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An Improved Algorithm for Match Point Purification

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Abstract: Aiming at the problem that the RANSAC algorithm has high computational complexity and low efficiency in image matching. A fast coarse-to-fine strategy is introduced in this paper: the RANSAC algorithm has been used in the inliers sub-set to estimate the point transformation matrix between two images accurately by using least square method. It filters the noisy or wrong input data iteratively, and then estimates the model parameters through pure data, so it has strong error-tolerant capacity for the image noise and inaccuracy of feature extraction.
Keywords: Image Registration; Corner detection; RANSAC algorithm.

INTRODUCTION

Image matching is one of the hot issues in current research and the basis of relevant theories in the field of computer vision. Among the many methods of image matching, the most widely used and most studied method is the feature-based matching method, which is based on some points, lines and edges with obvious marks in the original image that tend to be stable and not too many. The image matching is performed so that the amount of computation data can be reduced as much as possible during the processing, which has higher computational speed and efficiency, and has strong adaptability to image grayscale changes [1-3]. The fly in the ointment is that feature-based matching still requires a large number of ergodic matching operations in different images. This will make the matching process have a large amount of calculation, and the accuracy is not high.

Algorithm principles

Rough match of feature points

When the feature points are extracted, they need to be matched. Since the neighborhoods of the same feature points on different images are necessarily similar, they can be matched by neighborhood gray correlation. In this paper, the related window matching method LACC is used as the basis for matching two feature points [4].For a feature point (u_{1i}, v_{1i}) in image 1, a related window centered on the feature point and having a size of $(2n+1)\times(2n+1)$ is used. Then, a feature point (u_{2j}, v_{2j}) is selected in the matching image 2, and the correlation window of the same size is also used, and the similarity coefficient of the two related windows is calculated to determine whether the feature points match. This process can be represented by Fig 1.

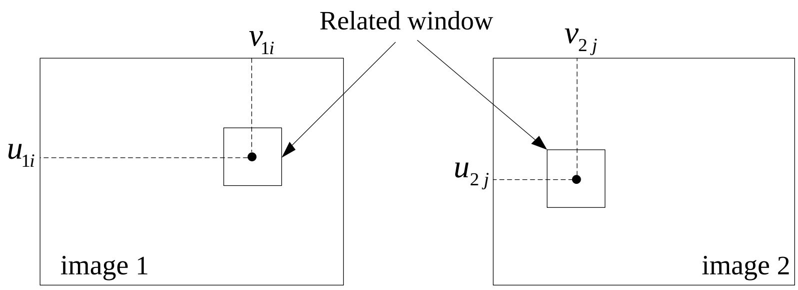


Fig-1: Local area correlation coefficient

The LACC expression is as shown in equation (1)

$$c_{ij} = \sum_{k=-n}^{n} \sum_{l=-n}^{n} \frac{\left[I_1(u_{1i}+k, v_{1i}+l) - \overline{I}_1(u_{1i}, v_{1i}) \right] \times \left[I_2(u_{2j}+k, v_{2j}+l) - \overline{I}_2(u_{2j}, v_{2j}) \right]}{(2n+1)(2n+1)\sqrt{\sigma_i^2(I_1) \times \sigma_j^2(I_2)}} \quad (1)$$

In formula (1), I_1 and I_2 are the gray values of the two images; (u_{1i}, v_{1i}) and (u_{2j}, v_{2j}) are the i-th feature point in image 1 and the j-th feature point in image 2, respectively; $(2n+1)$ is the side length of the associated window. $\overline{I}_1(u, v)$ is the average gray value of the feature point window area:

$$\overline{I}(u,v) = \frac{\sum_{i=-n}^{n} \sum_{j=-n}^{n} I(u+i, v+j)}{\left[(2n+1) \times (2n+1) \right]} \quad (2)$$

The standard deviation σ of the window area is:

$$\sigma = \sqrt{\frac{\sum_{i=-n}^{n} \sum_{j=-n}^{n} I^2(u+i, v+j)}{(2n+1) \times (2n+1)} - \overline{I}^2(u,v)} \quad (3)$$

Exact matching of feature points and estimation of transformation matrix

A rough set of corner points forms a set of mapping points between two adjacent images. Let the corresponding points on the two images be $p_i = [x_i, y_i]^T$ and $q_i = [x_i', y_i']^T$, respectively. They must satisfy $p_i = Hq_i$, which is shown in the formula (4).

$$\begin{bmatrix} x_i' \\ y_i' \\ 1 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & h_{13} \\ h_{21} & h_{22} & h_{23} \\ h_{31} & h_{32} & 1 \end{bmatrix} \begin{bmatrix} x_i \\ y_i \\ 1 \end{bmatrix} \quad (4)$$

Since a pair of matching points can determine two independent linear equations, theoretically four pairs of non-collinear matching points can obtain eight linear equations, as shown in equation (5), and then the perspective transformation parameters are obtained.

$$\begin{pmatrix} x_1 & y_1 & 1 & 0 & 0 & 0 & -x_1'x_1 & -x_1'y_1 \\ 0 & 0 & 0 & x_1 & y_1 & 1 & -y_1'x_1 & -y_1'y_1 \\ x_2 & y_2 & 1 & 0 & 0 & 0 & -x_2'x_2 & -x_2'y_2 \\ 0 & 0 & 0 & x_2 & y_2 & 1 & -y_2'x_2 & -y_2'y_2 \\ x_3 & y_3 & 1 & 0 & 0 & 0 & -x_3'x_3 & -x_3'y_3 \\ 0 & 0 & 0 & x_3 & y_3 & 1 & -y_3'x_3 & -y_3'y_3 \\ x_4 & y_4 & 1 & 0 & 0 & 0 & -x_4'x_4 & -x_4'y_4 \\ 0 & 0 & 0 & x_4 & y_4 & 1 & -y_4'x_4 & -y_4'y_4 \end{pmatrix} \begin{pmatrix} h_{11} \\ h_{12} \\ h_{13} \\ h_{21} \\ h_{22} \\ h_{23} \\ h_{31} \\ h_{32} \end{pmatrix} = \begin{pmatrix} x_1' \\ y_1' \\ x_2' \\ y_2' \\ x_3' \\ y_3' \\ x_4' \\ y_4' \end{pmatrix} \quad (5)$$

An improved Algorithm based on RANSAC

An improved Algorithm

The idea of the RANSAC algorithm is detailed based on straight line fitting: In Fig. 2(a), two points are randomly selected to form a straight line, and a certain threshold is used to find the inner point of the straight line. From this set of inner points, a new straight line is obtained linearly, and then the corresponding inner point is found according to the straight line. Such random sampling is continually repeated until a certain sampling maximizes the number of interior points, and the straight line estimate obtained therefrom is the best estimate of this set. As shown in Fig. 2(b), line l_1 obtains more interior points, which is the best estimate of this set, and effectively eliminates the outer points. Line l_2 is a wrong estimate. Fully utilizing all the measurement data is the characteristic of the RANSAC algorithm. According to the threshold, they are divided into inner and outer points. The more accurate characteristics of the inner point data are used to estimate the parameters and the inaccurate measurement data is eliminated. The result is obtained. It should be an optimized result.

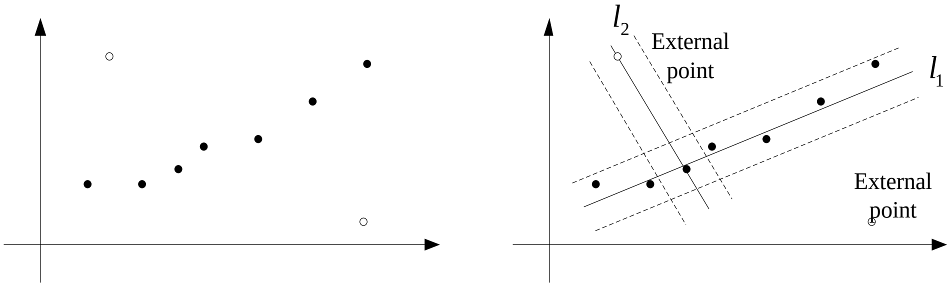


Fig-2: The schematic diagram of linear fitting by using RANSAC algorithm

Judgment criteria

In this paper, the geometric distance between the actual matching point and its estimated matching point is used as the decision criterion to determine whether the matching point satisfies the estimated projection transformation model, that is, whether it is an inner point [5,6]. Let points p and q be a pair of matching points. Points p' and q' are the corresponding points estimated by points p and q respectively in their respective images. The distance between the actual matching point of a point in the image and its estimated matching point is defined. As shown in Fig.3

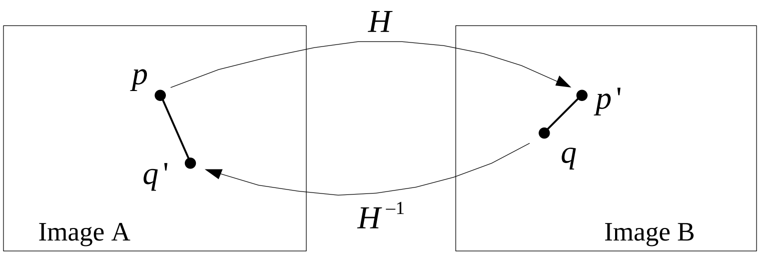


Fig-3: Geometric distance

$$dis(p,q') = dis(p,H^{-1}q) = \left\| p - H^{-1}q \right\| \tag{6}$$

$$dis(p',q) = dis(q,Hp) = \left\| q - Hp \right\| \tag{7}$$

$$\begin{aligned} D &= \sum_{i=1}^{n} \left[dis_i(p_i,q_i')^2 + dis_i(p_i',q_i)^2 \right] \\ &= \sum_{i=1}^{n} \left[\left\| p_i - H^{-1}q_i \right\|^2 + \left\| q_i - Hp_i \right\|^2 \right] \end{aligned} \tag{8}$$

Improve algorithm steps

Use the improved RANSAC to estimate the inter-image transformation matrix and repeat the random sampling:

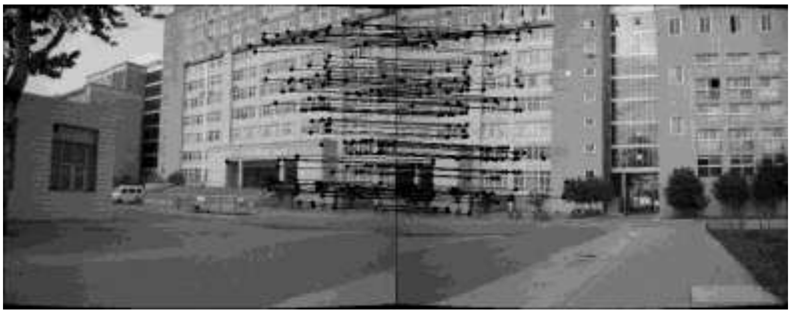
- Randomly select 4 pairs of pseudo-match points (the selected 4 pairs should ensure that the rank of matrix A is 3), and calculate the transformation matrix by linear least squares method;
- Calculate the vertical distance D of each pair of false matching points from A according to formula (8);
- According to the principle that the internal point distance is less than the threshold, that is, E is satisfied, the inner point of A is selected on the matching point set, and the number of inner points is recorded as point num;
- Compare the current number of points and the size of point_num, and always record and save the largest set of interior points;

- The maximum set of interior points is obtained by sub-random sampling of RANSAC, and the final transformation matrix is estimated by the least squares algorithm on the inner point domain.

It can be concluded from the analysis that if the diagonal points are pre-detected, a large number of background points are removed first, and only a small number of candidate points are finely judged, which can greatly save time? The purpose of this paper is to construct high-frequency information that is used to extract wavelets to extract images, and to screen candidate corners in high-frequency regions. Therefore, the paper focuses on the positive transformation of the wavelet lifting algorithm.

Experimental results and analysis

In this paper, two sets of pictures are used to test the performance of the RANSAC algorithm. The results are shown in Fig. 4.The coordinates of each pair of matching points are connected in a straight line, and all the lines are drawn in the same coordinate system, and each line represents a pair of matching points. The "mainstream" of the matching point connection represents the horizontal sweep of the camera, called the main motion. A point that conforms to the main motion is considered to be a valid matching point, which is an inner point.It can be from Fig. 4. After the error matching point is removed by the improved RANSAC algorithm, the connections in Figure 4(a)is more regular. Figures 4 (b) shows the set of interior points after exact matching. After 200 improved RANSAC algorithm iterations, the number of matching points between images is relatively reduced, effectively eliminating the false matching pairs. And the linear matrix least squares method is used to calculate the perspective matrix H between the images on the inner point domain, as shown in Fig. 4(c).



(a) Matching result of RANSAC algorithm

(b)Matching result purified by using improved RANSAC algorithm

$$H = \begin{bmatrix} 1.078 & -0.076 & 393.264 \\ 0.081 & 0.946 & -8.075 \\ 0.002 & -0.834 & 1.000 \end{bmatrix}$$

(c) Transformation matrix H

Fig-4: Optimization results by using RANSAC algorithm

CONCLUSION

In this paper, the RANSAC algorithm improves the slow and real-time performance of image corner matching. In the improved algorithm, the basic matrix is used as the model parameter estimation object, and the LACC image segmentation technique is used to extract the rough matching point pairs, and the matching matching points are pre-tested by the parallax gradient. Experiments show that the improved algorithm can reduce the computational complexity and improve the image matching speed while ensuring high precision and robustness.

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