

## A Novel Stable Algorithm for Image Feature Point Matching based on Gray Level Projection

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**Abstract** - The matching method based on feature points is divided into two steps: extraction of feature points and feature points matching. The first step has a direct influence on the quality of matching. Analysis and feature points extraction algorithm are done first to select the experimental effect by using Harris corner detection algorithm, followed by Gray image feature points extraction. Due to the traditional Harris corner extraction algorithm not being suitable in the presence of scale transform image, we develop a novel improvement within the scale space to make the new algorithm counter the effect of scale change.

**Keywords** - Feature Points Matching; Feature Point Extraction; Retrieving Similar Triangles; Cluster Analysis

### I. INTRODUCTION

Image matching in computer vision and image processing is an important research content. It refers to the two different sensors to obtain the same area of the image matching, to determine the relative position between the two image process, widely used in computer vision, pattern recognition, medical image processing, remote sensing image registration, image retrieval, splicing and other fields. Due to the time, Angle of view, and changes in the environment and the defects of the use of a variety of sensors and sensor itself, makes the images taken not only affected by noise. And there are serious gray distortion and geometry distortion. In this condition, the matching algorithm how to achieve high precision, high accuracy, high speed, strong robustness and anti-interference and parallel implementation become people the pursuit of goals.

Matching method based on gray level, also known as the correlation matching algorithm, using two-dimensional space slide template image matching. The difference between the different algorithms is mainly reflected in the choice of templates and related criteria. The most classic gray matching method is of normalized gray-level matching methods. Its basic principle is a per-pixel to a certain size of real-time image window gray level matrix [1]. And the reference images of all the possible Windows grayscale array, according to some similarity measure method compare search matching method. Subsequent methods mainly for matching speed, accuracy and the algorithm to improve the commonality.

Based on feature matching method first extracted features in the original image, and then establish feature matching corresponding relationship between the two images. Commonly used feature matching primitives including point, line, region and other significant features.

Due to the point of interest, the angular point and inflexion point is as well as T intersection of high information content. The number is relatively small and local invariant features and make it in matching based on feature is more popular with people. The method based on feature generally from the extraction of feature points and the establishment of stable feature point correspondence for research. Against the actual problem in the image could be affected by the interference of background noise [2]. It may also occur perspective, lighting, scale, translation, rotation and affine change. On the basis of the same theory of computer vision, image feature points invariance research become an important step in image processing and the research hot spot. It has made a lot of research results.

### II. IMAGE INVARIANT FEATURE POINTS EXTRACTION

Image feature point extraction is the first step of based on feature point matching method. The feature points while retain the image characteristic information, and effectively reduce the amount of data information, and feature point extraction as the basic image processing and computer vision technology. Images may be noise in the actual problem. The interference of background, also may be light, Scale and Rotating. Affine changes, such as how to choose reasonable image feature points, make these feature points not only has good noise resistance, and remains unchanged under the above changes [3]. The structure diagram of image pyramid is seen as Figure 1. It directly determines the effect of the matching method based on feature points. Due to the quality of feature points will directly affect the match result, according to the needs of subsequent matches

in this chapter, therefore, it needs to be studied for the extraction of feature points.

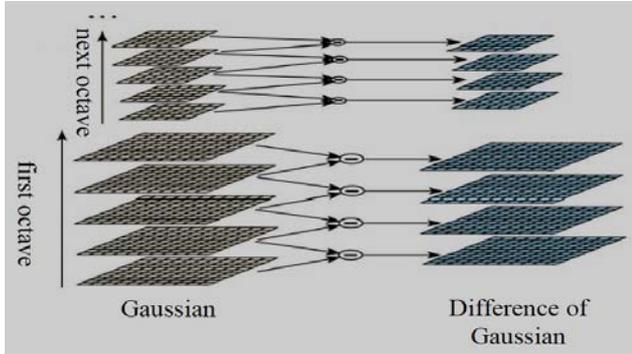


Fig. (1). The Structure Diagram of Image Pyramid

Image feature point is due to physical or geometric characteristics of the image, make the grayscale image in the local area produces significant change. Obviously, the number of image feature points have considerably less than the number of the whole image pixel, feature points while retain the image characteristic information. It has reduced the amount of data information effectively. Corner as is commonly used in image matching feature points. Its detection method is divided into based on edge extraction method and extraction method based on image gray scale. The former first detect the image edge, then on this basis to detect the edge of a sudden change point, as a result of corner detection [4]. This method is main drawback is that the edge detection algorithm dependency. The latter by computing the curvature and gradient to achieve the goal of corner detection. Because it does not need to extract edge work, and so has been widely used in practice. Because the match later in this article, you need two point sets for a certain number of valid points, and methods need to be is invariant to rotation and scale change.

$$\begin{cases} V_1 = \sum_{i=-k}^{i=k} (g_{r+i,c} - g_{r+i+1,c})^2 \\ V_2 = \sum_{i=-k}^{i=k} (g_{r+i,c+i} - g_{r+i+1,c+i+1})^2 \\ V_3 = \sum_{i=-k}^{i=k} (g_{r,c+i} - g_{r,c+i+1})^2 \\ V_4 = \sum_{i=-k}^{i=k} (g_{r+i,c-i} - g_{r+i+1,c-i-1})^2 \end{cases} \quad (1)$$

Harris corner detection operator is a kind of effective corner detection operator, but the traditional corner detection algorithm only within a single scale. When determining the final feature points. The effect of the angular point extraction depend entirely on the min value set. If the min value is too large may be missing the actual

angular point, value starts to extract pseudo angular point. Especially when occur between image scale transform, Harris corner can detect the inconsistent of angular point. When scale changes, may detect a new angular point, or the Angle of the old point shift or disappear. In this way, the proportion of efficient point will be greatly reduced, not conducive to the subsequent feature point matching. So, the traditional Harris corner detection operator is not anti-scale change. But in the concrete implementation of image matching, image often exist scale changes, so you need to improve traditional Harris corner detection algorithm. Geometric interpretation of the camera imaging is seen as Figure 2. Multi-scale technique as an ideal way to gain scale invariance feature will be used in subsequent feature point extraction.

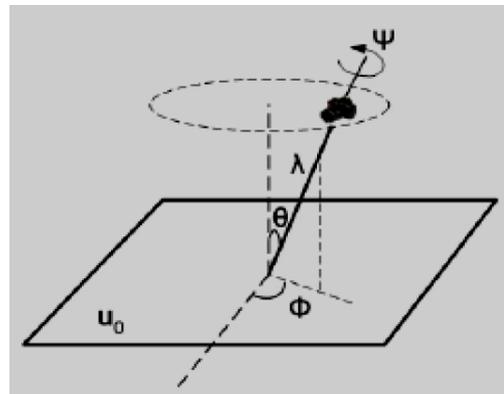


Fig. (2). Geometric Interpretation of the Camera Imaging

### III. FEATURE POINTS MATCHING METHOD

The purpose of the feature points matching between two images is to establish a match point to as much as possible. Because of the complexity of the environmental changes, it is very difficult to get a reliable matching results. Researchers in the field of feature points matching many matching method is proposed, but different methods have their applicability and limitations. This chapter through the analysis and research on several more commonly used and in some ways, such as the efficiency of the algorithm, the stability, versatility, etc., prominent feature point matching algorithm, can better clear the task of matching feature points and existing problems, and to analysis and study of the classic algorithm, at the same time provide a good basis for subsequent chapters fusion algorithm.

$$q^T = G(p) = s \begin{bmatrix} \cos \theta & -\sin \theta \\ \sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \quad (2)$$

The image feature points and the other image feature points matching, the most commonly used to a geometric transformation technology is image space transformation.

Feature points in an image is in order to transform and matching correctly. So, feature point matching needs according to different situation to choose the appropriate space transformation model. Common transformation models are: similarity transformation, affine transformation and projection transformation, polynomial transform, etc.

Feature points matching is to find out the corresponding relations between the two point sets and space mapping relation. Often, a point matching algorithm as long as can see the kind of a relationship, because you know that the one can easily determine another relationship. Overview of the ASIFT algorithm is seen as Figure 3. For example, the corresponding relationship between the given point set can be determined by the least squares method space mapping relationship, or a given space mapping relation we can through the simple greedy algorithm or better linear programming algorithm to determine the point correspondence.

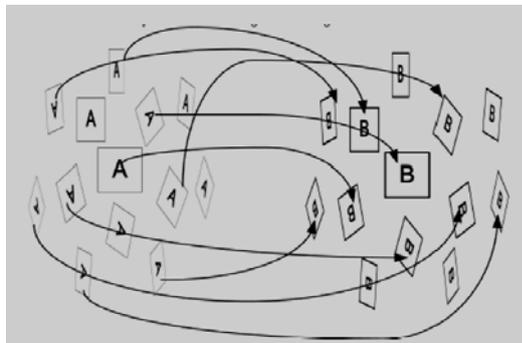


Fig. (3). Overview of the ASIFT Algorithm

This kind of method after the extraction of feature points, description of feature points are different, used to distinguish other feature points, then use the descriptor matching. Such as take a certain size of window around the feature point, then calculate each corresponding pixel gray value in the window of the sum of the squares of the poor, less than a min value of two points is a pair of initial matching points [5]. Or computing the gradient around the feature points, then different description, adopt the method of k - d tree matching. Matching method based on feature point geometry such method is not directly to matching of feature points one by one, it USES similar between feature points and the stable geometrical structures, such as edge, such as triangle matching. Fusion method with the single method has certain error matching, in order to enhance the robustness and stability of the algorithm, through the integration of different methods to improve the accuracy of the algorithm. The following will introduce and analysis and comparison of three commonly used feature point matching method: the method based on triangle similarity, based on two-dimensional clustering method and the method based on the descriptor.

$$s = \frac{|q_a q_b|}{|p_i p_j|} \tag{3}$$

$$\theta = \theta_{q_a q_b} - \theta_{p_i p_j} \tag{4}$$

Select triangle matching method is analyzed, because the triangle similarity with natural resistance to translation, rotation and scaling properties, for processing images between the translation, Rotating and Scaling, etc., has a unique advantage. So, the algorithm to implement more simple, thinking is more accepted by people. But after analysis and comparison, found that the time complexity is very large assuming that both the number of feature point set is n, so that each point set will constitute a flawed triangles. Method is needed to determine the similarity of each pair of triangles. The determination methods still need to involve more complex division and comparison. In addition the method of storage space is large, because of the need for a certain point in the process of matching triangle of centralized storage and sorting, as well as to the weight table storage, therefore, a fairly large space complexity. Because the proportion of the triangle with sides said. In the process of judging similar triangle, triangle similar to the size of the decision error range is bad control. And it did not use other information to eliminate some false matching triangle. May lead to a similar triangle logarithm is overmuch, easy to cause false matching again when template point of a point and target concentration multiple points matching, the problem of feature point correspondence can't find out. In the final match point pairs, each pair of points matching are independent in the weight table. So, in the far point is large, the weights of values in the table is bad choice.

Choose clustering method were because the method only involves the operation and comparison between vector. The algorithm's efficiency is the highest of the current feature point matching algorithm, but still exist as follows: the method in the algorithm of scaling and rotation parameters, looking for maximum matching support the corresponding amount of zoom. Algorithm introduces a min value, the meaning of it is large enough support. Role in the algorithm is that when two any pair of points on the maximum support degree [6]. If greater than this value, then the end of the algorithm. The point of the maximum support degree of the corresponding amount of scaling and rotation is to determine the parameter values. Due to the deformation for different images, noise and local distortion degree and will be a different number of matching point, matching the effect will be different, but these factors before the match is unknown, so big enough to support measurement is difficult to determine. This reduces the stability of the algorithm if support Settings, make sure the transform parameters (s,0) values are not reliable and unreliable transform parameters (s,0) to further determine the matching point to itself introduces some error, reduce the accuracy of the algorithm.

In addition, in point to determine the matching algorithm, if according to the calculation of unreliable, to calculate the possible match point to, and get the matching point to can be used to calculate the approximate affine transformation parameters, and finally to the second and third search to determine possible matching point, introduced three refer to value in the process. If the min value is undeserved, it will lead to lose the match point to and more of a case of mismatch, at the same time reduces the stability and accuracy of the algorithm. And this algorithm can solve the one-to-many, template point of a point and target point concentration multiple point matching. The problem, but did not consider to avoid a template for more multiple point and target of centralization of a point matching the situation of mismatch. So, Chang fast point matching algorithm, such as the execution effect of largely depend on the introduction of four min value to choose suitable or not. But in the actual application, because for different matching data, template point and target point sets, deformation, noise and local distortion degree and matching points for the number of different, lead to refer to value is difficult to determine, and the stability and accuracy of the algorithm is dependent on the proportion of efficient point.

Selection method based on the descriptor is analysed, because the method not only for scaling, rotation, scale brightness change keep invariance. And it changes in perspective, affine transform and noise also maintain a degree of stability. The conference image and the matching image is seen as Figure 4. And the method of the number of feature points and the proportion of efficient point there is no requirement. When the feature points are not many, the optimization of the SIFT matching algorithms, and even can reach the requirement of real-time. And can be easily combined with other forms of feature vector.



Fig. (4). The Conference Image and the Matching Image

SIFT algorithm, however, there are also some shortcomings. Method based on feature points 128 - dimensional vector, then the vector matching and this enough texture images have to be met, otherwise constructed 128 - dimensional vector difference is not too big, easy to cause false matching, limiting cases such as fingerprint image matching. This kind of image features such as star map recognition around no texture. The SIFT algorithm is then completely failed. In addition, three kinds of matching strategy for descriptor has a deficiency: based on the closest matching: recently, in the distance of the two descriptors, and two descriptors distance under the min

value, assume that a match. The matching result of two images is seen as Figure 5. In this kind of matching method, a point may have a match point, or may not match point. Based on value matching: if two descriptors distance under the min value, think a matching success, or the failure of a match. In this kind of matching method, matching point a point may have a few, or no matching points, its relationship with explaining of value size is very large. Matching: based on the ratio of this method and based on the closest matching is similar to require two nearest descriptor, but refer to value is the ratio of the first and the second closest.

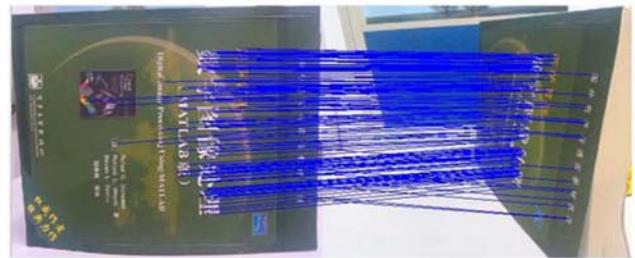


Fig. (5). The Matching Result of Two Images

#### IV. MULTIPLE METHOD FUSION FEATURE POINT MATCHING ALGORITHM

Different feature point matching method have their respective advantages and disadvantages. A single method in concrete application has certain limitations. Comparative analysis of the advantages and disadvantages of different algorithms, foster strengths and circumvent weaknesses, for effective integration, certainly can get better matching effect. Based on the thought, in the classic improvement method on the basis of the key steps, for multiple method fusion scheme is studied.

$$\Delta x = x_q - x_p (s \times \cos \theta) + y_p (s \times \sin \theta) \quad (5)$$

$$\Delta y = y_q - x_p (s \times \sin \theta) + y_p (s \times \cos \theta) \quad (6)$$

Section in detail and analyzes the traditional matching method of similar triangles and two-dimensional cluster matching method and the method based on two-dimensional clustering. A variety of methods have their own advantages and disadvantages, it provides multiple methods fusion with conditions. First of all for clustering method, the sample space of clustering and the effective sample size will directly affect the results of clustering method. Clustering method using vector set to match, but because of the far point can produce a large number of invalid vector. In this way, less effective samples in sample space, to calculate the parameters on the subsequent clustering algorithm bring serious disturbance. The difference of sample parameters is not conducive to the follow-up of cluster analysis.

Therefore, the two-dimensional fast clustering algorithm, but its stability is bad. It has a high requirement on the efficient point. According to the principle of clustering method, if the sample space of clustering can be reduced, and make the effective sample size remains the same, so you can get the results more accurate and true. Obviously if matching of two vectors is real is in the match in the image, the relations between the two vectors have to satisfy certain, for example. The corresponding feature points of vector grayscale value, the gradient and distribution is not a great difference between the vectors and so on, so you can according to the ideas of the method based on the descriptors. Description of vector feature points are different from the sample space to remove most of the matching vector, thus reducing the clustering sample space. In addition, easy to know three of the end-to-end vector can form a triangle, and if the image similarity transformation, only know the corresponding two triangle is must be similar. So, through the triangle similarity judgment can also eliminate most of the match vector. According to the above mentioned, the triangle method and two-dimensional clustering method, and it is necessary to carry out fusion method based on the descriptor, are also possible.

First of all, the traditional method based on similar triangle calculation process is relatively complex. And it make full use of the other, such as image gray level information. Information such as feature point type. Algorithm speed is slow, and the requirement of efficient point is quite high. So I have to improve traditional method first based on triangle matching method. The algorithm can improve the efficiency, and then again on the basis of the integration of clustering method and the method based on the descriptor, make the matching of the fused method is more stable, rapid and effective. The following detailed research and analysis integration schemes. Similar triangles have translation, Rotating and Scaling invariance. And its determination methods is already quite mature, for rotation and scaling of this kind of image matching. It has the advantageous superiority. Select the template image of triangle template to synthetic physical image feature point similar triangles retrieval, to realize the template image matching. It can greatly reduce the search space of traditional image matching method. But when the template feature points contains the point out of line, triangle matching triangle in the collection are searching for will not contain the same matching triangle, so as to get the accurate matching position. So, with a single triangle template matching is not reliable, the following will consider using multiple template matching triangles.

$$q^T = \begin{bmatrix} X \\ Y \end{bmatrix} = G(p) = S \begin{bmatrix} \cos \theta & \sin \theta \\ -\sin \theta & \cos \theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} \Delta x \\ \Delta y \end{bmatrix} \quad (7)$$

Assuming that the template image to the physical image of quad transformation parameters, the algorithm can just

find out the transformation parameters. This parameter can be calculated by the triangle with matching with the same template, but match the triangle in which belong to the same matching is difficult to determine. But you can know is: each template triangle with matching with the same parameters calculated in the same, and matching with pseudo triangle calculation parameters are relatively large. Clustering analysis as research in mathematical statistics, birds of a feather flock together

A way of developing rapidly in the recent ten years. Algorithm firstly calculates each template transformation parameters between the triangle and matching, and then spatial clustering set of parameters to get the real transformation parameters. Schematic diagram of the histogram equalization is seen as Figure 6. Because of the matching triangle number is larger. In order to improve the accuracy of clustering, it is necessary to eliminate some false matching triangles.

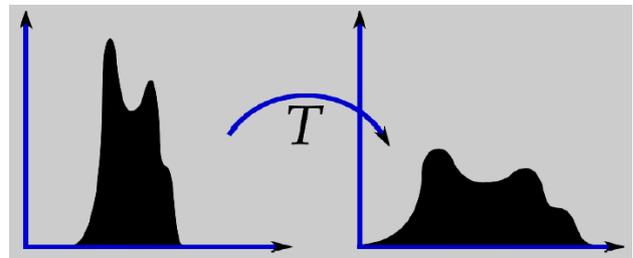


Fig. (6). Schematic Diagram of the Histogram Equalization

First extract the image feature points in the image selected characteristic value high and uniform distribution of feature points as the triangle vertices, set a triangle; Then from the template image triangle child templates, selected from the set of physical image feature points in the similar triangles retrieval to realize image coarse matching. According to descriptor method, using the calculation simple information, the gray information such as the apex of the triangle or special point, fingerprint images such as intersection and endpoint, eliminate most of the false matching triangle. The image processed by the histogram equalization is seen as Figure 7. Finally to compute the triangle to transform parameters between the transform scales, rotation Angle, and the parameter set clustering to realize image exact match.



Fig. (7). The Image Processed by the Histogram Equalization

Synthetic similar triangle retrieval will get a large number of matches, but most for matching triangle, which is unfavorable for the subsequent clustering analysis, therefore, it is necessary to eliminate partial matching triangle. Because now you get to a higher similarity matching triangle is through judgment, triangular area of the image information has not been used. So, it can use the method based on the descriptor thought at this moment, quickly remove part of the more obvious false matching triangles, but according to the different image content need to adopt different information is described. Such as if the image is greyscale images, it is generally, the triangle can be used to image gray correlation computation to eliminate, but this method needs the image to zoom in and interpolation, effect and speed will depend on the specific selection of interpolation method.

$$\left| \begin{matrix} x_2 - x_1 & y_2 - y_1 \\ x_3 - x_2 & y_3 - y_2 \end{matrix} \right| \left| \begin{matrix} x'_2 - x'_1 & y'_2 - y'_1 \\ x'_3 - x'_2 & y'_3 - y'_2 \end{matrix} \right| > 0 \quad (8)$$

The shortest distance clustering algorithm and the clustering accuracy is very high, but it will need to finish all parameter calculation, and then in turn select two recent nodes operate merge and insert, high time complexity. When the number of nodes, time complexity. Through experimental analysis found that its biggest time-consuming is used in looking for the operation of the shortest distance between two nodes; And when the number of cluster nodes is more. Clustering nodes separability is very poor, it will seriously affect the efficiency of matching algorithm. Beaver image with larger scale changes is seen as Figure 8. Based on the above analysis, the realization of a kind of dynamic shortest distance clustering algorithm. Dynamic shortest distance clustering method to calculate the parameters of the dynamic clustering to the parameters in the sample space. Use a two-dimensional array to save the generated nodes, initial two-dimensional array is empty. Due to calculate the parameters is two-dimensional, so the new parameter is easy to locate to the nearest node. If find meet the conditions of clustering nodes, using the formula will merge two nodes, when a node of the confidence level to achieve a given min value, the end of the clustering, and subsequent child templates don't need to match, otherwise, insert the merged node two-dimensional array. Due to good separation of the cluster nodes, the initial node is less, so the dynamic clustering algorithm complexity is reduced greatly.

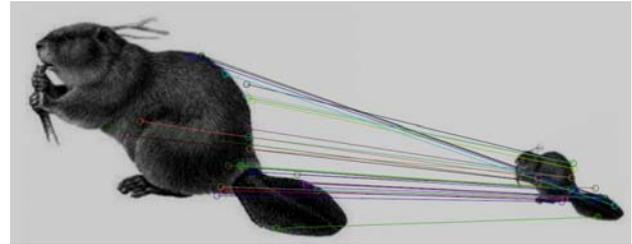


Fig. (8). Beaver Image with Larger Scale Changes

Fusion of several characteristic points algorithm are analyzed, after fusion algorithm is introduced in detail, and gives the specific implementation of the algorithm. By improving the traditional synthetic similar triangle retrieval method, time complexity from the mouth to. By referencing the descriptor method to eliminate most of the false matching triangles, it can not only improve the efficiency of the subsequent clustering algorithm. And it improved the accuracy of clustering. The shortest distance by using the dynamic clustering method, on the basis of the algorithm accuracy, improve the efficiency of the algorithm. Fusion algorithm inherits the advantages of resistance to rotate and zoom feature point matching method. It improves the speed triangle matching algorithm and reduce the point matching algorithm for efficient point number. Points sizes and types styles are seen as Table 1. Based on triangle method, similar to that of the basic clustering method and the method based on level together organically, improve the stability, accuracy and rapidity of the algorithm.

TABLE 1. POINTS SIZES AND TYPES STYLES

Algorithm	Average Value (%)
This Paper	92.53
ORB	24.26
SIFT	96.46

Image feature point extraction is the first step of based on feature point matching method, in practical problems, the image could be subject to the interference of background noise, may also occur illumination, scale, rotation and affine changes, such as how to choose reasonable image feature points, make these feature points not only has good noise resistance, and remains unchanged under the above changes. It directly determines the effect of the matching method based on feature points. Due to the subsequent need to image matching method under the rotation and scale transform still satisfy a certain proportion of efficient point, so this article need to rotation and scale invariant feature points extraction were studied. Multiple method fusion feature point matching due to the current various matching methods have their advantages and disadvantages and applicability. Triangle matching method is easier to implement, for example, thought is more accepted by people, but in the feature points is large, need a higher similarity judgment on a large number of triangles, algorithm efficiency is low. And clustering algorithm, the

efficiency is very high, but also to point the proportion of efficient point requirement is very high. SIFT method does not require the efficient point of ratio, but the requirement of image texture is higher, its stability is determined by the same feature point extraction, is not suitable for the environment is bad situation. Choose which method and how to integrate and merge the effect after how are content to research on this topic.

## V. CONCLUSIONS

This paper proposes a multiple method fusion feature point matching method. In the analysis and comparison of traditional method of similar triangles, two-dimensional clustering method, and the method based on descriptor. Summarizes the merits and defects of the method. First of all, the similar triangle matching method in the treatment of the rotation and scale transform has advantaged superiority condition, but due to large number of triangles and traditional similar triangles and retrieval method of complex, makes the algorithm efficiency is low. And clustering method is simple, algorithm efficiency is high, but the number and proportion of efficient point to demand higher. Descriptor based method to process image perspective of existence and the local image distortion is larger, but to the image texture is rich, and cannot handle multiple target object appeared, the miss match to eliminate also need to other methods. After fusion methods, inherited the

advantages of various methods, improve the stability of the algorithm, quickness and versatility.

## CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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