# A New Registration Algorithm for of ASAS Multi-Angle Images

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**Abstract**

A new area-based image registration scheme is proposed in this paper for of ASAS 0° and 30° images. It includes a series preprocessings and a resolution hierarchical relational algorithm, and a fast algorithm is used for pixel matching in every layer. The new method is not the same as the feature-based one we used in ASAS 0° and 15° image registration, and makes it possible to improve the accuracy of big angle image registration without losing the speed.

## INTRODUCTION

Image registration is necessary when we compare or analyze two or more images on pixel level. The algorithms of image registration, according to the processing object, can be classified into two types, the one based on area and the one on image feature.

When we do the image registration between two images(0° and 15°) of the advanced solid-state array spectroradiometer(ASAS), we use the speedy feature-based algorithm. First the zero-cross algorithm [D.Marr & E.Hildreth, 1980] is used for edge detection. The operator of Laplacian of Gaussian (LOG) is:

$$\nabla^2 G(r)=\frac{r^2-2\sigma^2}{2\pi\sigma^6}\exp(-\frac{r^2}{2\sigma^2}) \tag{1}$$

Where $r^2=x^2+y^2$. The cross and corner points on the edge consist the selected point feature of the image which are abtained through straight line trace method. Besides, a few pairs of correspoding points are selected by man to cut down the searching area for next step — feature matching. Then, we use probability relaxation algorithm to match the points on the restriction of parallax continuity and straight line direction deviation. The last step is to produce the registration image. We use the surface splines [R.L.Harder & R.N.Desmarais, 1992] for camber fitting:

$$X(x,y)=a_0+a_1x+a_2y+\sum_{i=1}^{N}F_i r_i^2\ln r_i^2 \tag{2}$$

Where $r_i^2=(x-x_i)^2+(y-y_i)^2$, $N$ is the number of control points. $Y(x,y)$ is computed so on and so forth. Furthermore, a local weighted average is used to strengthen the role of near points and effectively correct the local distortion. It is:

$$W(R_i)=\begin{cases}1-3R_i^2+2R_i^3 & (0\le R_i\le 1)\\ 0 & (R_i>1)\end{cases} \tag{3}$$

Where $R_i=[(x-x_i)^2+(y-y_i)^2]^{1/2}/R_N$, $R_N$ is the distance between $(x_i, y_i)$ and its nearest control point.

When there is only regional error in the images and the signal noise ratio (SNR) is high, using feature-based registration algorithm can get steep relational result and comparatively high position precision. While to the satellite images of big angle, which have serious geometric distortion and low SNR, the registration method based on edge point feature cannot be indiscriminately imitated. On the other hand, there are some questions in feature detection such as the inconsistence between geographic and geometric features and the inconsistence of smooth binding among features. It may also happen in feature matching algorithm that correspoding feature is not exist, the description of correspoding features is not identical, the correspoding points are insufficient and resulting in an unrealistic interpolation surface, etc. Because of all these shortcomings, to the ASAS big angle image registration(0° to 30°), we choose an area-based strategy including a series preprocessings and a resolution hierarchical relational algorithm. Time is saved because of the using of a fast speed algorithm.

## THE METHOD OF BIG ANGLE IMAGE REGISTRATION

### Preprocessings

*Removing the mean:* Because the mean of an image is usually not zero, when the two images are relational compared, a direct current component will show in result. It will make the extreme value to background voltage ratio lower and the relational peak wider, and will make it difficult for the correspoding point detection and reduce the position precision. In order to diminish all these defects, we count the mean — $\overline{F(j,k)}$ of image $F(j,k)$, remove it from the image, then we get a zero mean image.

*Linear filtering:* This preprocessing is used to diminish random noise and enlarge the dynamic range of image grey. It can weaken the slow-changing signal and enlarge the contrast and the visibility of fine details through restraining the lower frequency component of divergent Fourier transform (DFT). The filter is 2-dimensional separable recursion filter:

$$\hat{a}_{k,l}=g_1a_{k,l}+g_2\Big(a_{k,l}-\frac{\sum_{m=-N_{11}}^{N_{12}}\sum_{n=-N_{21}}^{N_{22}}a_{k+m,l+n}}{(N_{11}+N_{12}+1)(N_{21}+N_{22}+1)}\Big)+(1-g_1)\bar{a} \tag{4}$$

Where $a_{k,l}$ is original image signal, $g_1$ is the coefficient for determining the weakening degree of lower frequency signal, $g_2$ is the const for determining the enlarging degree of fine details, $N_{11}$, $N_{12}$, $N_{21}$ and $N_{22}$ are the rectangle parameters fitting the detail size, $\bar{a}$ is the estimate mean of the image after the processing.

*Geometry correct:* The perspective error in ASAS big angle image shouldn't be neglected, so the linear perspective transform is included to do this geometry correct. The transform expression is:

$$\begin{bmatrix}WX\\WY\\WZ\\W\end{bmatrix}=\begin{bmatrix}T_{11}&T_{12}&T_{13}&T_{14}\\T_{21}&T_{22}&T_{23}&T_{24}\\T_{31}&T_{32}&T_{33}&T_{34}\\T_{41}&T_{42}&T_{43}&T_{44}\end{bmatrix}\begin{bmatrix}x\\y\\z\\1\end{bmatrix} \tag{5}$$

Take $T_{44}=1$, distortion image and correct image on common surface, so $Z=z=0$. Equation(5) is changed to be:

$$\begin{bmatrix}WX\\WY\\0\\W\end{bmatrix}=\begin{bmatrix}T_1&T_2&0&T_3\\T_4&T_5&0&T_6\\0&0&0&0\\T_7&T_8&0&T_9\end{bmatrix}\begin{bmatrix}x\\y\\z\\1\end{bmatrix} \tag{6}$$

According to equation(6), we get:

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$$\begin{cases} X = \dfrac{T_1 x + T_2 y + T_3}{1 + T_7 x + T_8 y} \\ Y = \dfrac{T_4 x + T_5 y + T_6}{1 + T_7 x + T_8 y} \end{cases} \tag{7}$$

In order to solve the parameters $T_1 \sim T_8$ in equation(7), we need at least 4 pairs of correspoding points coordinate, and by least square method we can get the result $T$ matrix. Through the transform shown in equation(7), the correct image with about no distortion is obtained. Doing relational comparison between this image and objective one, we can nearly maintain the registration accuracy which we get when there is no error.

**Resolution hierarchical relational algorithm**

In this algorithm, relational operation is in progress step by step from the rough spatial resolution to fine resolution. It includes two main process.

*Resolution hierarchical structure:* Take the original image $f_0$ as an array of $2^N \times 2^N$. In each $2\times2$ region, do grey average and result in image $f_1$ of $2^{N-1} \times 2^{N-1}$. Do the same thing to $f_1$, we get $f_2$ of $2^{N-2} \times 2^{N-2}$. Do it so on and so forth to the last $f_K (K \le N-1$, $K$ is determined according to the request roughest resolution). All these images ($f_0 \sim f_K$) consist a tower structure. (See Fig. 1)

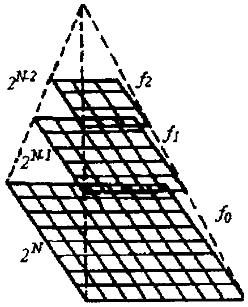


Fig. 1. Resolution hierarchical structure

To the reference and input images, we do the same thing and get two image sequences.

*Hierarchical relational operation:* From the top level of this tower structure, do the relational operation between the input and reference images. Because the pixels in each image, at this time, are fewer, the calculations times are not high. The relationship can be counted on every searching position, and the rough correspoding position can be determined. The second operation is on the next level of the tower. this time, we calculate the relationship only on the positions near the rough correspoding position we get last time. From the top of the structure tower to the bottom, through this hierarchical operation, we get the accurate correspoding points between the original images, and then use interpolation to form the registration image.

*Sequence similarity detection algorithm(SSDA):* This is the fast algorithm we select for point matching on each level of the resolution tower. In the matching windows of image $f_1(j,k)$ and image $f_2(j,k)$, add up the error of every pixel:

$$\varepsilon(m,n) = \sum_j \sum_k \left| f_1(j,k) - f_2(j+m, k+n) \right| \tag{8}$$

If before all the $(J \times K)$ points in windows have been checked, the predetermined threshold has been caught, this window position can be discarded and the program goes to the next step with no checking the remainder points. If $\varepsilon(m,n)$ goes up slowly, record the number of adding points. After all the probable matching windows under the restriction of parallax continuity have been detected, the one which has the biggest number of adding points is the correspoding point.

An improvement upon the resolution hierarchical relational algorithm is to abandon the obvious dismatched points using SSDA, and to calculate the extreme matching value among the probable windows through statistical relational algorithm(SAR). The combination of SSDA's speed and SRA's accuracy shows its advantage.

## RESULT & CONCLUSION

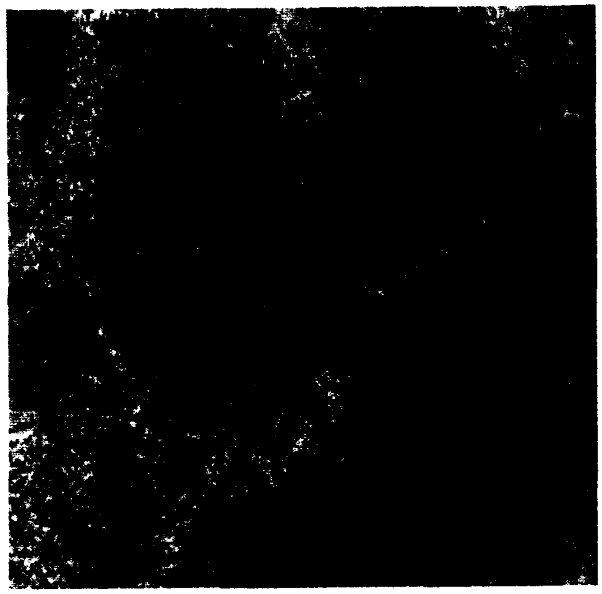

Fig. 2. 0° original image

Fig. 3. 15° original image

## Conclusion

The random noise and geometric distortion deteriorate in big angle images, the preprocessings mentioned above are necessary.

The unity of the resolution hierarchical relational algorithm on each level and the inclusion of SSDA, make the prospect of hardware realization captivating.

The solid information of topography and vegetation can be attainable after image registration of different angles.

Fig. 4. 30° original image

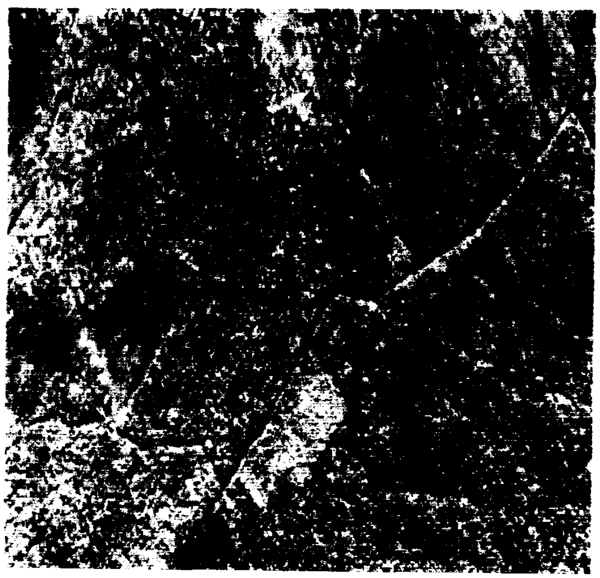

Fig. 5. 0°~15° registration image

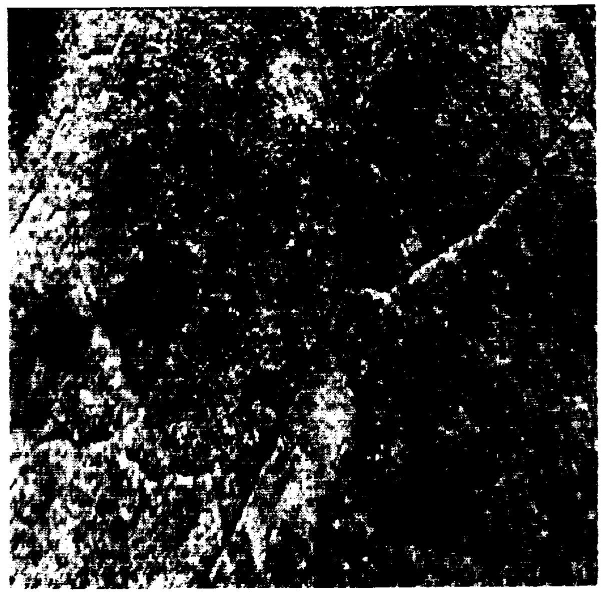

Fig. 6. 0°~30° registration image

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## ACKNOWLEDGEMENTS


This work was partially supported by Chinese National Natural Science Foundation (49331020) and NASA (NAS5-31369).