Face Recognition Using Genetic Algorithm

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Abstract. Recently human faces recognition has become a significant problem in many fields especially in criminal investigation area. In order to minimize the scope of searching for a suspect, it is necessary to adopt a method to search the suspect quickly and efficiently. This paper achieves the recognition of human faces by using genetic algorithm. The unique selection of chromosome coding method and the method to select a fitness function are presented. Since human faces include various expressions and different angles of photographs which added to the difficulties of recognition, this article adopts the face, eyes and mouth as the feature extraction which reduces the risk of adverse factors and increases the recognition rate. These three characteristics are fused to make a new face. In the procedure of matching, the foundation to the similarity calculation is the principal component of each feature. Besides, it is the fitness function that measures the characteristics of the suspect and the Euclidean distance between the principal components of each human feature. It implements the value of the fitness of chromosome and accomplishes the automatic recognition.

Keywords: Genetic algorithm · Recognition · PCA

1 Introduction

Nowadays human face recognition becomes more and more important and it has become one of primary subjects in the research areas of image processing. Discriminating between faces is not easy because they contain the same features such as eyes, mouth, nose etc. Small differences could be found in the positions of these features in the faces, the general face shape and in color [1]. Many approaches for face recognition have been developed; Chellappa et al. present in [2] an overview of the different face recognition techniques. Among these techniques, subspaces based methods (such as Eigenfaces [3] and Fisherfaces [4] etc.) have been successfully applied, because these methods allow efficient characterization of a low-dimensional subspaces while preserving the perceptual quality of a very high-dimensional face image. Eigenface method based on PCA is the most popular method [5]. Criminal Investigation using genetic algorithm to achieve a high efficiency is of practical significance. GA identifies the characteristics of main suspects and performs automatic matching. By using this method, the number of identified suspects could be reduced from hundreds to a few. Thus, the police could narrow down the scope of investigating the suspects.

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2 GA and PCA Methods

Genetic algorithm was formally introduced in the 1970s by John Holland at University of Michigan [9]. In the computer science field of artificial intelligence, genetic algorithm (GA) is a search heuristic that mimics the process of natural selection. This heuristic (sometimes called a meta heuristic) is routinely used to generate useful solutions for optimization and search problems [6]. Genetic algorithm generates solutions to optimization problems using the techniques inspired by natural evolution. These techniques include selection, crossover and mutation, which involved various fields such as computational science, engineering, economics, chemistry, manufacturing, mathematics, physics and others.

Principal component analysis (PCA) is an analysis technique to simplify data sets. Principal component analysis is often used to reduce the dimension of a data set. The data set maintains the largest contribution to the variance of characteristics. This is the main component by keeping low-level, while ignoring the higher-order principal components. Such low-level components are often able to retain the most important aspect of live data. However, it is depending on the specific application. Since the dependency of the principal component analysis is on the data, it will have a great influence on the accuracy of the data analysis.

3 Proposed Method

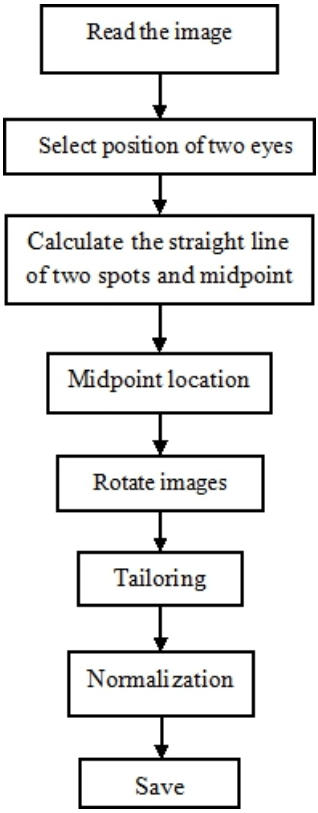
3.1 Pre-processing Database

Since the results of experiment are easily affected by external interference such as facial expressions, illumination, differences of positions etc. The first procedure is to pre-process image database. Figures 1 to 3 represent before and after rendering of locating human eyes and the normalization of size.

Human face images trimming puts all the pictures into a same size and were stored. After pre-processing the size of each image will be unified to the same dimension (128*128 temporarily). The resource of database is obtained from ORL human faces in university of Cambridge. This is a well-known database of faces, which includes a set of face images taken between April 1992 and April 1994 at the lab. The database was used in the context of a face recognition project carried out in collaboration with the Speech, Vision and Robotics Group of the Cambridge University Engineering Department [7].

3.2 Segmentation

After human face images are pre-processed, the next part is to divide eyes and mouth into different area as shown in figure 4. It does the calculation to obtain the principal component analysis of three facial features which are the facial contours, eyes and mouths. Calculated results are saved as the positions of eyes and mouth respectively as well as the PCA of eyes, mouth and faces of database.



Flowchart 1: Pre-processing Steps

Fig. 1. & **2.** Size normalization

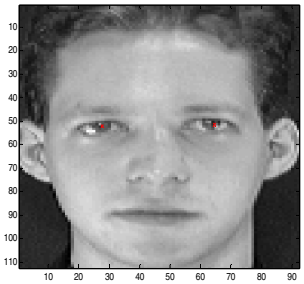


Fig. 3. Locating human eyes

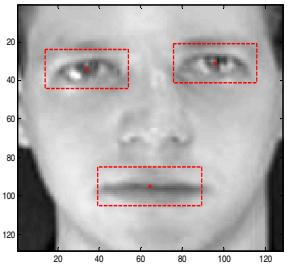
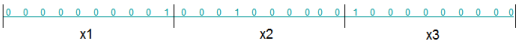


Fig. 4. Dividing eyes and mouth into areas

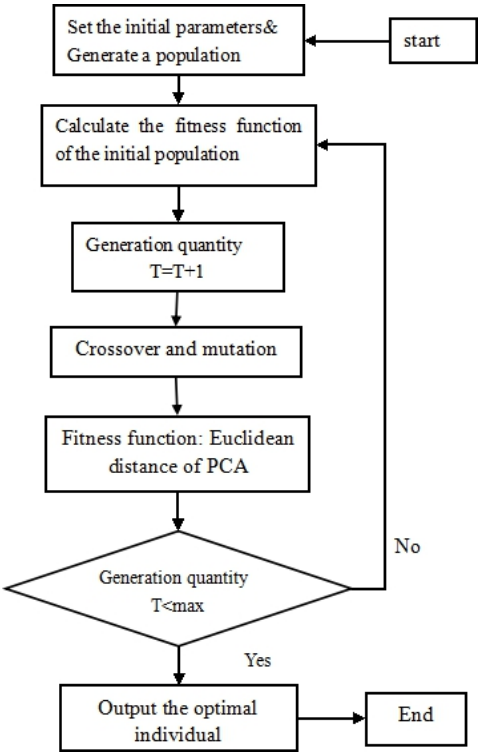
3.3 Recognition

GA is used to perform recognition automatically. The steps are shown in flowchart 2.

We perform recognition by using genetic algorithm. First of all we need to consider how to code the features of images. Coding is an important step in genetic algorithm and a key to design a good method. Encoding method for GA affects the computation time of crossover, mutation and genetic operators, which largely determines the efficiency of genetic evolution. There are several kinds of coding methods that include binary coding, gray coding and floating point coding etc. Because of the availability of binary coding and decoding and the easiness to realize the selection, crossover and mutation operation, this paper adopts the binary coding. In order to achieve the automatic matching of a suspect, it is necessary to perform feature partition of human faces. Besides, we choose the face, eyes and mouth that represent facial features best as a basis for identification. Thus each chromosome should illustrate the characteristics of three variables: x1, x2 and x3 which denote the face, eyes and mouth respectively. Each variable accounts for the chromosome length of 1/3. Moreover, the only one gene showing "1" means that the corresponding characteristics of the person selected from database is the most optimal matching as shown in the following figure (Note: the chromosome length represents the number of people in the image database).



(1)



Flowchart 2: Recognition Steps in GA

4 GA Operations

4.1 Fitness Function

After chromosome coding, it needs fitness assessment for each chromosome that determines which chromosome should be selected and copied into the crossover and mutation stages in the process of evolution. The functions, g1, g2 and g3 represent the Euclidean distance of the human face, eyes and mouth of principal component among the suspects and the image database. It is evident that genetic algorithm implements the automatic matching features by searching for the optimal chromosome and identifying the most approximation of feature matching from database to the suspect.

$$\min \boldsymbol{f}(\boldsymbol{x}1, \boldsymbol{x}2, \boldsymbol{x}3) = \sum_{\boldsymbol{i}=1}^{10} \boldsymbol{x}1(\boldsymbol{i}) * \boldsymbol{g}1(\boldsymbol{i}) + \sum_{\boldsymbol{i}=1}^{10} \boldsymbol{x}2(\boldsymbol{i}) * \boldsymbol{g}2(\boldsymbol{i}) + \sum_{\boldsymbol{i}=1}^{10} \boldsymbol{x}3(\boldsymbol{i}) * \boldsymbol{g}3(\boldsymbol{i}) \quad (2)$$

4.2 Selection of Chromosomes

The selection (reproduction) operator is intended to improve the average quality of the population by giving the high-quality chromosomes a better chance to get copied into the next generation [8]. Based on roulette algorithm, it implements the selection

and duplication. The probability of each chromosome selected to next generation is shown as follows

$$P(i) = fitness(i) / \sum fitness \tag{3}$$

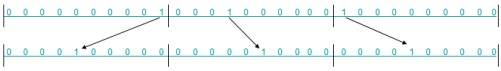
4.3 Mutation

To guarantee diversity of individuals, it is essential that chromosome crossover and mutation be applied to avoid obtaining partial optimal solutions.

The traditional genetic algorithm generally chooses between two individuals of single point crossover using random variation. Namely first generates a random variation of the location of the chromosome, the original 1 of the genetic variation is changed to 0. If the variation of the location of the gene is 0, it will be changed to 1. Moreover, the probability of crossover and mutation is fixed, which is not beneficial to the preservation of elite individuals and reduces the search efficiency of the algorithm.

4.3.1 Mutation of Chromosome Location

When a code is set that the chromosome of each section can only have one "1", it will occur that the chromosome variation could be both "1" or "0". So the traditional method of mutation is not applicable. This paper proposes the mutation in the position of chromosome represented by "1", as shown in the following figure, in which the location of mutation is randomly selected.



4.3.2 Probability of Crossover and Mutation

Under the condition that the probability of crossover and mutation is fixed in the traditional GA, elite chromosome is likely to be changed into a new individual that will cause the decline of searching efficiency. Consequently, we use a sigmoid curve to implement the transformation of fitness. According to the formula, with the higher fitness of a chromosome, the probability to be crossed over and mutated is much smaller. With this method the elite chromosome would get greater chance to be preserved. The following equation represents the self adjustment of the probability of performing cross over and mutation. In our method, we change this probability based on the fitness of a chromosome.

$$P = \begin{cases} \dfrac{p_{\max} - p_{\min}}{1 + \exp(9.9034(\dfrac{2(f - f_{avg})}{f_{\max} - f_{avg}}))} + p_{\min}, f \geq f_{avg} \\ p_{\max} \qquad\qquad\qquad\qquad\qquad\qquad f < f_{avg} \end{cases} \tag{4}$$

5 Result Analyses

When it comes to the training and testing results, after selection, crossover and mutation, we record the best individuals and the fitness of chromosomes.

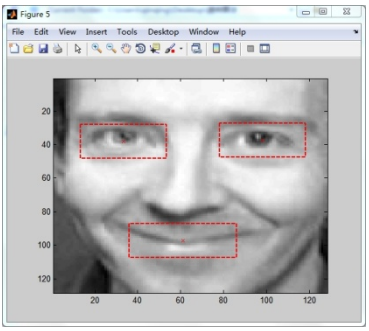


Fig. 5. Original image

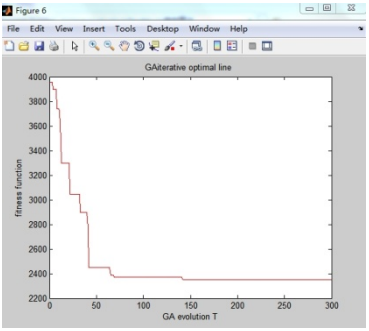


Fig. 6. GA Cycle in recognition

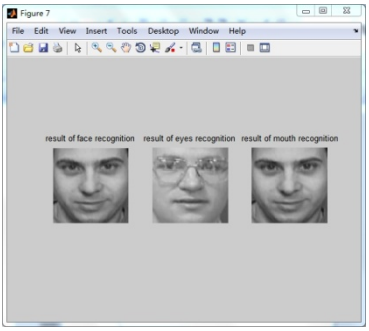


Fig. 7. I dentified images

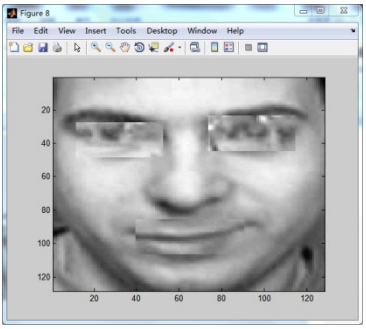


Fig. 8. Combined image

The best result is shown as follows:

Best face individual: 0 0 0 0 0 0 0 0 0 1
Best eyes individual: 0 0 0 0 0 0 1 0 0 0
best mouth individual: 0 0 0 0 0 0 0 0 0 1

It can be seen from the recognized chromosomes that genetic algorithm is feasible and useful in solving many face recognition problems.

6 Conclusion

This paper achieves the face recognition by using genetic algorithm. It solves the problem by choosing the faces, eyes and mouth as the characteristics to optimize every part separately, which benefits a lot in criminal investigation. If we pay too much attention to coding, fitness function will be the only goal programming method that only runs a simple weighted calculation, which will bring disadvantages to the results of matching and recognition considerably. In our method there are some drawbacks

existed in the fusion of images. The new faces that consist of segmentations have not been obtained accurately so far.

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