Fundamental Research on Face Recognition by Genetic Algorithm

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Abstract

Object recognition is playing an increasingly important role in modern intelligent control. Traditionally, special object can be recognized by the template matching method, but the recognition speed has always been a problem. In this paper, the genetic algorithm (GA) -based face recognition method is proposed. The chromosomes generated by GA contain the information of the facial model, by which can we recognize it in an image. The purpose of the paper is to propose a practical method of face recognition. Finally, the experimental results, and a comparison with the traditional template matching method, and some other considerations, are also given.

Key Words: Face recognition, Genetic algorithm, Template matching

1. Introduction

We know that the higher the degree of intelligence in a control system, the more important the image recognition technology. For an intelligent control system (autonomous mobile vehicle, robot, etc), 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. That is to say, the system endeavors to find out what is in an image (the environment) taken by the camera: traffic signs, obstacles or guidelines, etc.

The reliability and time-response of object recognition have a major influence on the performance and usability of the whole object recognition system [1]. The template matching method is a practicable and reasonable way used to the object detection [2]. This paper gives an improvement in the general template matching method.

Since GA has been considered to be a robust and global searching method (although it is sometimes said that GA cannot be used for finding the global optimization) [3], it is used as the recognizer. In this paper, 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. Searching for the best match is the goal of the paper.

In this paper, section 2 gives the encoding method of the GA and the experimental settings that is used. In section 3, the experiment and the analysis are addressed. Some conclusions are given in section 4.

2. Theory and experimental settings

For an image recognition system, the interested part that has special features has to be detected and recognized from the original image. The whole procedure is shown in Figure 1.

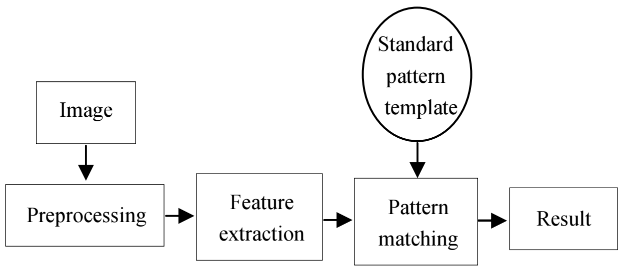

Figure 1 Object recognition system

One of the oldest techniques of pattern recognition is matching filtering [4], which allows the computation of a measure of the similarity between the original image $f(x, y)$ and a template $h(x, y)$. Define the mean-squared distance

$$d_{fh}^2 = \iint \{f(x, y) - h(x, y)\}^2 \, dxdy \tag{1}$$

$R_{fh} = \iint f(x,y)h(x,y)dxdy$, if the image and template are normalized by

$$\iint f^2(x,y)dxdy = \iint h^2(x,y)dxdy \tag{2}$$

and then

$$\begin{aligned} d_{fh}^2 &= \iint \{f(x,y) - h(x,y)\}^2 dxdy \\ &= \iint \{f^2(x,y) - 2f(x,y)h(x,y) + h^2(x,y)\}dxdy \\ &= 2\iint f^2(x,y)dxdy - 2R_{fh} \end{aligned} \tag{3}$$

For the right hand side of eqn.(3), the first term is constant, and thus R_{fh} can measure the least-squared similarity between the image and template [5]. If R_{fh} has a large value (which means that d_{fh}^2 is small enough), then the image is judged to match the template. If R_{fh} is less than a preselected threshold, the recognition process will either reject the match or create a new pattern, which means that the similarity between the object in the image and the template is not satisfied.

2.1 Genetic encoding

As introduced above, the chromosomes generated by the GA contain information about the image data, so the first step is to encode the image data into a binary string. The parameters of the center of a face (x, y) in the original image, the rate of scale to satisfy eqn.(2), and the rotating angle θ are encoded into the elements of a gene [6]. Some important parameters of the GA used here are given in Table 1, and the search field and region are given in Table 2.

As shown in Table 2, one chromosome contains 4 bytes: the coordinate (x, y) in the original image, the *rate* of scale and the rotation angle θ .

2.2 Experimental setting

The experiment is done by first loading the original and the template images. The GA is used to find whether or not there is the object of the template in the original image. If the answer is YES, then in the original image the result gives the coordinates of the center of the object, the scale, and the rotating angle from the template [7].

For comparison, the general template matching method is also presented [8]. The executive time shows the effectiveness of the GA-based recognition method.

Figures 2 and 3 are the template and original images for the experiment. The values are the width × height in pixels of the image.

Table 1 Some GA parameters

Source	The original and template images
Fields	*x*, *y*, *rate*, θ
Generations	Max = 300 (the stopping criterion)
Population Size	200
Reproduction (selection)	P_r of the best individuals will be selected to survive. The remainder ($1-P_r$) 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. General random changes occur at the rate of P_m

Table 2 Settings for the experiment

Parameters	Length	Region
x	8 bits	(0, *max_x*)
y	8 bits	(0, *max_y*)
rate	8 bits	(1.0, 3.0)
θ	8 bits	(-35°, 35°)
P_r	0.6	
P_c	0.2	
P_m	0.2	

32 × 32

Figure 2 Template for matching
(size: *temp_x* × *temp_y*)

320×240

Figure 3 The original image (size: *max_x*, *max_y*)

3. Experiment and comparison

The genetic operations and GA parameters are presented in Table 1 and Table 2. The fitness is defined as

$$fitness = 1.0 - \frac{\sum_{j=0}^{temp\_y} \sum_{i=0}^{temp\_x} | f(x, y, rate, \theta) - temp(i, j) |}{(temp\_x) \times (temp\_y) \times 255} \tag{4}$$

In eqn.(4), *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 is calculated by translation from (x, y), and by changing the scale and the rotation angle θ from the template [6, 7]. Since the images are 256 gray-level images, in eqn.(4), division by 255 ensures that the resulting fitness is between 0 and 1.

Figure 4 Result of the GA-based recognition

The maximum number of generation is limited to 300, and the threshold of the matching rate is set to 0.9. Thus if within 300 generations the matching rate can reach 0.9, then 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 Figure 4 and Table 3. The result shows that it reaches the matching rate 0.944 at the 112th generation.

Table 3 Results of searching by GA

Fitness	0.944
Generation	112
Time [sec]	5
(x, y)	(112, 107)
Rate	1.02
Angle [deg]	2.24

For the purpose of comparing the effect of the GA-based algorithm, the result of the general matching method [8] is also presented. From Figure 5, we see that although both the original image (the top-left image in Figure 5) and the template (the top-right image) are simplified by binarization, the matching time is 3 min 18s. The recognized result is the bottom-left image in Figure 5.

Figure 5 Result for the general matching method

4. Conclusions

In this paper, the GA-based image recognition method is tested, and a comparison with the general matching method is presented.

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 [9].

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 extract, and are calculated by the general pattern recognition theory and method [10]. 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 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 [7]. This work is important and necessary in order to improve the GA-based face recognition system.

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