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Application of the Genetic Algorithm on Face Recognition

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Abstract: Computer vision and recognition is playing an increasing important role in the modern intelligent control. Object detection is the first and the most important step in object recognition. Traditionally, special objects can be detected and recognized by the template matching method, but the recognition speed has always been a problem. Also for recognition by the neural network, training the data is always time consumption. In this paper, the genetic algorithm-based face recognition system is proposed. The genetic algorithm (GA) has been considered as a robust and global searching method. Here, the chromosomes generated by the GA contain information (parameters) of the image, and we use the genetic operators to obtain the best match between the original image and the face of interest. The parameters are the coordinate (x, y) of the center of the face in the original image, the rate of scale and the angle Θ of rotation. Finally, the experimental results and some other considerations are also given.

Keywords: Face detection and recognition, Genetic algorithm, Image processing, Template matching method**.**

I. INTRODUCTION

Lots of papers and applications are presented on the web, in conference proceedings or journals about the intelligent control. Among them, image processing and recognition occupy a very large percentage [1-3]. The higher the degree of intelligence is, the more important is the image detection and recognition technology.

For an intelligent control system, it is necessary to acquire information about the external world automatically by sensors, in order to recognize its position and the surrounding situation. A camera is one of the most important sensors for computer vision: the intelligent system endeavors to find out what is in an image taken by the camera: traffic signs, obstacles or guidelines, etc.

The reliability and time-response of the object detection and recognition have a major influence on the performance and usability of the whole object recognition system [4]. The template matching method is a practicable and reasonable method for object detection [5], but the recognition speed has always been a problem.

In addition, in order to search for the object of interest in an image, lots of data need to be processed. The genetic algorithm (GA) has been considered to be a robust and global searching method (although it is sometimes said that GA can not be used for finding the global optimization [6]). Here, the chromosomes generated by GA contain information about the image data, and the genetic and evolution operations are used to obtain the best match to the template [7]: searching for the best match is the goal of this paper.

This thought emerged from the features of GA, and the need to recognize the faces of special people easily and quickly by an intelligent system. The single concept and feature of image processing and the GA will not be introduced here, because there is already extensive literature on these subjects.

In this paper, the encoding and decoding method of the GA and the experimental setting, the experiment and the analysis, and conclusion are addressed sequentially.

II. THEORY AND EXPERIMENT

If we want to find a special person in an image, we first have to detect people in the image, and then recognize which one is the person of interest (sometimes these two steps will be executed simultaneously).

1. Genetic encoding

Since the chromosomes generated by the GA contain information about the image data, the first step is to encode the image data into a binary string to the GA [8].

Some important parameters of GA are given in Table 1, and the search field and region are given in Table 2. Table 2 shows that there are 4 image parameters: the center of a face (x, y) in the original image, the rate of scale of the face, and the rotating angle Θ, are encoded into the elements of gene (the meanings of which will be introduced below). Since one parameter uses 8 bits

(1 byte), and there are 4 image parameters, thus one chromosome contains 4 bytes shown in Fig.1.

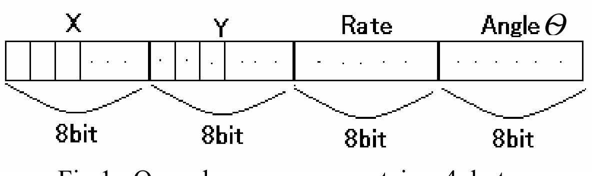

Fig.1. One chromosome contains 4 bytes

Table 1. Setting for the GA parameters

Source	The original and the template images
Generations	Maximum = 300 (the stopping criterion)
Population Size	200
Reproduction (selection)	P_r of the best individuals will be selected to survive. The remained (1-P_r) will be treated by the genetic operators (crossover and mutation)
Crossover	Offspring are produced from parents by exchanging their genes at the crossover point, the ratio is P_c
Mutation	Produce spontaneous random changes in various chromosomes. Th e general random change method is used at the rate of P_m

Table 2. Setting for the experiment

Image parameters (field)		
x	8 bits	(0, max_x)
y	8 bits	(0, max_y)
rate	8 bits	(1.0, 3.0)
Θ	8 bits	(-35^o, 35^o)
GA parameters		
P_r	0.6	
P_c	0.5	
P_m	0.01	

2. Genetic algorithm

The fitness is defined as [9]

$$\text{fitness} = 1.0 - \frac{\sum_{j=0}^{\text{temp\_y}}\sum_{i=0}^{\text{temp\_x}} | f(x, y, rate, \theta) - \text{temp}(i, j) |}{(\text{temp\_x}) \times (\text{temp\_y}) \times 255} \quad (1)$$

In Eq.1, temp(*i*, *j*) is the gray level of the coordinate (*i*, *j*) in the template image, the width and height of which are temp_x and temp_y. *f*(*x*, *y*, *rate*, *Θ*) gives the gray level in the original image, the coordinate of which are calculated by translation from (*x*, *y*), and by changing the scale and the rotation angle *Θ* from the template. Since the images have 256 gray levels, in Eq.1, division by 255 ensures that the resulting fitness is between 0 and 1.

Based on Eq.1, in the program, the fitness is calculated by the following four steps, and Fig.2 gives the figural example.

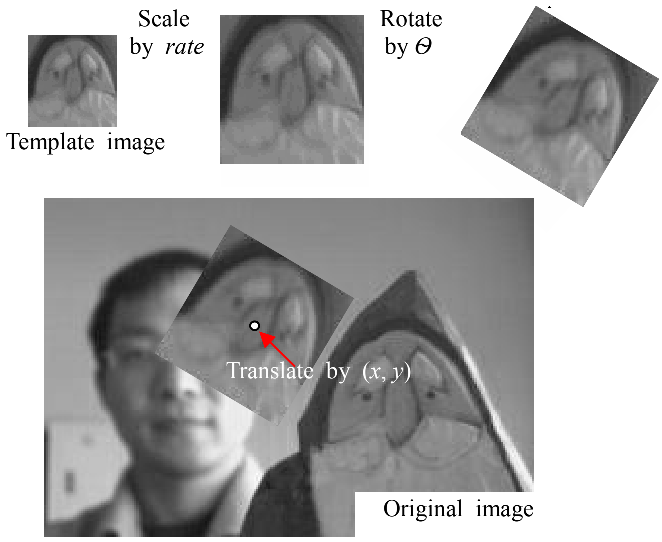

Fig.2. Figural example of calculation by Eq.1

(1) The coordinate (*i*, *j*) in the template is scaled by the value of parameter rate, then we get the result *f*(*x*, *y*, *rate*, *Θ*) = f(0, 0, *rate*, 0) = (*i* × *rate*, *j* × *rate*);
(2) The result of step (1) is rotated by the value of parameter *Θ*, thus *f*(*x*, *y*, *rate*, *Θ*) = *f*(0, 0, *rate*, *Θ*);
(3) The result of step (2) is translated from the coordinate (*x*,*y*) in the original image, then the gray level of the pixel *f*(*x*, *y*, *rate*, *Θ*) is gotten;
(4) All the differences between the gray level of the coordinate (*i*, *j*) in the template and that of the calculated *f*(*x*, *y*, *rate*, *Θ*) in the original image are summarized by Eq.1 to calculate the fitness.

If the value of the fitness is lager than the preset threshold, the search process is over and the result is given, otherwise the loop will be continued.

3. Decoding

In order to obtain the true value of the image parameters from the chromosome, decoding is needed. In Eq.2, after decoding from datum of GA, the value of each parameter is standardized. A figural example is given in Fig.3.

$$\text{Value} = \text{MIN} + \frac{\text{MAX} - \text{MIN}}{255} \times (\text{datum from GA}) \quad (2)$$

4. Experiments

The experiment is done by first loading the original and the template images. GA is used to find whether or not there is the object (face) of a template in the original

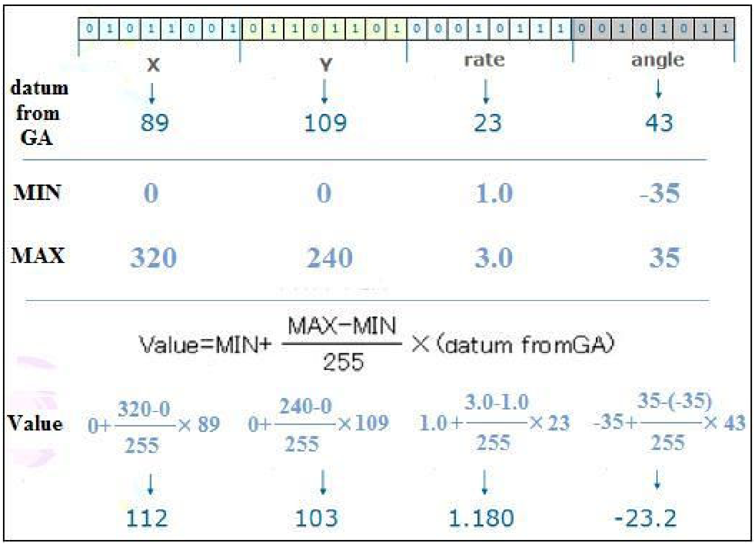

Fig.3. Figural example for decoding

image. If the answer is YES, then in the original image the result gives the coordinate of the center of the face, the rate of scale, and the rotation angle from the template.

Fig.4 and Fig.5 are the template and the original images for the experiment. The values are the width × height in pixels of the image. In Fig.5, two original images are presented, the sizes of which are the same 320×240.

30×35

Fig.4. Template for matching (temp_x × temp_y)

The maximum number of generation is limited to 300, and the threshold of the matching rate is set to 0.85. Thus if within 300 generations the matching rate can reach 0.85, it is said that the template is found in the original image (the template matched the original image by the threshold). The result of the GA-based face recognition is given in Fig.6 and Table 3.

Table 3. Results of searching by GA

	Result for Fig.5a	Result for Fig.5b
Fitness	0.858	0.875
Generation	28	18
(x, y)	(71, 108)	(51, 107)
Rate	2.0039	1.9333
Angle [deg]	12.59	-9.76

III. CONCLUSION

In this paper, the GA-based image (face) recognition method is tested.

The GA starts with an initial set of random solutions called the population. Each individual in the population is called chromosome, and represents a solution to the problem. By stochastic search techniques based on the mechanism of nature selection and natural genetics, genetic operations (crossover and mutation) and evolution operation (selecting or rejecting) are used to search the best solution [10].

In this paper, the chromosomes generated by the GA contain information about the image, and we use the genetic operators to obtain the best match between the original image and the template. The parameters are the coordinate (x, y) of the center of the object in the original image, the rate of scale, and the rotation angle Θ.

In fact, translation, scale and rotation are three main invariant moments in the field of pattern recognition. However, for face recognition, the facial features are difficult to be extracted and calculated by the general pattern recognition theory and method. Even these three main invariant moments will not be invariant because the facial expression is changed in different images.

Thus the recognition only gives the best matching result within an upper predetermined threshold. The result in the paper shows that the recognition is satisfied.

By using the GA-based recognition method, the settings of the search field (in this paper, (x, y, $rate$, Θ) is selected), the determination of the genetic operations, and the selection and the optimization of the fitness function all have a strong effect on the level of recognition of the resultant image.

Based on the results of experiments described here, further work will emphasize (i) optimizing the fields of chromosomes, and (ii) improving the fitness function by adding some terms to it. This work is important and necessary in order to improve the GA-based face recognition system.

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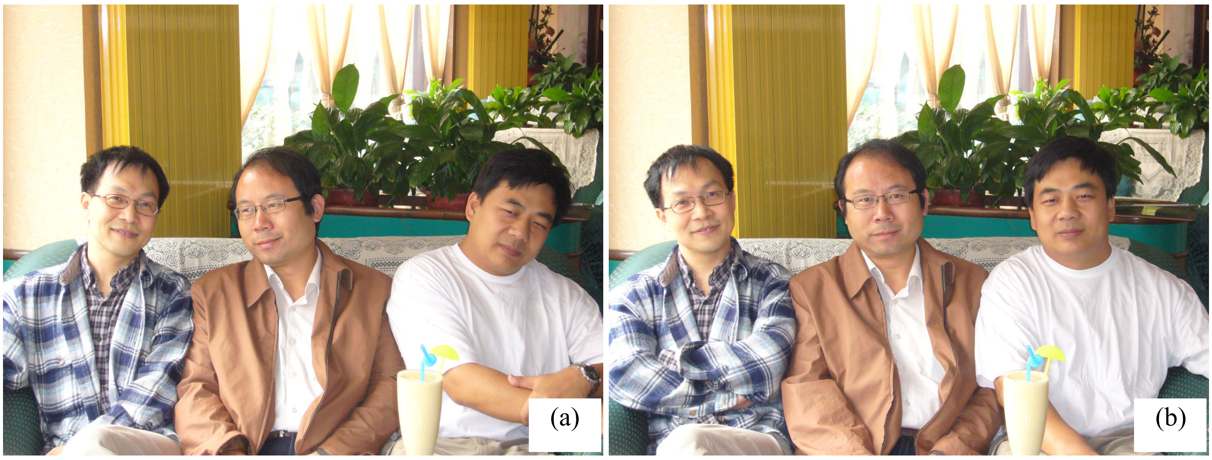

Fig.5. The original images (size: max_x, max_y = 320×240)

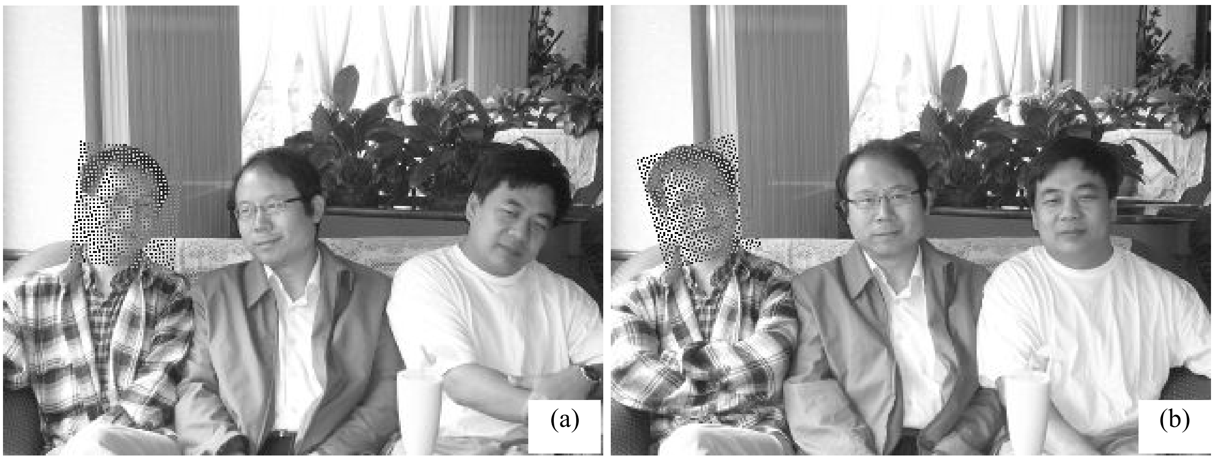

Fig.6. Results of the GA-based recognition