Research on Image Rotation Recognition Based on Histogram Feature Description

Chunrong Zhou*
Chongqing Vocational College of Transportation, Chongqing 402247, China

*Corresponding author: rongmtyme8900@163.com

Abstract. Image recognition is a statistical pattern recognition problem in pattern recognition, which mainly includes four steps: image acquisition, preprocessing, feature extraction and selection, and pattern classification. In this paper, an omni-directional sequential feature description method based on F histogram is proposed. In this method, shapes are segmented by directional lines in all directions, the sequential feature description quantity between object segmentation segments in each direction line is calculated, the omni-directional sequential feature description quantity of shapes is constructed, and the similarity between shapes is calculated. In this method, the normal vector histogram is used as the point cloud feature descriptor, which can optimize the search of the corresponding point set, thus improving the ICP algorithm. By selecting the appropriate expansion center and expansion order, the recognition ability of the filter is improved. At the same time, using the concept of image moment, the characteristic moment vector of the target is constructed to identify the target with in-plane rotation and scale change. Based on the optimization strategy based on histogram feature description, the recognition speed of the algorithm is significantly improved.

Keywords: F histogram, Feature description, Rotation invariant recognition

1. Introduction
Image rotation invariant recognition is one of the hot issues in the field of image processing and pattern recognition. It has a good application prospect in many fields such as machine vision, satellite remote sensing, medical diagnosis, etc. It is also one of the topics that many science and technology enthusiasts are interested in [1-2]. The main purpose of image preprocessing is to improve the quality of images, strengthen certain features or separate objects to be recognized, which mainly involves image enhancement, image restoration and image segmentation techniques. In order to reconstruct the high-resolution 3D molecular structure, it is necessary to collect a large number of 2D molecular image data. Because the filter is only matched with a certain level of circular harmonic components of the target, but not with the whole target image, the signal-to-noise ratio of the filter output will decrease [3]. Zhang et al. [4] uses the features of the surface of the point cloud model to find the corresponding point set. Huang et al. [5] used curvature map as the feature description of point cloud data. The two-step method of rough registration of curvature map features and accurate registration with classical ICP algorithm effectively reduced the iteration times of ICP and achieved satisfactory
point cloud registration results.

Traditional target recognition is based on the amplitude information of diffracted light of objects, and the phase information of objects is discarded. In order to achieve better recognition effect, a large number of images at different positions have to be recorded to facilitate recognition. In this paper, a normal vector histogram feature descriptor is introduced, which combines surface normal vector with histogram to describe the relationship between normal vectors in local area of point cloud, and to express the concave-convex changes in local area of point cloud. In view of the shortcomings of boundary-based and region-based shape description models, this paper expands the F histogram model for spatial orientation relationship description by describing the main direction of shape and the sequential feature of shape, and proposes an omni-directional sequential feature description method of shape based on F histogram [6].

2. F Histogram Model

The f histogram [7] describes the spatial orientation relationship of a pair of two-dimensional objects A and B by measuring the proposition "the authenticity of object a in the α direction of object B", as shown in fig. 1, it is assumed that there is a point \( P \) on the point cloud \( P \), and its normal vector is \( \vec{n}_P \). when looking for the corresponding point on the point cloud \( Q \), there are two \( q_1 \) and \( q_2 \), and the angles between the normal vectors \( \vec{n}_{q_1}, \vec{n}_{q_2} \) and \( \vec{n}_P \) of these two points are the same, which are all \( \phi \), with the same included angle, it is impossible to determine which point is the best matching point. The in-plane rotation invariance of the input target can be realized by using the first-order circular harmonic expansion of the target as a filter, which has not only rotation invariance but also translation invariance for target recognition. This algorithm can effectively solve the problem of random orientation of molecular images. At the same time, this kind of feature is insensitive to noise, which can overcome the interference of noise. In the research and application of image, only some parts of the image are interested, which generally correspond to specific and unique areas in the image. In order to identify and analyze targets, they need to be separated and extracted.

![Figure 1 Normal vector angle](image)

The normal vector histogram of point cloud combines normal vector with histogram, that is, it takes the normal vector of point cloud as the basis for statistics, so as to construct histogram, which can be used as a feature descriptor of point cloud. It needs to be obtained according to the three-dimensional coordinates and normal vector of point cloud. The object segments on the same direction line are straight lines, and there is no shape difference, and there is a sequence between the object segments. If an appropriate unfolding center cannot be selected, the output correlation peak may not be sharp enough, and the central correlation point is not necessarily the maximum point of correlation output, which can not achieve a good recognition effect, so unfolding center has an important impact on the discrimination ability of circular harmonic filter. Image degradation is the combination of convolution operation and noise infection. If deconvolution and denoising can be performed, the degraded image can be restored [8]. Selecting several optimal weak classifiers can not only avoid the interference of other weak classifiers with higher classification errors and improve the recognition
accuracy, but also significantly improve the recognition speed.

3. All-directional Sequential Feature Description of Shape

3.1 Omnidirectional Sequential Feature Descriptor

Based on the F histogram, a new object shape description model is proposed by describing the main direction and shape order features of the object shape. This normal vector histogram can better describe the local geometric features of point cloud, thus solving the problem of non-uniqueness of matching points. Histogram can directly describe the distribution of data. At present, histogram is not only used in statistics, but also used in image processing. In order to make the calculation simple and identify the target with varying scales, we can use the moment component of the image to identify the target. Moment function is widely used in image processing. Moment set calculated from an image usually describes the global characteristics of the image shape and contains a lot of information about the set characteristics of the image. All the strong classifiers are linearly weighted and combined in a specific weighting way, thus a comprehensive classifier is obtained.

The pixel value \( f(x, y) \) of an image can be regarded as a two-dimensional density distribution function, and its \((p+q)\) moment can be expressed as

\[
\Phi_{pq} = \int\int_{\mathbb{R}^2} x^p y^q f(x, y) \, dx \, dy
\] (1)

\( \zeta \) represents the area of the image on the \( x-y \) plane. When \( p \) and \( q \) are both 0, we can calculate the "quality" of the image, and if the image is a silhouette image, we can calculate the area of the image. Using moments, we can calculate the centroid positions \((x_0, y_0)\), the center moment of the image can be calculated by using the centroid position in the image

\[
\Phi_{pq} = \int\int_{\mathbb{R}^2} (x-x_0)^p (y-y_0)^q f(x, y) \, dx \, dy
\] (2)

In 1962, Hu derived a series of moments that remained unchanged during rotation, translation and scale transformation, such as the moments of images

\[
\Phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2
\] (3)

In the formula

\[
\eta_{pq} = \Phi_{pq} / \Phi_{00}, y = 1 + (p + q) / 2.
\] (4)

When the noise infection rate is high, the filtering effect of median filter is affected, and the details and edge information of the filtered image are seriously lost [9]. At the same time, the feature vector of the template can be calculated by the same method only after scanning the template image once, and then it can be used to match each sub-image, and compare the similarity function value after matching to determine whether the two images match, which improves the matching speed. The filters synthesized by this method have a remarkable property: although they only consist of absorption patterns, they can effectively control the amplitude and phase of the transfer function at the same time. If the pixel value of an image is regarded as a two-dimensional density distribution, the geometric moment function related to the spatial position can provide some shape information of the image, such as the area of the image and the coordinates of the image moment center. Histogram counts the normal vectors in local neighborhood, which can reflect the relationship between normal vectors in local area, thus showing the concave-convex changes in local area in detail.

3.2 Shape Similarity Measure

First of all, it can be determined that when the target rotates in the plane, the position of the centroid
relative to the target is constant, so the image moment that we first think of to determine the feature vector is the centroid. High-level instructions can quickly realize parallelization and multithreading of programs, and have strong flexibility, which can easily adapt to different parallel system configurations. Shape omni-directional sequential feature description uses the directional lines in each direction to segment the shape, and calculates the sequential feature description quantity between object segments on each directional line, which has nothing to do with the absolute position of shape feature points.

In order to determine the corresponding segmentation direction, it is necessary to calculate the minimum inertia axis of shapes A and B, which does not change with the shape transformation, and only preserves the main direction of shapes. The main direction of the shape lies on a straight line which passes through the center of gravity of the shape and has an inclination angle \( \theta \), and the formula of inclination angle \( \theta \) is

\[
\theta = \frac{1}{2} \arctan \left( \frac{2u_{11}}{u_{20} - u_{02}} \right)
\]

In which \( u_{11}, u_{02}, u_{20} \) is the \( p + q \) central moment of the shape.

Let the corresponding direction of shapes A and B be \( \bar{r}(a), \bar{r}(b) \), and from the corresponding direction, calculate the difference degree of sequential feature description quantity in each corresponding segmentation direction of shapes A and B by formula (4) to obtain \( \{D_0, D_1, \ldots, D_{n-1}\} \), and the difference degree of omnidirectional sequential feature description quantity of shapes A and B is

\[
D_{all} = \frac{1}{N} \sum_{i=0}^{N-1} D_i
\]

The shape similarity \( S \) of shapes A and B is

\[
S = 1 - D_{all}
\]

Through binarization and normalization of images, the scale change invariant analysis is realized, but the normalization process of images will introduce resampling and weighting errors, and many details and useful information will be lost in the binarization process. In feature-based recognition algorithms, the features that can be shared by most molecular images of the same kind are the key features needed to recognize molecular images. Therefore, the weighting method of the comprehensive classifier meets this demand well.

3.3 Time Complexity Analysis of Shape Omnidirectional Sequential Feature Description

The time complexity of shape omni-directional sequential feature description is divided into two parts: the calculation time complexity of omni-directional sequential feature description and the shape matching time complexity. And four variables are used to express the relationship between each pair of points’ neighborhood normal vectors, and then the histogram is determined and constructed according to the included angle value of normal vectors and four variables, so that the relationship between neighborhood points can be described by histogram. Because the input image is discrete, the minimum value of the output is not zero, and the derivative at the minimum value of the output is the largest. In order to find the position of the minimum value, Laplace transform can be performed on the output, and the position corresponding to the maximum value is the centroid position. The geometric moment of an image is the integral of an image function in a spatial region. The limited image space is considered in image research, and it is considered that all integrals are carried out in this limited space. It can not only identify many kinds of objects, but also identify objects with different rotation angles in the same class, and reduce the number of matched filters, which is a feasible method. If the complex amplitude transmittance of a spatial filter is conjugate with the frequency spectrum of the input signal, the filter is called a spatial matched filter, and the matched filter is a complex filter, which can be
made by optical holography or computational holography.

4. Test Results and Analysis

The normal vector relationship of points in the neighborhood is described by the normal vector histogram, which is reflected in 125 regions, thus better describing the geometric characteristics of the local surface of the point cloud, and thus obtaining a satisfactory stitching effect. For the point cloud surface, the point cloud data output by the acquisition equipment generally has the geometric coordinates and normal information of the points. If the point cloud obtained by structured light scanning method also contains the color information of points, the point cloud data with only geometric coordinates can be calculated by the point cloud normal vector estimation method in Section 2 of this paper. Table 1. shows the normal vector calculation time of the image rotation model to be spliced.

| Point cloud model | Point cloud scale | Normal estimation time (s) |
|-------------------|------------------|---------------------------|
|                   | Model A | Model B | Model A | Model B |
| Face model        | 213985  | 385310  | 7.24    | 10.28   |
| Animal model      | 232371  | 296757  | 8.96    | 7.74    |

The standard data set MPEG-7 CE-1 Part B is widely used to test the performance of shape retrieval. The database contains 70 types of shapes classified according to semantics, 20 in each type, with a total of 1,400 shape images. In this paper, the retrieval rates of shape omni-directional sequential feature description method and tar, HSC and other shape description methods on MPEG-7 CE-1 Part B shape data set are shown in Table 2.

| Serial number | Shape description method | Retrieval rate/% |
|---------------|--------------------------|------------------|
| 1             | SC                       | 88.01            |
| 2             | IDSC                     | 75.14            |
| 3             | TAR                      | 89.63            |
| 4             | HSC                      | 87.56            |
| 5             | Sequential feature description | 90.34   |
| 6             | Omnidirectional sequential feature description | 87.55 |

Rotation moment has many advantages, and it has ideal rotation invariance without the aid of geometric invariant theory; Most of these algorithms use pixels as image matching features, so the computational complexity has not been substantially reduced. On the contrary, the computational complexity is often reduced at the expense of accuracy. When the number of sample set partition is 1, it means that the algorithm has not been optimized by divide and conquer. With the increase of the number of sub-samples, the corresponding recognition rate increases rapidly. It is difficult to find a fixed relationship between the change of pixel number and the transformation scale, which makes it difficult for us to normalize the complex moments after scaling transformation to achieve the desired results. With the idea of integrating images, seven quantities of Hu moments can be calculated only by traversing the image once, so the selection of template size hardly affects the calculation amount, so that the appropriate template size can be selected to improve the matching accuracy.

The above experiments are the simulation results when the intensity of the target is linear transformation, but in reality, the gray level changes of objects are not all linear changes, so we propose a gray level change model

$$h(x) = f^y(x) \quad (8)$$

When the intensity of the object changes exponentially, we can take the logarithm of the intensity
to get $\gamma \ln(f(x))$, it can be seen that $\gamma \ln(f(x))$ is the linear change of the logarithm $\ln(f(x))$ of the true target image $f(x)$. We can make the logarithm $\ln(f(x))$ of the original true target image $f(x)$ as the true target.

![Figure 2 Filter output](image)

It can be seen from the relevant output Figure 2 that when the gray scale transformation of the target is not linear transformation and the target is not covered, the output peak value of the real target is still very high, while that of the false target is very low.

5. Conclusion
In this paper, the shape description method expands the F histogram model, so that the F histogram can describe the spatial orientation relationship and shape information simultaneously. The normal vector histogram proposed in this paper describes the relationship between normal vectors in local areas, and shows the concave-convex changes in local areas in detail. The feature quantity of the normal vector histogram is used to match the corresponding points, which makes the algorithm iterative to convergence. A nonlinear comprehensive discriminant function filter is constructed, which eliminates the influence of target distortion on target recognition and greatly improves the recognition ability of the filter. By extracting rotation invariance and translation invariance features of molecular images, the problem of random orientation of molecular images is effectively solved, and the extracted features are insensitive to noise. This algorithm makes full use of the local features of the image, and when processing images infected with mixed noise of impulse noise and Gaussian noise with arbitrary mean, the effect of the algorithm is obviously better than that of other filtering algorithms.

References
[1] Chen Derong, Wang Wenbin, Liu Bingtai, et al. Object description method of rotation invariant gradient histogram. Journal of Electronics and Information Technology, vol. 38, no. 001, pp. 23-28, 2016.
[2] Lou Yuqiang, Jiang Huatao, Chang Lin, et al. Vehicle detection based on EdgeBoxes and rotation invariant features. Information Technology and Network Security, vol. 493, no. 05, pp. 50-53, 2018.
[3] Huang Huanhuan, Cheng Xu, Zhong Kai, et al. Automatic point cloud registration method for rotation invariant feature descriptors. Journal of Heilongjiang University of Science and Technology, vol. 26, no. 003, pp. 316-322, 2016.
[4] Zhang Dongbo, ZHANG DongBo, Chen Honglei, et al. Anti-rotation high-efficiency and high-discrimination feature representation method for circular images. Journal of Software, vol.30, no. 9, pp. 2904-2917, 2019.
[5] Huang Qingyu, Zhang Dengyi. Texture image classification algorithm based on local feature multi-axis rotation invariant characteristics. Computer Science, vol. 045, no. 012, pp. 206-209, 2018.
[6] Luo Junli. A texture feature extraction method of rotation-invariant symbiosis pattern. Journal of Xuchang University, vol. 38, no. 02, pp. 129-136, 2019.
[7] Gao Pan, Liu Guangshuai, Ma Ziheng, et al. Enhanced pairwise rotation invariant symbiosis extended local binary mode. Journal of Image and Graphics, vol. 23, no. 007, pp. 1024-1032, 2018.
[8] Wang Chunhua, Han Dong. An effective median filter image blind forensic detection scheme. Journal of China Academy of Electronics, vol. 012, no. 006, pp. 668-674, 2017.
[9] Wang Kaili, Zhang Yanhong, Xiao Bin, et al. A texture image classification method based on two-dimensional local binary mode. Chinese Journal of Electronics, vol. 046, no. 010, pp. 2519-2526, 2018.
[10] Sun Wei, Zhao Yupu. Enhanced Rotation Invariant LBP Algorithm and Its Application in Image Retrieval. Computer Science, vol. 046, no. 007, pp. 263-267, 2019.