Research on Image Segmentation Technology and Intelligent Language Recognition Based on Ant Colony Algorithm

Jinghui Li

***Abstract*—Aiming at the problems of large image segmentation error and low intelligent language recognition accuracy in existing image segmentation and intelligent language recognition, an image segmentation technology and intelligent language recognition method based on ant colony algorithm are designed. First, the internal structure of the image is regarded as a network, and its mapping relationship is determined. Then, the Gaussian function is used to determine the gray, color, texture and other characteristic values of the image, set the constitutive matrix, calculate the weight value of the segmented image, and use the histogram method to complete the effective segmentation of the image. Finally, the advantages of the ant colony algorithm are used to determine the spatial position of the intelligent language in the image, and Fisher's law is used to judge the language recognition results, and the discrete degree within the language class represents the classification density, thus completing the intelligent language recognition. The experimental results show that the image segmentation error is small and the intelligent language recognition accuracy is high.**

***Index Terms*—Ant colony algorithm, image segmentation, intelligent language, adjacency matrix, gaussian function**

I. Introduction

Image is the basis of human vision and an important source of human understanding and perception of the world; It refers to the objective objects that produce visual impression in human visual system (including characters, pictures, photographed photos, natural scenery, etc.) [1]. However, natural images are analog. Before the widespread application of computers, the storage and transmission of images such as cameras, video recorders, movies and televisions were carried out according to analog signals [2]. However, with the continuous development of computer science and technology, through sampling and quantization, the image is displayed and processed on the computer to form a digital image. In recent years, with the rapid development of computer and information technology, image processing and analysis has gradually formed its own discipline system. New processing methods and technologies emerge in endlessly. Although its development history is not long, it has attracted extensive attention of talents all over the world. Firstly, vision is the most important means of human perception. More than 95% of the information obtained by the human brain comes from the visual system, and image is the basis of the visual system. Therefore, image processing technology is widely used in medicine, agriculture, forestry, biology, sports, military, remote sensing, product detection, intelligent transportation, industrial automation There is a growing demand in applications such as production process control. In addition, digital image processing technology has also become an effective tool and external method for scholars in many fields such as computer science, medicine, artificial intelligence, physiology, psychology and so on. Image segmentation is a preprocessing in image recognition and computer vision system. Image segmentation will lead to the poor effect of subsequent image processing, which will lead to major problems in tracking and recognition. Therefore, image segmentation and language recognition have become a hot issue in image research [3]. Image segmentation refers to the technology and process of using some low-dimensional visual features of the image to divide the image into a series of non-overlapping homogeneous regions according to a certain similarity criterion, and extracting the object of interest from the complex background environment. The low dimensional visual features here can be color, spatial texture, geometry, etc., and the target corresponds to a single or multiple regions. From the perspective of graph, image segmentation is the first step of image analysis. It is the key step to realize from image processing to image analysis, and then to complete image understanding. The segmentation results directly affect the effectiveness of subsequent high-level related tasks. Therefore, image segmentation has become a basic problem and key in many fields, such as image processing, pattern recognition, computer vision and image understanding.

In recent years, the research of image technology has received great attention from experts and scholars at home and abroad. In order to carry out comprehensive research and integrated application, Professor Zhang of Tsinghua University proposed to establish an overall framework called image engineering. The content of the framework is very rich. It is a new interdisciplinary subject that systematically studies various image theories, technologies and applications. According to the degree of abstraction, data objects and research methods, it can usually be divided into three levels of abstraction, which are both related and different. Image processing, image analysis and image understanding [4]. Among them, image processing is to transform the input original image in a specific way to obtain the output image of beautification or other special processing. It includes filtering the noise in the image, compressing the image data, using the multi-scale expression of the image and so on. Image processing is

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Jinghui Li is an associate professor of Department of Computer Science and Technology, Tianjin Ren'ai College, Tianjin, 301636, China (e-mail: li_jinghui2011@163.com).

mainly aimed at pixel level, which is a low-level operation in image engineering. Image analysis has entered the middle-level operation, the objects of operation are mainly targets. Their objective information is obtained through detection and measurement, so as to form an objective description of the image. It mainly includes detection, segmentation, tracking, recognition, etc. Image understanding, also known as computer vision [5][6], studies the deep meaning expressed by images on the basis of image analysis, this operation is considered as an advanced operation in image engineering.

Reference [7] proposed a variational level set image segmentation method based on visual saliency. In this method, the visual saliency data model is established through lab color space, the image contrast is strengthened, and the visual saliency region is extracted. The image of this region is de dried to prevent the loss of detail information in the image Then, using the variational level set without initialization, combined with the energy function to complete the internal energy constraint, the partial differential equation of curve evolution is obtained, and the image segmentation is completed through the minimum energy function The segmented image has a certain stability, but the language has not been considered too much, and there are some shortcomings.

Reference [8] proposed canny SLIC image segmentation algorithm based on gradient direction. An improved canny SLIC image segmentation algorithm based on gradient direction is proposed. The improved Canny algorithm is combined with SLIC by using the difference between the edge and noise in the gradient direction, the complex operation is used to reduce the feature dimension of the image edge. The hexagon is used to describe the super-pixel generated by SLIC. The algorithm can generate a super-pixel segmentation image closely fitting the object boundary and with high segmentation accuracy, which verifies the effectiveness of the proposed algorithm. However, this method does not effectively identify the existing languages through the methods in literature [7], so it has some limitations.

In order to solve the shortcomings of the above methods, a new image segmentation technology and intelligent language recognition method based on ant colony algorithm are designed in this paper. The main steps of this method are as follows:

Step 1: Regard the internal structure of the image as a network and determine its mapped relationship; The unknown pixels, foreground pixels and background pixels of the image are analyzed, the form of weighted network diagram is constructed, and the image mapping relationship is characterized by adjacency matrix;

Step 2: Determine the gray, color, texture and other characteristic values of the image with the help of Gaussian function, set the constitutive matrix, calculate the weight value of the segmented image, and use the histogram method to complete the effective segmentation of the image.

Step 3: Analyze the advantages of ant colony algorithm, determine the spatial position of intelligent language in the image, determine the recognized language results with the help of Fisher’s law, and obtain that the dispersion within the language class represents the classification density, so as to complete the intelligent language recognition.

Step 4: Experimental analysis.

Step 5: Conclusion.

II. Research On Image Mapping Representation And Image Segmentation Technology

A. Representation of image mapping relationship

In order to realize the research of image segmentation technology and intelligent language recognition, we first start with the mapping relationship of the image, which determines the accuracy of subsequent image segmentation and the effectiveness of language recognition in the image. The image is composed of pixels, and the network graph is composed of vertices (nodes). Therefore, the simplest graph mapping is the graph cut algorithm based on pixels, which establishes a mapping relationship between pixels and vertices (nodes) in the network graph [9]. For gray-scale images, the gray similarity between pixels is taken as the weight. The closer the spatial position between pixels is, the higher the similarity between them is. The farther the spatial position is, the lower the similarity between them is. According to the division criteria, we divide pixels with high similarity into the same category, and pixels with low similarity into other categories [10].

The internal structure of the image can be regarded as a network relationship. The mapping relationship after segmentation has corresponding meaning. The corresponding relationship is shown in Figure 1:

The pixels in the image are the key to the composition of graphics. The pixels in the image include three types: unknown pixels, foreground pixels and background pixels [11]. According to the mapping of the structural relationship in Figure 1, the image studied in this paper is constructed into a weighted network diagram to effectively characterize it.

(1) Construct the vertex set V of the network diagram H

The vertex set V of the network Figure H consists of two parts A and B, as shown in Equation (1):

$$V = Q \cup \{A, B\} \tag{1}$$

In formula, Q represents the set of pixels in the original image; A is the set of manually annotated foreground pixels; B is the set of manually annotated background pixels.

Construct the edge set E of the network Figure V.

E is the edge set of the network diagram G, which mainly includes two categories: n-connection (n-links) and t-connection (t-links), {K, L}, is pixels, n-connection (n-links) is the edge [12] not connected to the source (sink) vertex in the item point set V, recorded as:

$$M \in \{K, L\}, K, L \in V \tag{2}$$

The t-connection (1-links) is the edge connected to the source (sink) vertex, with n-links and t-links for each pixel recorded as:

$$\{p, a, p, T\}, p \in V \tag{3}$$

Therefore, the edge set E of the image can be represented by the following formula, it is:

$$Y = M \cup \{p, a, p, T\}, p \in V \tag{4}$$

The constructed directed graph is shown in Figure 3:

As shown in Figure 2, the figure can be represented as a G(VE), where the set of vertices is:

$$V(H) = \{1, 2, 3, 4, 5, 6\} \tag{5}$$

The vertices are the elements in the set; the set of the edges is:

$$V(H) = \{(1,2)(1,3)(2,3)(2,4)(2,5)(2,6)(3,4)(3,5)(45)\} \tag{6}$$

Based on the determined directed graph, the paper determines the feature data of the directed graph with the help of the adjacency matrix to lay the foundation for the subsequent segmentation. Adjacency matrix is the matrix [13] representing the relationship between each vertices (nodes). Let a Figure $V(H)$ with m vertices (nodes) whose adjacency matrix can be represented by a 2-dimensional array of $Edg[i][j]$, as shown:

$$Edg[i][j] = R\begin{cases} 1(i, j) \in V, \langle i, j\rangle \in G \\ 0 \quad other \end{cases} \tag{7}$$

Where, (i, j) indicates the directed graph node position and R represents the weight of the image point.

Finally, the features of the extracted digraph are:

$$\mu = \frac{1}{N}\sum_{i=1}^{n} f(x) \tag{8}$$

In the formula, $f(x)$ represents the directed graph feature and the weight values of each point in the image is μ.

In the representation of image mapping relationship, firstly, the internal structure of the image is regarded as a network, and the mapped relationship is determined. On this basis, the unknown pixels, foreground pixels and background pixels of the image are analyzed [14], the form of weighted network diagram is constructed, and the image mapping relationship is characterized by adjacency matrix, which lays a foundation for subsequent research [15].

B. Research on image segmentation technology

According to the above determined image mapping relationship, the image is segmented effectively. In image segmentation, pixels with the same color are clustered into the same region, and the parallax and depth in the same region are approximately in the same spatial plane. Therefore, the depth map can be further modified by plane fitting, and whether the region is a horizontal support region can be determined according to whether the normal amount of the depth plane where the region is located is perpendicular to the horizontal plane. In this paper, means if image segmentation algorithm is used to over segment color images [16]. In the research of image segmentation technology, firstly, the eigenvalues such as gray, color and texture of the image are determined with the help of Gaussian function, and the constitutive matrix is set to calculate the weight value of the segmented image. Finally, the histogram method is used to complete the effective image segmentation.

After the image is mapped into a graph, a function needs to be defined to reflect the feature changes between image pixels, that is, the weight between nodes in the graph is defined by the feature values such as gray, color and texture of the image [17]. The Gaussian function shown in equation (9) defines the weight:

$$w_i = \exp\left(\delta\left[x_i - x_j\right]^2\right) \tag{9}$$

Among them, w_i is the eigenvalues of pixels in the image, δ representing free parameters, x_i is the size of the adjusted weights and the random segmentation walk odds is x_j. When the feature difference between similar pixels in the image is not very large, its probability of occurrence is small.

Since the transition probability of random walk is the same as that of the combined Dirichlet problem [18], the result of the random walk image segmentation process is obtained by solving the combined Dirichlet problem. Firstly, the combined Laplacian matrix shown in equation (10) is defined as:

$$L_i = \begin{cases} -w_i & if \quad i = j \\ c_i & if \quad i \neq j \\ & 0 \quad 0 \end{cases} \tag{10}$$

When the vertices of the image are jointly determined, its width changes, when the edge association matrix [19] of the segmented image is defined as:

$$K_i = d\begin{cases} 1 & if \quad i = k \\ -1 & if \quad i \neq k \\ 0 & other \end{cases} \tag{11}$$

Where, k represents the specified direction of the image segmentation, d representing the vertex values of the association matrix. According to the determined image segmentation direction, the joint gradient operator after image segmentation is determined. The calculation result of this value reflects the degree of dispersion in image segmentation. It is defined by setting the constitutive matrix, namely:

$$S_{ij} = \begin{cases} e_{ij} & i = k \quad {}^{\circ}F\sum K_i \\ 0 & other \end{cases} \tag{12}$$

Where, e_{ij} representing the diagonal matrix of the segmented image, ${}^{\circ}F$ represents the weight size on the segmented image lines.

According to the above determined image segmentation weights, the color histogram is used to complete the image segmentation [20]. Color histogram is a statistical attribute of image color distribution, which reflects the distribution of image color in color space and represents the number of pixels in each given color range. The histogram is defined as follows:

$$Z_i = \frac{1}{m}\sum_{i=1}^{k} \in \omega \quad (13)$$

Where, ϵ represents the number of pixels with color value in the image, ω represents the number of possible color value range, Z_i represents the total number of pixels.

For the color depth map pair (RGBD) collected by Kinect, the data set has registered the color map and depth map, and supplemented the depth map collected by Kinect [21], so we can directly calculate the three-dimensional space point coordinates according to the following formula:

$$\begin{cases} X = \dfrac{U - h_j}{h_j} depth \\ Y = \dfrac{U - h_i}{h_i} depth \end{cases} \quad (14)$$

Finally, according to the determined three-dimensional coordinates of the image, it is determined that the segmented image result is:

$$\vartheta_i = q \arg ax\left\{\left|s_i \cap s_j\right|\right\}\sum U \quad (15)$$

Where, ϑ_i represents the area of the image segmentation area, q represents the segmented image pixels.

III. Research On Intelligent Language Recognition Based On Ant Colony Algorithm

Based on the above effective image segmentation, it is very important to recognize the intelligent language in the image. Through the research on the recognition language expressed in the image, the research of the image can be improved. In this paper, ant colony algorithm is used to effectively recognize the intelligent language in the image [22]. In intelligent language recognition, the advantages of ant colony algorithm are analyzed. By determining the spatial position of intelligent language in the image, and judging the recognized language results with the help of Fisher's law, it is obtained that the dispersion in language class represents the classification density, so as to complete intelligent language recognition. The characteristics of ant colony algorithm are summarized as follows:

First, it can detect the situation in a small range around, and quickly judge whether there are pheromone residue tracks or food of other partners. Then, the secreted pheromones are divided into two categories: "nest" pheromones and "food source" pheromones. Again, pheromones can be secreted only after ants carry food or carry food back to their nests. The amount of pheromone secreted by ants will decrease with the increase of crawling path. After ants randomly crawl away from the nest, they are only affected by pheromones near the nest. The random crawling of leech mosquitoes is only affected by the pheromone near the "food": when the "food" is detected. When the pheromone tracks, it will only crawl along the track with the strongest concentration. As long as ants find food, they can carry away some food and begin to secrete "food" pheromones. Ants are affected by the "nest" pheromone in the process of transporting food [23]. Finally, as long as the ant returns to the nest, it will put down its food and begin to secrete the "nest" pheromone.

Ant colony algorithm treats the data to be processed as ants with different attributes, and the clustering center is the food source in the ant colony algorithm model. Ant colony clustering process is the process of ants looking for food.

Set $a = \left\{a_{ia} \middle| A\{a_1, a_2, a_3, \ldots a_n\right\}, i = 1, 2, \ldots n$ makes the food source in the ant colony algorithm to be processed, at this order:

$$o_{ij} = \beta \left\| T\left(X_i - X_j\right) \right\| \left(Y_i - Y_j\right)^2 \quad (16)$$

Where, o_{ij} represents the European-style weighted distance, T is the weight factor, β represents the degree of clustering in the components that should be considered when setting.

In language recognition in the image, the σ represents the cluster, τ τ representing errors in statistics and residual information data, τ_{ij} represents the residual information data.

At this point, the number of pheromones identifying the intelligent language in the image using the ant colony algorithm is:

$$\tau_{ij}(t) = \begin{cases} 1, o_{ij} \le \sigma \\ 0, o_{ij} > \sigma \end{cases} \quad (17)$$

Among them, $\tau_{ij}(t)$ represents the result of intelligent language recognition in the image. The spatial diagram of its intelligent recognition is shown in Figure 4:

In image recognition, there are many types of language in the image, so it is necessary to effectively distinguish the resulting data, that is, reduce the dimension. To be exact, the dimension of the mode is compressed to one dimension. According to Fisher projection criterion, the sample data of the same category should be gathered together as much as possible while the projection dimension should be reduced, while the samples of different categories should be separated as much as possible. Figure 3 shows the distribution diagram of two types of two-dimensional space. The projection of these sample data is irregular on the two coordinate axes, so it is impossible to distinguish and identify them simply from the coordinate axes. However, according to Fisher's law [24], we can find a straight line and project the sample on it, so that we can distinguish it effectively.

Based on this, a judgment model is necessary to construct a model to determine the direction W of the classification, and then use this determination function to evaluate the degree of separation of different categories on this line projection. The greater the mean difference in the projections between the classes, the better the classification effect. Let g_i be the mean of the class i d-dimensional sample, yielding:

$$g_i = \frac{1}{n}\sum_{i=1}^{n} X \tag{18}$$

Then the average projection value of the intelligent language in the image is:

$$g_i = \frac{1}{n}\sum_{i=1}^{n} X \sum_{i=1}^{n} W^t \tag{19}$$

At this time, the projection mean distance of intelligent language in the image is:

$$\|b_1 - b_2\| = \|W^t (b_1 - b_2)\| \tag{20}$$

The classification effect can also be better by concentrating the projections of the same kind as much as possible. In order to know better and intuitively. The classification aggregation degree of channel projection can be represented by an intra class dispersion. Equation (21) is within class dispersion:

$$D_i^2 = \sum_{i \in d_i} \left(R - \left\| W^t \left(b_1 - b_2 \right) \right\| \right)^2 \tag{21}$$

On this basis, the intelligent language recognition is completed with the help of ant colony algorithm. The three-dimensional search strategy of ant colony algorithm is an important leading idea that ant colony algorithm can realize in three-dimensional model space [25]. Similar to the path search of ant colony algorithm in two-dimensional plane, the realization of path planning in three-dimensional space also requires a function to find the next point to move from the current point in the visual area, so as to complete the recognition of intelligent language, that is:

$$\gamma(i,j) = sql\left[c_m - c_n\right]^2 + \left[c_m + c_n\right]^2 \tag{22}$$

Where, $\gamma(i,j)$ represents the final identified result, sql represents the ant pheromone.

IV. Experimental Analysis

A. Experimental scheme design

In order to verify the effectiveness of the proposed method, image segmentation and intelligent language recognition are carried out. In the experiment, an image is randomly selected from BC Berkeley image library as a sample image. The image size is 351 × 345. The sample image is segmented. The total number of segmented areas in the first layer is 10. The sample image is shown in Figure 5:

Based on the above experimental scheme design, the sample image segmentation error and image character recognition accuracy are studied by comparing the methods in this paper, literature [7] and literature [8], and the experimental results are analyzed. The experiment then compares the particle swarm optimization algorithm with other common image segmentation algorithms to determine the recognition accuracy under complex transformation, scale transformation, perspective transformation and rotation transformation, and determine the quality effect of the image under the four factor changes. Finally, the Precision Recall (PR) curve is used to analyze the performance of four different image processing technologies.

B. Analysis of experimental results

In the experiment, firstly, the methods of this paper, literature [7] and literature [8] are analyzed to analyze the effect of sample image segmentation. The image effect after segmentation is shown in Figure 6 .

By analyzing the experimental results in Fig. 6, it can be seen that the sample image segmentation results are different by using the methods in this paper, literature [7] and literature [8]. Among them, after the sample image is segmented by this method, the contour of the sample image can be completely retained. The sample image segmented by the methods of literature [7] and literature [8] has incomplete contour and large-area distortion. In contrast, this method can effectively segment the image in the sample, and the segmented image has good effect and certain feasibility.

On the basis of the above segmentation experiments, the methods in this paper, literature [7] and literature [8] are used to recognize the language in the sample image. In order to intuitively show the recognition results, the experimental results are discounted and counted, and the recognition results of the three methods are obtained, as shown in Figure 7:

By analyzing the experimental results in Fig. 7, it can be seen that there are some differences in the accuracy of language recognition in the sample image by using the methods in this paper, literature [7] and literature [8]. Among them, the accuracy of this method for language recognition in sample images is always high, and always higher than 90%, while the accuracy of literature [7] method and literature [8] method for language recognition in sample images fluctuates greatly, which is always lower than that of this method. This is because this method determines the spatial position of the intelligent language in the image, determines the recognized language results with the help of Fisher’s law, obtains that the dispersion within the language class represents the classification density, completes the intelligent language recognition, and then improves the effectiveness of this method.

The research evaluates the effect of image recognition through Peak Signal to Noise Ratio (PSNR) and structural similarity (SSIM) as two objective evaluation indicators. The results are shown in Table 1. Generally, the normal range of SSIM is [- 1, 1], and the normal value of PSNR is 30-40dB. The PSNR and SSIM under the transformation of the four images meet the requirements, and the value ranges are 28.789-31.254dB and 0.799-0.854 respectively. Therefore, the objective quality evaluation of the identified image is good. PSNR and SSIM of different images have no significant transformation rule under different factor transformation. On the whole, all images meet the corresponding standards.

In order to further analyze the performance of the ant colony optimization algorithm (method 1) in image segmentation, the research verifies its particle swarm optimization algorithm, genetic algorithm and immune algorithm, which are represented by method 2 - method 4 respectively. Figures 8 (a), 8 (b), 8 (c) and 8 (d) refer to the comparison of recognition accuracy under complex transformation, scale transformation, view angle transformation and rotation transformation respectively. Under the four different image categories, the convergence times of the four algorithms are roughly the same. The convergence times under the four conditions of complex transformation, scale transformation, view angle transformation and rotation transformation are 2400, 2700, 1200 and 1200 respectively. The accuracy of ant colony optimization algorithm is the highest, and the accuracy of hybrid transformation, scale transformation, perspective transformation and rotation transformation is 95.6%, 93.6%, 92.1% and 92.6% respectively. The accuracy of the other three image segmentation and recognition algorithms has a wide range of values, among which the performance of particle swarm optimization algorithm and genetic algorithm is the second, and the performance of immune algorithm is the weakest.

The research proposes to use PR curve to compare with other image segmentation algorithms, and set the classification threshold to 0.4 and 0.6 respectively. The performance of the model is shown in Figure 9 (a) and Figure 9 (b) respectively. On the whole, compared with other image segmentation algorithms, the intelligent language recognition technology combined with ant colony algorithm has better performance, followed by particle swarm optimization algorithm and genetic algorithm, and the model with the worst performance is immune algorithm. When the accuracy rate and recall rate are the same, the classification threshold is 0.4 and 0.6, and the accuracy rate of image segmentation technology combined with ant colony optimization algorithm is 0.85 and 0.86 respectively; The accuracy of image segmentation technology of immune algorithm is 0.78 and 0.76 respectively. Therefore, the new image segmentation technology presented in this paper has better performance.

V. Conclusion

Image segmentation technology and intelligent language recognition technology have been widely used in various fields. However, there are some problems in the existing image segmentation and intelligent language recognition, such as large image segmentation error and low accuracy of intelligent language recognition. This paper designs an image segmentation technology and intelligent language recognition method based on ant colony algorithm. The internal structure of the image is regarded as a network and its mapped relationship is determined. The unknown pixels, foreground pixels and background pixels of the image are analyzed, the form of weighted network diagram is constructed, and the image mapping relationship is characterized by adjacency matrix. With the help of Gaussian function, the gray, color, texture and other characteristic values of the image are determined, the constitutive matrix is set, the weight value of the segmented image is calculated, and the histogram method is used to complete the effective segmentation of the image. The advantages of ant colony algorithm are analyzed. By determining the spatial position of intelligent language in the image, and judging the language recognition results with the help of Fisher's law, it is obtained that the dispersion within the language class represents the classification density, so as to complete the intelligent language recognition. The experimental results show that the image segmentation error is low and the intelligent language recognition accuracy is high. Although this method has obtained some research results at this stage, there are still many deficiencies. In future research, it will be effectively studied for more complex images.

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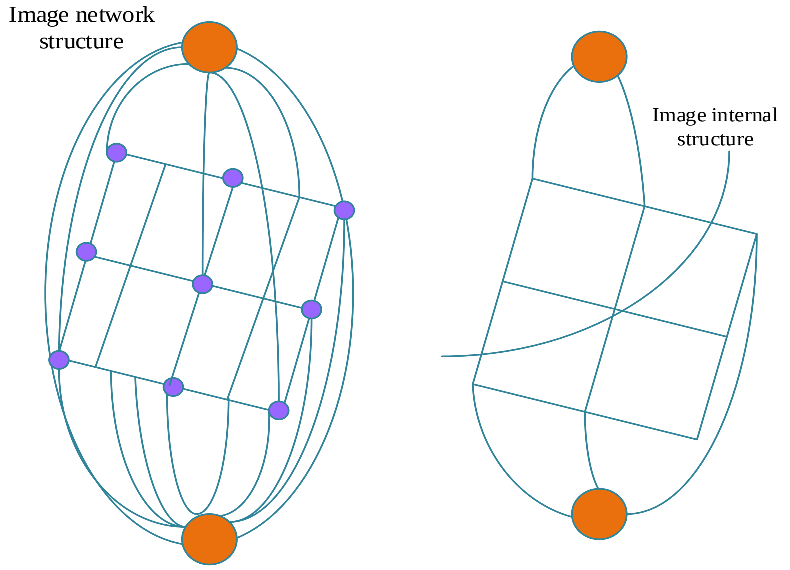


Figure 1. Representation of internal structure network mapping relationship of image

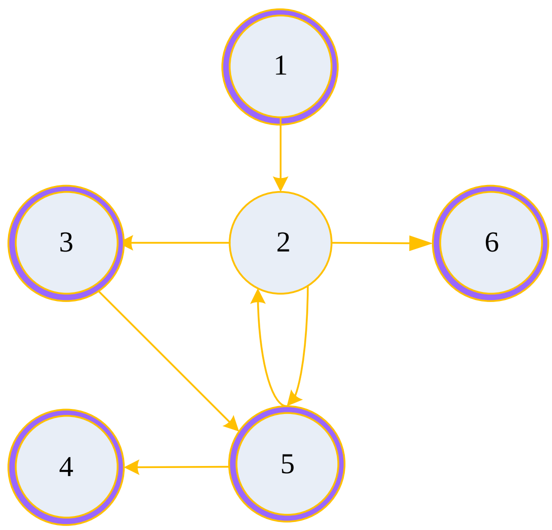


Figure 2. Schematic diagram of directed graph

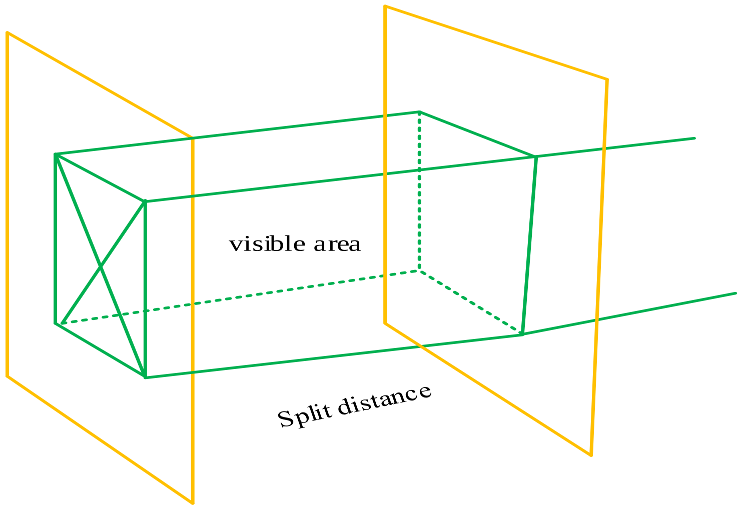


Figure 3. Visual area recognized by intelligent language ant colony algorithm in image

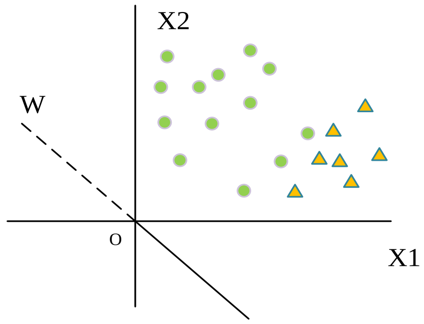
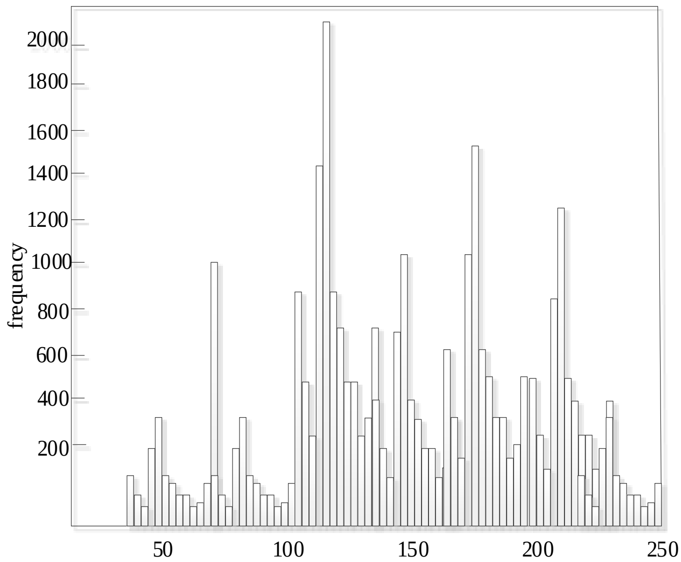


Figure 4. Distribution diagram of intelligent languages in the image 2-dimensional space

Sample gray image



Gray histogram

Figure 5. Sample image

(a) Proposed method

(b) Literature [7] methods

(c) Literature [8] methods

Figure 6. Effect Analysis of different image segmentation methods

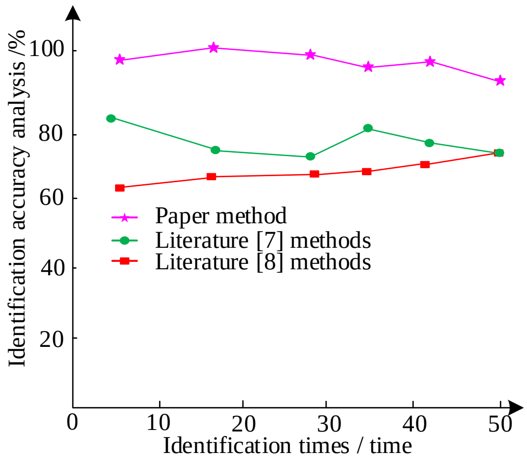


Figure 7. Accuracy analysis of language intelligent recognition with different methods

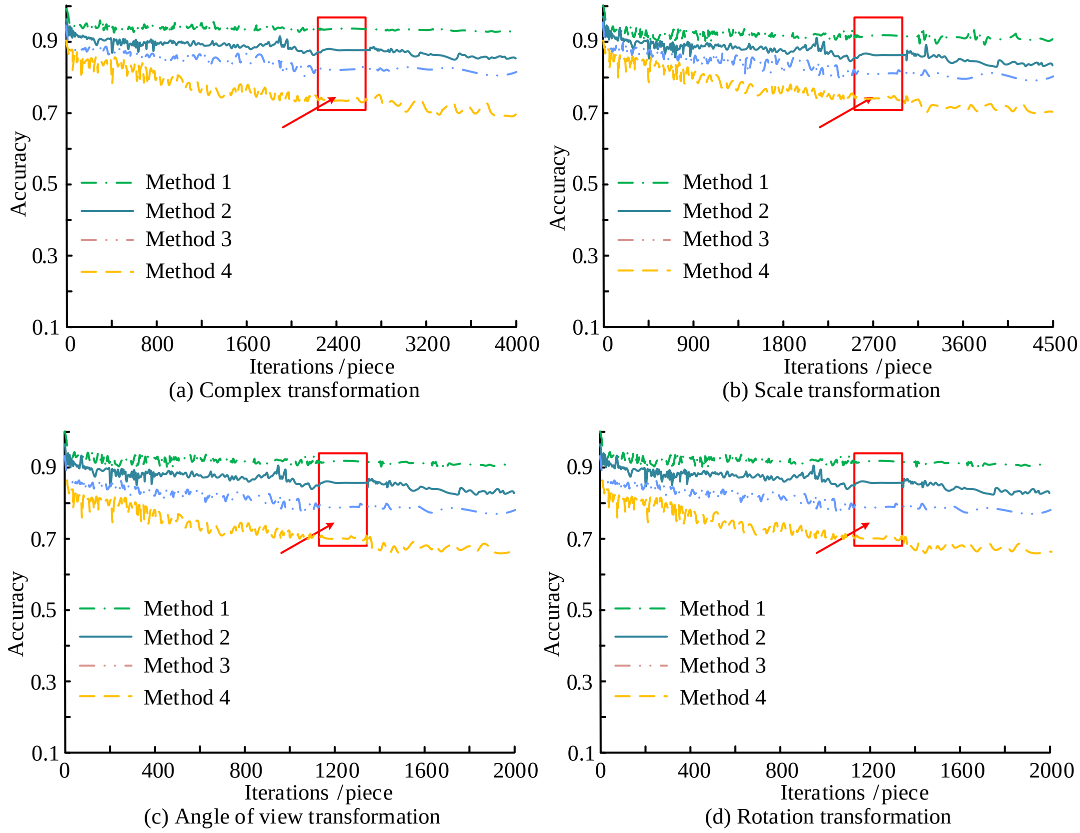


Figure 8 .Comparison of accuracy under three data sets A-C

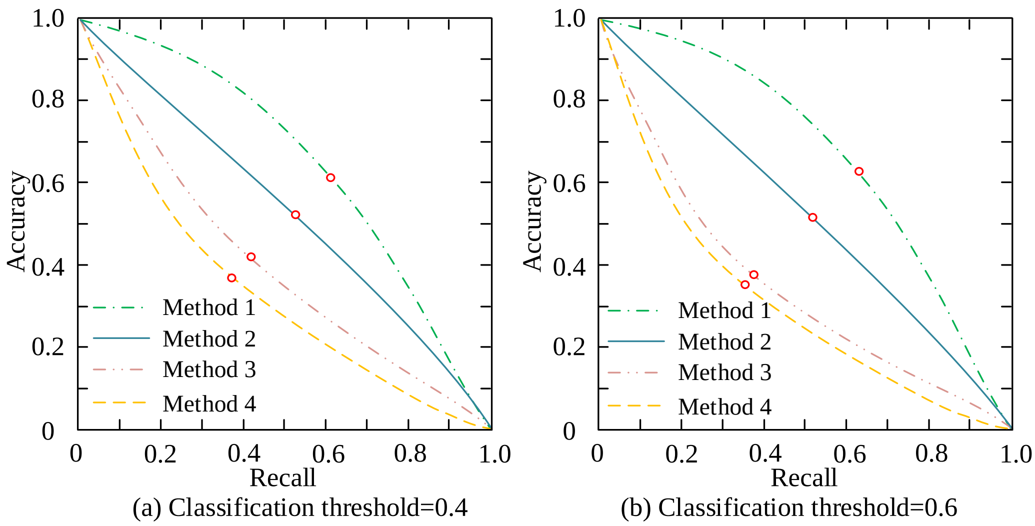


Figure 9. PR Curves of Four Different Image Processing Methods

Table 1 Objective Quality of Image Recognition

Type	No	PSNR/dB	SSIM	Type	No	PSNR/dB	SSIM
Complex transformation	1	29.816	0.841	Angle of view transformation	1	30.978	0.886
	2	31.254	0.852		2	29.865	0.829
	3	30.985	0.853		3	30.346	0.846
	4	29.798	0.799		4	28.788	0.897
	5	30.978	0.841		5	29.254	0.816
	6	30.754	0.831		6	29.736	0.825
Scale transformation	1	30.103	0.813	Rotation transformation	1	30.124	0.813
	2	28.789	0.817		2	30.102	0.824
	3	29.358	0.808		3	29.358	0.810
	4	29.732	0.834		4	30.247	0.825
	5	29.321	0.835		5	29.361	0.834
	6	29.326	0.824		6	30.211	0.867
Mean value	-	29.941	0.834	Mean value	-	29.86	0.839