Image Mosaics Algorithm Based on SIFT Feature Point Matching and Transformation Parameters Automatically Recognizing

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Abstract—**A mosaic algorithm of different scale image registration and adaptive is proposed in this thesis, against to the large amount of calculation and poor robustness, as well as cannot well solve the problem of image mosaic of images who are in different scales in the traditional image mosaic method. The match and mosaic of different scale and rotated images is achieved through feature point matching and automatically recognizing of transform geometric parameters between images. First, using SIFT extraction algorithm to extract the feature points of the image to be mosaic. Second, achieving feature points matching according to the principal of mutual information maximum. Third, automatically recognize the relationship of transformation parameters between two images according to the geometric information of the matching pairs. Finally, the projective transformation matrix that reflected the image translation, rotation and scaling information can be obtained and the image stable mosaic can be achieved.**

Keywords-SIFT, Image mosaic, Feature point matching, Automatic recognize of transformation parameters

I. INTRODUCTION

Image mosaic technology is one of the gradual developing digital image processing technologies applied to various fields. With the help of a computer, it can do matching work automatically, and from a seamless, high-definition, wide viewing angle image through aligning a series of spatial overlapping images. The emergence of image mosaic technology makes the images collecting equipment becoming more and more universal, so the required images can be obtained by using ordinary digital cameras. The research on image mosaic technology has a good prospect of application and practical value. It can be widely used in space exploration, remote sensing image processing, medical image analysis and other fields. It has become the focus of computer graphics research, and to do deep research on image mosaic technology has very important significance.

So far, the researchers both domestic and foreign have proposed a variety of image mosaic algorithm. The main algorithms can be divided into two main types: one is region-based mosaic algorithm, Region-based registration method is starting from the gray value of the image to be mosaic, and to confirm the degree of similarity by calculating the correlation of the two images' gradation, and then the range and position of overlapping areas of the images to be mosaic can got, thereby the image mosaic will be achieved. Another one is mosaic algorithm based on feature related. Feature-based registration method is to apply match search in the corresponding feature area of the overlapping portion of the images by extracting image feature points. Such mosaic algorithm has high stability, and therefore, more extensive application. In the process of image mosaic, a variety of different situations may be encountered, such as the translation of the image, image rotation, and different scales image mosaic. And therefore, the requirement to the applicability of algorithm is also increasing. Gao and some other people proposed a mosaic algorithm based on planar perspective view transformation. This kind of algorithm uses the Harris corner detection to extract image feature points, uses L-M algorithm to extract feature points, and finally uses a matrix that has 8 parameters to achieve the projection transformation between two images[1]. Although, this algorithm achieves the mosaic of two transitional images stably, it is helpless to the images having rotation characteristics or images in different scales. For the limitations of the above algorithms, Lin Chengkai better solved the problem of rotating images[2]. So far, the existing algorithm both home and abroad have been better solved the mosaic problems of translation and rotation images, but the research on the mosaic algorithm between different scale images is still very less. For the deficiencies of the existing algorithms, this thesis gives a mosaic algorithm of different scale images registration and adaptive to make the different scale images flatted stably and also has good robustness to translation and rotation between images. This algorithm mainly includes the steps of feature extraction, feature points matching; the geometric parameters (translation, rotation and scale parameter) of matching images identified automatically, geometric transformation of the image, and the image fusion and mosaic.

II. IMAGE REGISTRATION

A. *Image feature extraction*

In the process of image mosaic, image registration is one of the important steps. The accuracy and quantity of feature extraction in image registration will directly affect the quality of the mosaic image. The characteristics of the image can be point features or line features. Nowadays, Harris corner detection and Scale Invariant Feature Transform (SIFT) algorithm proposed by D.G. Lowe in 1999 are mainly used. Harris corner detection has high accuracy in extracting the feature points and is relatively fast. However, if the image has rotation or scale changes, it will lead to the misplacement of extracted points or wrong extraction. Considering that it lacks of reliability in the case of matching objects got changed, this thesis uses SIFT algorithm in mosaic image feature points extraction[3].

The SIFT algorithm is a kind of algorithm that extracting local features and then looking for extreme points in the scale space, extracting the invariant like location, scale, rotation and so on. The principal of this algorithm as follows: SIFT algorithm first does the feature detection in the scale space, to make sure the position and scale of the feature points. Second, takes the main direction of the neighborhood gradient of feature point as the direction feature of this feature point. In order to detect stable key points in the scale space effectively, Difference of Gaussian Scale Space was proposed, using different scale kernel of Difference of Gaussian to convolution with images to generate:

$$D(x,y,\delta)=(G(x,y,k\delta)-G(x,y,\delta)) \\ *I(x,y)=L(x,y,k\delta)-L(x,y,\delta) \quad (1)$$

Formula (1) is the function of Difference of Gaussian. In the above formula, $G(x,y,\delta)=\frac{1}{2\pi\delta}e^{-(x^2+y^2)/2\delta^2}$,and δ is scale coordinates and (x, y）is spatial coordinates. In the process to find the extreme point of scale space, each sampling point should be compared to its all neighbor points, and the middle detection point needs to be compared to its 8 neighbor points who are in the same scale with it and 18 points corresponding to its vertical neighbor scales, that is to say, 26 points totally. If it is the maximum or minimum value, it is considered that this point is a feature point of the image in this scale, so that can ensure extreme points can be detected both in scale space and the two-dimensional image space[4].

After detected the extreme point of scale space, the key points' position and scale still needed to be accurately ascertain (should in subpixel precision), and at the same time, to remove the low contrast key points and the unstable edge response points, with the aim to enhance the matching stability and improve noise immunity.

This thesis uses the SIFT algorithm to confirm the position of the extreme points of the image, and does not uses the Euclidean distance to match the feature points, so there is no need to make sure the direction and descriptor of feature points. In order to extract more stable feature points, this thesis adopts SIFT algorithm to get the image feature points, and matches the feature points we got, using mutual information algorithm.

B. *Matching criteria*

The matching accuracy of feature points will directly affect the accuracy of image mosaic. The traditional grayscale based matching algorithm has bad noise immunity and poor ability to against the local geometric deformation. This thesis adopts the feature matching algorithm based on the local maximum entropy. And to obtain a matching result which having the maximum confidence through the correlation match of the area where the feature points located[5][6].

The entropy expresses the complexity or uncertainty of a system. It can be used to describe the mutual information, and indicates the statistical correlation between two random variables. Image mosaic based on the mutual information is to search the largest mutual information point-pairs in the two images to be registered and to get image feature point matching pairs. For an m*n image block, the definition of the entropy can be expressed as:

$$H=-\sum_{i=1}^{m}\sum_{j=1}^{n}P_{ij}\log P_{ij} \quad (2)$$

In the above formula, P_{ij} is the image's gray distribution when at the coordinate (i, j). If uses H (A) and H (B) to represents the entropy of image A and image B respectively, then H (A,B) represents the joint entropy of the two images, and the amount of information expression can be described as:

$$K(A,B)=H(A)+H(B)-H(A,B) \quad (3)$$

In the image mosaic process, after the space transformation, to look for the feature point-pairs between the two images that made K (A,B) reaches the maximum value, and that is the matching feature points. In order to solve the problem of mutual influence of the mutual information changes brought by the overlapping area, can do some normalization treatment to the mutual information:

$$L(A,B)=\frac{H(A)+H(B)}{H(A,B)} \quad (4)$$

C. *Feature point matching*

Feature point matching is to define the reference point in an image, and to search for a matching point in another image. Therefore, choose a proper searching area becomes particularly important[7]. The circular area was chosen as the search area in this thesis, and the area radius r selected as 1/10 of the height of the image to be registered[6]. The specific steps are:

- Assuming the two images to be registered are image A and image B, and to select feature points p1 and p2 in the two images respectively. In the image A, chooses matching circle c1 as the p1 is the center and r is the radius; and in the image B, chooses matching circle c2 as p2 is the center and r is the radius.

- Taking the point p1 as the standard feature point and c1 as the standard circle, to calculate the mutual information matrix K in the matching circle of image B, and to choose the point corresponding to the maximum in the matrix K as the registration point.
- Recording registration points as p1_max and p2_max and the matching circles as c1_max and c2_max. In this way, the first pair of registration points can be obtained. In accordance with the above-mentioned registration method to calculate the registration points needed in image mosaic.

III. Automatic Identification of Image Parameters and Image Mosaic

A. *Automatic identification of image parameters*

Image parameters analysis is to make sure the geometric transformation relationship of two images to be mosaic. To project via the projection transformation matrix A, to let the images in the same coordinate system, so that the image can go on mosaic according to the information of the overlapping region. The steps to calculate the transformation matrix A between the two images are:

- Supposing there are N pairs of feature points between two images (1, 2), and divided these feature points into M groups (M=N/2, rounded up), make sure that each group has two pairs of feature points. Calculated the transformation parameter of the two pairs of matching feature points in each group($P_{11}(i)$,$P_{21}(i)$)and($P_{12}(i)$,$P_{22}(i)$). Where in i=1, 2,…M.
- Calculating the scale change ratio k(i) of the image, as shown in the following formula. Calculating the slope of the straight line $p_{11}(i)$ ($p_{12}(i)$ and $p_{21}(i)$ $p_{22}(i)$, the angle between them is $\theta(i)$ the rotation angle of the image, and to rotate the images to be mosaic according to the angle $\theta(i)$, at the same time to calculate the translational distance $\tau_x(i), \tau_y(i)$ of the two images.

$$k(i) = \frac{|p_{22}(i) - p_{21}(i)|}{|p_{12}(i) - p_{11}(i)|} \quad (5)$$

- Repeat the above steps to get the parameters $k(i)$, $\theta(i)$, $\tau_x(i)$, and $\tau_y(i)$ of group M, suppose that the function f(x) indicates to take the median value of the variable x and let f(k(i))=k, $f(\theta(i)) = \theta$, $f(\tau_x(i)) = \tau_x$,and $f(\tau_y(i)) = \tau_y$. Calculate the projective transformation matrix A in the way shown in formula (6). Ascertain the positional relationship between the images so can provide the basis for image mosaic.

$$A = \begin{vmatrix} k\cos\theta & 0 & \tau_x \\ 0 & k & \tau_y \\ k\sin\theta & 0 & 1 \end{vmatrix} \quad (6)$$

B. *Fusion mosaic of images*

Regard the first image as the mosaic benchmark, after carry out the multiplication on the second image with transformation matrix, and then it can be transformed into the coordinate system of the first image, so image mosaic can be achieved from visual. The specific algorithm flow is shown in Figure 1.

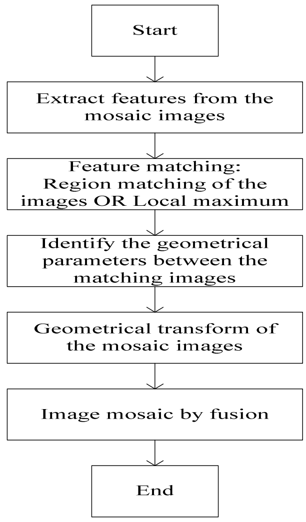

Figure 1. Flow chart of algorithm

IV. Simulation Experiment and Results Analysis

The images in this experiment are all photographed by the same digital camera. Two groups of simulation experiments were carried out to vivificate the feasibility of the algorithm. The algorithm implemented by using Matlab 7.5 program and the operating environment is Windows XP. The algorithm mosaics the images in different scales stably, and also has good robustness on the translation and rotation between images.

(a) (b)

Figure 2. The original image A and B to be mosaic Image (a) is the original image A, and (b) is the original image B

Figure 3. Matching images of scale changes

Figure 2 (a) and Figure 2 (b) are the original Image A and Image B, the images captured to be mosaic. The sizes of two images are equal, and there has overlapping area between them. The first set of experiments is to verify the effectiveness of the algorithm to the scale transform image mosaic. To scale down the Image B in arbitrary portion and can get Figure 3. Next will be image mosaic. Figure 3 is the result of mosaic, and the experiment can approve that the algorithm can define the matching feature points of the two images. 3,403 feature points were found in A, and 1,818 feature points were found in B, then 88 pairs of points were got after screening. The algorithm restored the scale of transformed images, and achieved the image mosaic of different scale images, as shown in Figure 4.

Figure 4. Image of scale changes mosaic

And the second set of experiments is based on the first set of experiments. To rotate B in arbitrary angle, an experimental sample with both rotation and scale transformation can be got, as shown in Figure 5. After the program began running, to extract 3,043 feature points in A and to extract 1,781 feature points in Figure 5, 68 pairs of feature points can be get after screen. And the mosaic result is shown in Figure 6, this verify the effectiveness of algorithm in the image mosaic which has rotation and scale transformation.

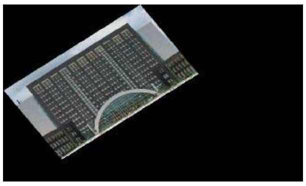

Figure 5. Matching figure of rotation scale change

Figure 6. Mosaic figure of rotation scale change

V. CONCLUSION

In this thesis, the SIFT algorithm was used to extract image feature points, and then the circular area was adopted, and based on the principle of mutual information maximum the matching points in two images were founded. Proceed from the position information of matching points, to recognize the scale, rotation and translation parameters of images to be mosaic, calculated the transformation matrix, and eventually, achieved the image mosaic of two images stably and seamlessly. This is a better solution to the limitations that the traditional algorithm does not suitable for different scale images mosaic. The experiments show that the algorithm adopted in this thesis inherits the good robust of SIFT algorithm and as well as has higher parameter identification and mosaic accuracy, and good adaptability to image translation, rotation and scale transform.

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