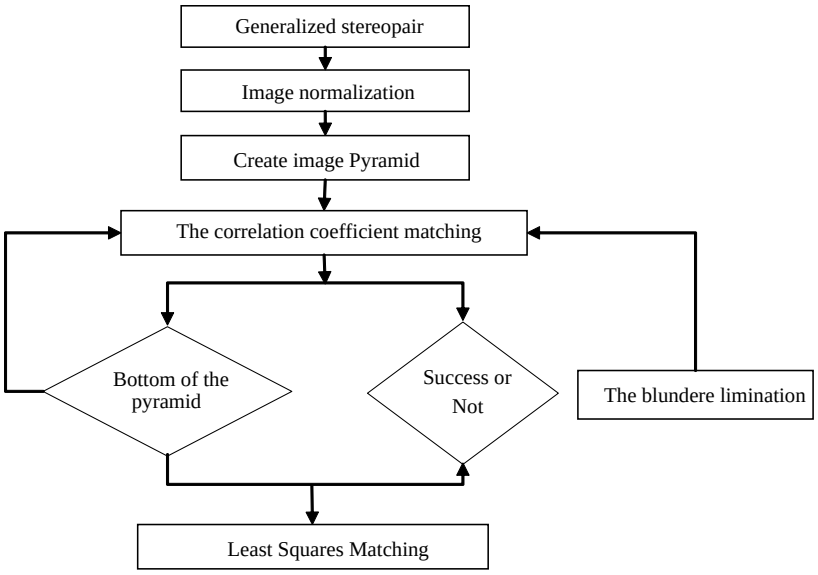
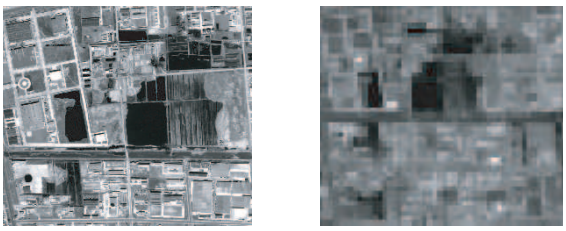


Figure 2: Matching flowchart.



(a) (b)

Figure 3: (a) Raw image. (b) Top of the pyramid image.

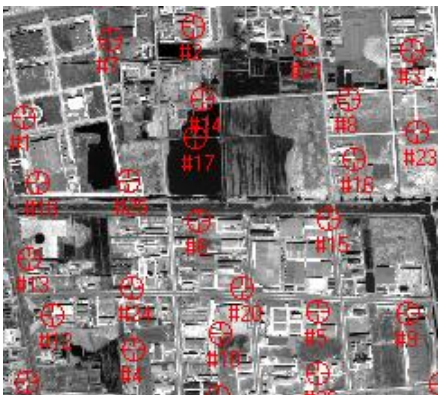


Figure 4: Matching points of verifying.

Pyramid image was created by using the Haar wavelet. It is shown in Figure 3, Figure 3(a) is a raw image, Figure 3(b) is the top of the image pyramid.

In this article, 1386 points were selected for image matching, matching window size is 5×5, the search window size is 9×9, the correlation coefficient threshold is 0.6, and the minimum is 0.4. In order to check up the accuracy of correlation matching hierarchical pyramid, 26 pairs of corresponding points were selected by artificial in the experiment; the points were shown in Figure 4. In normal circumstances, the parallex of matching points should be within 2 pixels. The result of the experiment showed that 23 matching points were correct; the correct rate was 88.5%.

5. CONCLUSIONS

In this article, the least squares and the generalized correlation coefficient methods were used in generalized stereopair. Haar wavelet was used in pyramid hierarchical. Twenty six control points with same places in two images were selected for verifying the experimental results. The success rate of matching points was 88.5%. The experiment has achieved better results. The experiment result showed the technical process of the generalized stereopair matching in this article was feasible and reliable.

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