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Research of Image Registration Algorithm By corner's LTS Hausdorff Distance

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ABSTRACT: Registration Algorithm is one basic task of image processing. To resolve the problem of high calculation of Image registration based on gray and low adapting ability, this paper researches an Registration Algorithm based on SIFT corner. The common two feature detection method: Harris algorithm and SIFT algorithm have been analyzed , SIFT corner was choosed as feature point by performance comparing. Considering the SIFT operators extract feature point may focus on a small region, the biggest statistical filtering on image non-maximal suppression method to control the distribution of the angular point has been put forward. Proved by the experiment, the feature points detected by the method is even. For the registration of feature points, LTS Hausdorff distance to match feature points has been first used, remove false matching of feature points with the help of a random sample of consistency. Experiment results show that this method realizes the precise image registration.

KEYWORDS: feature point detection; biggest statistical filtering;LTS Hausdorff distance; Image registration

I.INTRODUCTION

Image registration is one of the basic tasks of image processing, which is widely used in remote sensing data analysis, computer vision, medical image processing and other fields. Image registration technology is an image processing process that matches two or more images of the same scene acquired at different times, different sensors or different perspectives.[1-3] Image registration methods can be roughly divided into two categories: gray-based image registration method and feature-based image registration method. Feature-based image registration technology has become a research hotspot in recent years due to its advantages of small computation, good adaptability and high matching accuracy. In feature based image registration technology, features can be points, lines, edges, surfaces, etc. Considering image registration technology, real-time performance is an important indicator. Because of the small amount of point features compared with other feature data, the speed of registration is better than other feature matching technologies. Firstly, two feature point extraction algorithms, Harris and SIFT, are studied. Through comparison, SIFT algorithm is selected to extract corner points as feature points. Then LTS Hausdorff distance is used for initial matching of feature points. Finally, random sampling consistency algorithm based on Sampson distance is used to remove pseudo-matching feature point pairs. Experimental results show that this method can achieve accurate registration of images.

II. Feature points extraction

A.Harrisfeature points extraction

Harris and Stephens proposed the Harris corner detection algorithm in 1988. The algorithm uses the first-order difference of the image to calculate the average square gradient matrix at each pixel, and gives the corner response through eigenvalue analysis. C. Schmid et al. [4-6] reported that Harris corner extraction method is a better feature point extraction algorithm at present. It is not affected by camera attitude and illumination. Its principle is that if a small offset of a point in any direction will cause a great change in gray level, which shows that the point is a corner.

Harris operator R is:

$$R = \det C - k\,\mathrm{tr}^2 C \quad (1)$$

$$C(\mathrm{x}) = \begin{bmatrix} I_u^2(x) & I_{uv}(x) \\ I_{uv}(x) & I_v^2(x) \end{bmatrix}$$

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$I_u(x)$,$I_v(x)$ and $I_{uv}(x)$ are the partial derivatives of the gray level of the image point X in the direction of u and V and the second-order mixed partial derivatives respectively. K is the empirical value, usually 0.04-0.06. In this paper, K is 0.04. When the Harris operator R of a certain point is greater than the set threshold T, the point is the corner point. When the value of T increases, the extracted corners will decrease, which will affect the recognition accuracy; otherwise, the extracted corners will increase, which will affect the real-time performance. In this experiment, T takes 15.

B.SIFT feature points extraction

In 1999, David G. Lowe proposed SIFT feature extraction operator [10-13] on the basis of image scale space theory, and improved it in 2004. The full name of SIFT operator is Scale Invariant Feature Transform, that is, scale invariant feature. Firstly, it detects feature points in multi-scale space of Gauss difference to determine the location and scale of feature points, then uses the main direction of the neighborhood gradient of feature points as the direction of the point, and finally generates feature descriptors by using gradient histogram.

C.Performance comparison between Harris algorithm and SIFT algorithm

In order to compare the performance of the algorithm and improve the accuracy and real-time performance of image registration technology, Harris corners and SIFT corners are extracted from 4-spoke images (Fig. 1, Fig. 2, Fig. 3 and Fig. 4), respectively, and the results are shown in Fig. 2. Comparisons are made between the two algorithms in terms of the number of feature points extracted and the running time. The comparison results are shown in Table 1.

Fig1 fig 2

Fig3 fig4

b. Extraction of Haris feature points from a. Extraction of SIFT feature points from experimental images

Experimental images

Fig. 2 Comparison of feature points extraction between Harris and SIFT

c. Extraction of SIFT feature points from experimental images

Fig. 2 Comparison of feature points extraction between Harris and SIFT

Table 1. Harris and SIFT performance comparison tables

	Harris algorithm			SIFT algorithm		
	Number of characteristic points	Matching point pair	Run time (SEC)	Number of characteristic points	Matching point pair	Run time (SEC)
Fig 1	117	95	10.6	6521	500	12.1
Fig 2	105	86	10.6	6344	259	11.7
Fig 3	47	40	9.75	5421	167	10.0
Fig 4	64	57	9.85	6089	109	11.2

III.image registration

Using SIFT algorithm to extract corners, it can be used as feature points for image registration. The feature points extracted by SIFT operator may be concentrated in a small area. Firstly, the maximum statistical filter is used to control the corner distribution, then LTS Hausdorff [7] distance is used for initial matching of feature points, and finally, random sampling consistency calculation based on Sampson distance is used. The method removes the pseudo matching feature points.

A.non-maximal suppression

In order to avoid the corner detected by SIFT operator concentrating in a small area, this paper proposes a method of non-maximum suppression of image using maximum statistical filtering to control corner distribution.

Let the number of pixels in filter window W be N=n*n (let N be odd). When W slides to the first position of s, the sequence of pixels in the window is marked as:

$$W_N(s)=\{x_1^{'}(s),x_2^{'}(s),x_3^{'}(s),\cdots x_i^{'}(s),\cdots x_N^{'}(s)\}$$

$$Q=sort(W_N(s))=\{x_1(s),x_2(s),x_3(s),\cdots x_i(s),\cdots x_N(s)\} \quad (2)$$

$$x_1(s)\le x_2(s)\le x_3(s)\le\cdots x_i(s),\cdots\le x_N(s)$$

Sorting $W_N(s)$ by statistics filtering OSF(Order Statistic Filter), sorting statistics filtering (OSK) of K, the output result is:

$$OS^k=\sum_{i=1}^{n^2}a_iW_N(i) \quad (3)$$

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$$a_i = \begin{cases} 1 & ,i = k \\ 0 & ,i \neq k \end{cases}, (k = 1,2,\cdots i,\cdots n^2)$$

This maximum statistical filter is equivalent to the gray scale expansion in the morphological algorithm of image. Their common feature is that the brighter part than the background is expanded while the darker part is suppressed.

B.LTS Hausdorff distance

Hausdorff Distance (HD) is a maximum and minimum distance defined on two sets of points. It is a measure of similarity between two sets of points, if given a finite set of two points. $A = \{a_1, a_2, ..., a_m\}$, $B = \{b_1, b_2, ..., b_n\}$, The Hausdorff distance betwin A and B is defined as:

$$H(A,B) = \max(h(A,B), h(B,A)) \quad (4)$$

$h(A,B) = \max\limits_{a \in A} \min\limits_{b \in B} \|a-b\|$ is the directed Hausdor distance from A to B ; $h(B,A) = \max\limits_{b \in B} \min\limits_{a \in A} \|a-b\|$ is the directed Hausdor distance from B to A ; $\|\bullet\|$ is a distance norm defined on the point set and above, where Euclidean norms are used.

If defined $d_\theta = \min\limits_{b \in B} \|\theta - b\|$, $\hat{d}_\theta = \min\limits_{a \in A} \|\theta - a\|$ (θ is Represented as any point in space) ,Hausdorff distance can be defined as

$$H(A,B) = \max(\max_{a \in A} d_a, \max_{b \in B} \hat{d}_b) \quad (5)$$

From the above deduction, if the distance between a point and a finite set is defined as the minimum distance between the point and all points of the set, then h (A, B) is the maximum distance between each point in point set A and point set B. Hausdorff distance takes the maximum values of H (A, B) and H (B, A). By calculating the maximum values of the two points, the maximum mismatch between the two sets can be obtained.

Because Hausdorff distance is the most mismatched distance between two sets of points, it is very sensitive to noise points and missing detection points far from the center, which is unavoidable when extracting image feature points. In order to overcome this shortcoming, the definition of Hausdorff distance needs to be extended. Huttenlocher et al. proposed the definition of partial Hausdorff distance in 1993.

$$H_{LK}(A,B) = \max(h_L(A,B), h_K(B,A)) \quad (6)$$

$$h_L(A,B) = L^{th}_{a \in A} \min_{b \in B} \|a-b\|$$

$$h_K(B,A) = K^{th}_{b \in B} \min_{a \in A} \|a-b\|$$

$h_L(A,B)$ Represents that the "distance" from a point in set A to set B is sorted, and the L distance is taken as the Partial Hausdorff distance from set A to B, The size depends on the parameter f, $f = L / N_A$,and N_A is the number of points in the set A., $0 < f \leq 1$. $h_K(B,A)$ calculation is similar to $h_L(A,B)$.

Based on the above definition, we propose an improved Hausdorff distance definition, LTS Hausdorff distance, which is defined as:

$$h_{LTS}(A,B) = \frac{1}{H} \sum_{a \in A} d_B(a)_{(i)} \quad (7)$$

$H = h \times N_A$, $0 < h \leq 1$, N_A is the number of points in the set A. $d_B(a)$ Represents the distance from the point a to the B set in the A set, $d_B(a)_{(i)}$ indicating the first distance after sorting. $d_B(a)_{(1)} \leq d_B(a)_{(2)} \leq \cdots d_B(a)_{(i)} \leq \cdots d_B(a)_{(N_A)}$. The advantage of this measure is that it can eliminate the

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noise in the image and improve the accuracy of image matching. This measure is used as image similarity measure in this paper.

C.Eliminating mismatches

Random Sampling Consistency (RANSAC) algorithm is usually used to eliminate mismatching pairs when using LTS Hausdorff distance to match. This algorithm is a relatively robust estimation method widely used in the field of computer vision. This paper mainly introduces the basic RANSAC algorithm proposed by Fischler and Bolles in 1951.

The input of RANSAC algorithm is a set of measured data μ . A certain proportion of data in a set satisfies a pattern with unknown parameters, which are called interior points. The remaining data of a certain pattern that does not satisfy an unknown parameter is called an outer point.

This paper illustrates the idea of RANSAC algorithm by taking straight line fitting as an example. In Figure 3(a) of data set, two points are randomly selected to form a straight line, and the interior points of the straight line are searched through a certain threshold value. New straight lines are solved linearly from the set of interior points. The largest number, then this straight line estimate is this. The best estimate of set. As shown in Figure 3 (b):

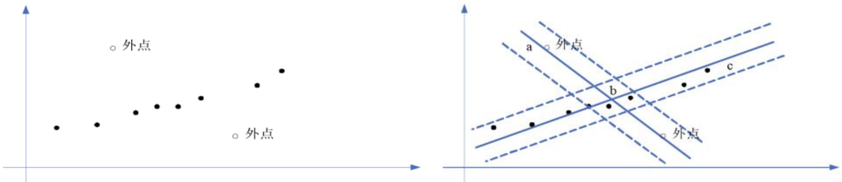

Fig. 3.line fitting based on RANSAC

Straight line BC obtains more interior points. It is the best estimate of this set and effectively eliminates the outer point. The characteristic of this method is to make full use of all the measured data and divide them into interior and exterior points according to the threshold value. The interior point data is used to estimate the parameters accurately and the inaccurate measurement data is eliminated. Therefore, the result should be an optimized one.

IV.Registration results

All experiments were performed on Intel (R) core 2.6 GHz Windows XP machine with 4-gigabyte memory. The programming environment Matlab 10.0 was used. The registration results using SIFT corners were shown in Figure 4. The algorithm can also achieve accurate matching of rotating images. The results are as follows: Fig. 5(a) is the original image(b) is the rotated image, (c) and (d) are the original image and the rotated image SIFT feature points extraction results(e) is the rotated image registration results.

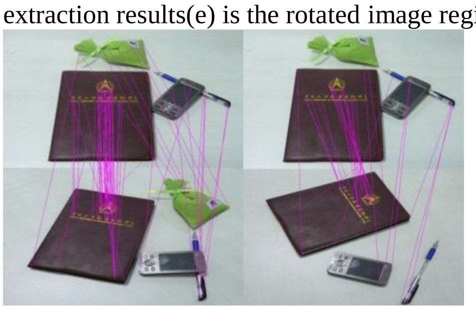

Fig. 4.SIFT corner registration results

a. original image b. rotation imagec original feature points d. rotation feature points

e.Registration of original and rotated graphs
Fig. 5 image registration effect of rotating image

V. concluding remarks

Aiming at image registration based on feature points, this paper firstly introduces Harris and SIFTS, two widely used feature point extraction operators in feature point extraction method, and then analyses their advantages and disadvantages through experiments. After feature points are extracted, it is important to match the feature points. In this paper, LTS Hausdorff distance is used for initial matching of feature points, and Random Sampling Consistency (RANSAC) algorithm is used to eliminate mismatching. The experimental results show that the method can achieve image registration accurately and quickly, and is suitable for rotating image registration.

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