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Combination of Genetic Algorithm and Neural Network to Select Facial Features in Face Recognition Technique

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ABSTRACT

Face recognition methods are computational algorithms that follow aim to identify a person's image according to the bank of images they have of different people. So far, various methods have been proposed for face recognition, which can generally be divided into two categories based on face structure and based on facial features. Based on this, many algorithms have been introduced and used for face recognition. Genetic algorithm has been one of the successful algorithms for face recognition. In this article, we first briefly explained the genetic algorithm and then used the combination of neural network and genetic algorithm to select and classify facial features The presented method has been evaluated using individual features and combined features of the face region. Composite features perform better than face region features in experimental tests. Also, a comprehensive comparison with other facial recognition techniques available in the FERET database is included in this paper. The proposed method has produced a classification accuracy of 94%, which is a significant improvement and the best classification accuracy among the results established in other studies.

1. Introduction

A facial recognition system is a computer program to automatically identify or authenticate a person from a digital photo or video from video sources. One of the ways to do this is to compare the features selected from the face image with the existing database. This method is commonly used in security systems and can be combined with other known biometrics such as fingerprint or iris. Humans usually use faces to identify people. Advances in computing power over the past decades have made it possible to perform face recognition automatically. Early facial recognition algorithms used geometric models, but today's recognition processes use complex mathematical models for feature extraction [1]. Major advances in the last ten to fifteen years have led to the advancement of facial recognition technology. Face recognition algorithms can be used to confirm or identify faces [2].

Many algorithms have been proposed for face recognition, including: Gabor algorithm, PCA, BFO-GA, boosting algorithm, SVM algorithm, firefly algorithms and etc. [3][4].

One of the most successful techniques used in face recognition is principal component analysis (PCA). Among the advantages of this method is the simplicity of its application and use, the acceptable level of efficiency and its positive effect on large databases. Therefore, many researchers have focused on improving this method. Among the advantages of this method is its simplicity of application and use, acceptable performance level and its positive effect on large databases. Therefore, many researchers have focused on improving this method. Some studies have also addressed the problem of choosing the best eigenvectors, which increase and improve the efficiency of PCA by removing noise eigenvectors and reducing time by using image compression. By reviewing the training data using the PCA method, it is possible to obtain different directions for the eigenvectors. Then, from these different special vectors, the vectors that have optimal virtual space can be selected for identification. As a result, the facial recognition system can be improved by excluding some images from the existing training data [5].

In the last decade, face recognition has become one of the most active areas of cognitive pattern research. The most common matching method of face recognition methods can be easily classified into three matching categories based on comprehensive features, based on local features and multiple matching methods [6]. In the comprehensive feature-based matching method, the entire face region is used as the raw input to the detection system, such as the principal component analysis (PCA) method. In the matching method based on local features, first local features such as eyes, nose and mouth are extracted and then their location and spatial statistics (geometrically or appearance wise) are entered into the structural classifier. Geometric shape method and Elastic Bunch Graph Matching method belong to this category [7]. A hybrid scheme of facial recognition features by merging global and local features was first proposed in 2002 [8]. Genetic algorithm can be used to select a set of desirable features for pattern classification problems [9].

In this article, the genetic algorithm is first explained in the Section 2, and then we explained the features and mechanisms of the genetic algorithm. Then, in Section 2.2, an overview of researchers using the genetic algorithm and its combination with other algorithms is given. In Section 3 and its subsets, which is the most important part of our work, we first presented the proposed method and then extracted the main features of the face with the PCA algorithm. Section 4 describes the combination of genetic algorithm and neural network. In Section 5, a small set of FERET database was used to implement the genetic algorithm and combine it with the neural network and compare it with other facial recognition methods. In Section 6 the results of simulation have shown that the accuracy and precision of classification is evident in our proposed method.

2. Genetic Algorithm

Genetic algorithm is a search technique in computer science for finding approximate solutions to optimization and search problems. Genetic algorithm is a special type of evolutionary algorithm that uses biological techniques such as inheritance and mutation. Genetic algorithm is a learning method based on biological evolution. This method is also called Evolutionary Algorithms. It is an optimization method inspired by living nature, which can be classified as a numerical method, direct and random search. This algorithm is an algorithm based on repetition and its basic principles are adapted from the science of genetics [10]. This algorithm is used in various problems such as optimization, system identification and control, image processing and combination problems, topology determination and artificial neural network training and decision-based systems [11].

2.1. Features and Mechanism in GA Algorithm

Genetic algorithm can be used in problems that have a large search space. Also, GA can be used for searching in problems with a complex hypothesis space where the effect of its components on the general hypothesis is unknown. It is also widely used for discrete optimization. Genetic algorithms can be easily executed in parallel; therefore, cheaper computers can be used in parallel. Genetic

Algorithm, as an optimization computational algorithm, effectively searches different regions of the solution space by considering the sets of solution space points in each calculation iteration. In the search mechanism, although the value of the objective function of the entire answer space is not calculated, the calculated value of the objective function for each point is involved in the statistical averaging of the objective function in all the subspaces to which that point depends. And these subspaces are statistically averaged in parallel in terms of the objective function. This mechanism is called implicit parallelism.

This method causes the search of the space to move to areas where the statistical average of the objective function is high and the possibility of the absolute optimal point is higher. Because in this method, unlike single-path methods, the solution space is comprehensively searched, there will be less possibility to converge to a local optimal point. Another advantage of this algorithm is that it does not require any restrictions for the function to be optimized, such as derivability or continuity, and in its search process, it only needs to determine the value of the target function at different points and it does not use any other auxiliary information, such as the derivative of the function, so it can be used in different problems of linear, continuous or discrete [12].

2.2. Literature Review

With the aim of how to determine the dimensions of feature vectors in principal component analysis, Li et al. proposed a new feature selection method based on the improved Chaos Genetic Algorithm (ICGA). First, they presented two types of Chaotic mapping in different phases of ICGA, which preserves population diversity and improves general search ability, then they used PCA to extract feature vectors of face images. Then, using ICGA, they selected the feature that finds the feature subspace for proper classification. The results showed that this method, in addition to reducing the dimensions of the feature space, also achieved a higher detection rate [13].

Nazari and Shouraki used genetic algorithm along with LBP in face recognition. Their goal is to find the optimal priority through genetic algorithm. This paper proposes a modified method for correcting defective chromosomes. The results show that the proposed method has a higher detection rate on LBP [14]. Mahmud et al. presented an approach for face recognition using principal component analysis based on genetic algorithm. PCA is used to extract features from images. Genetic Algorithm is an optimization method that obtains optimal paths from the generated large search space [15]. Subban et al. presented a face recognition method based on genetic algorithm. This method consists of three main phases of face representation, face recognition and face reacquainting. The proposed method has achieved better results than PCA and LDA in one sample for each person [16]. Sukhija et al. proposed a genetic algorithm-based approach for face recognition. The proposed method identifies an unknown image by comparing it with known training images stored in the database. This proposed algorithm has been compared with other famous face recognition algorithms such as PCA and LDA and has achieved a higher recognition rate. Any face recognition system must handle high data volume and dimensions of image data [17]. To overcome this problem, Verma et al. presented a new model. This system uses radial basis function kernel to manage small training sets of high-dimensional images along with weighted optimization method based on genetic algorithm. This system is suitable for large databases. The genetic algorithm provides effective and fast training of RBF neural network, reducing the search efforts and significantly reducing the recognition time. This system also provides accurate and fast recognition in public places [18]. In the proposed technique, genetic algorithm (GA) is used for feature selection and ANN artificial neural network is used for classification. The presented technique has been tested in a separate feature set from each face area and its comparison with the combined feature set. A large set of data sets from the FERET benchmark database was used for the test.

3. Method

This section describes the proposed feature selection and fusion technique for face recognition. An overview of the method is provided in Section 3.1. Section 3.2 introduces the threshold distance

method used to find face regions. The average value of the gray level of the features is discussed in Section 3.3. Section 3.4 describes the features of PCA. The details of the combination of genetic algorithm and neural networks for feature selection and classification are discussed in Section 4.

3.1. Overview

The purpose of the proposed technique is to select the most impressive facial features and find the best combination of these features for classification. This proposed technique targets the most important areas of the face from which the remarkable features have been extracted. Face area refers to any area of the face that includes a local organ, such as the left eye area, the right eye area, the nose area, and the mouth area. These areas of the face have the most distinctive features in the human face. Face regions are the basis of local feature based feature extraction technique. Even among the distinct regions of the face, some internal regions may be more important than others in face recognition. To identify the most important areas of the face, the proposed method actually removes the noise information created by the non-important areas. It may also remove some of the various information caused by changes in facial expression, head rotation, and lighting changes. Focusing on these important areas allows us to extract the most important facial features to show human faces. These features may improve the classification of facial recognition systems. The first step in the proposed technique is to identify facial regions in face images. The facial feature extraction technique has been performed on these facial areas. After feature extraction, the selected features were integrated and classified. By selecting, the important areas are identified and by classifying, the input face image is identified and confirmed. The experiment using separate and combined features is shown in the FERET benchmark data set. More details are described Section 3.2.

3.2. Identification of Facial Areas

We first identify the face regions on each face image and then extract the features. Then the experimental face images are extracted from the FERET database. Coordinate center information is provided for each face region, including eye coordinate center, nose tip coordinate center, and mouth coordinate center, and the threshold distance method was used to identify facial regions. The threshold distance method defines the threshold distance in horizontal and vertical directions for the local face area. These thresholds decide the size of the face area. Using the information of the coordination center, it becomes easy to identify the areas of the face. Based on the images in the experimental database, the distance threshold is determined as follows. For the eyes and nose areas, the vertical threshold distance is set to 16 and the horizontal threshold distance is set to 30. For the mouth, these distances are set to 11 and 63 separately.

3.3. The Average Gray Level Value of the Feature

After determining the location of the face regions, each face region is divided into small rectangular regions with the same size, and the average value of the feature gray level is extracted from these small rectangular regions. The average value of the feature gray level is expressed as follows:

$$gi = \frac{\sum p(x,y)}{w \times h \times v} \quad (1)$$

where gi is the average feature gray level value for the small rectangular area i, $p\ (x,y)$ is the gray level value of the pixel p inside the rectangular area i, w is the width of the small rectangular area, and h is its height. v is the maximum value of the gray level of the image, which is 155 for our database. After dividing, the average feature gray level was extracted from these small rectangular areas from left to right and top to bottom. In this experiment, the size of the small rectangular area was chosen to be 64 ($h = 4, w = 6$). Then, for the left eye region, the same as the right eye region and the nose region, the size of the extracted feature set was 20. For the mouth region, the size of the extracted feature set was increased to 30 due to the larger size of the mouth.

3.4. PCA Feature

The PCA projection method for face recognition, which is also called the Eigen face method, is a classic method for face recognition. The simple idea in this method is to get the biggest variance from the set of face images and then use this information to code and compare the face images. Suppose the set $\{X_1, X_2, X_N\}$ is a set of N sample images that takes the values of the next n image space and each image belongs to one of the classes C $\{X_1, X_2, X_C\}$. For linear transformation on the map, the original n-dimensional image must be transferred to the m-dimensional feature image, so that m is smaller than n. The new feature vector y_k is defined by (2).

$$y_k = W^T X_K, \quad K = 1,2, \dots, N \tag{2}$$

where W is a matrix with orthonormal columns and W is chosen to maximize the total dispersion of the matrix S of the design samples.

$$S = \sum_{K=1}^{N} (X_K - \mu)(X_K - \mu)^T \tag{3}$$

$$W_{\text{opt}} = \arg\max_w |W^T S W| = (W_1, W_2, \dots, W_m) \tag{4}$$

Where N is the number of sample images and μ is the average image of all samples. $\{W_i | i = 1.2. \dots . m\}$ is the set of n-dimensional eigenvectors of s, which corresponds to the largest eigenvalues of m. To extract the features in this experiment, the PCA method was used to identify the face regions instead of the whole face image.

4. GA-ANN Technique

The method based on Artificial Neural Network (ANN) and Genetic Algorithm (GA) was used to identify the important areas in each face area and merge and select features for face recognition. In this paper, genetic algorithm was used to find potential important features that would generate more recognition. Areas that contain these important features were considered as important areas. Chromosomes represent important selectable traits. Binary coding was used for chromosomes, where 1 indicates that the feature is selected and 0 indicates that the feature is not selected. In one generation, each chromosome is multiplied along with the input feature set and the input feature vector is generated to the artificial neural network. The input feature vector F can be displayed as follows:

$$F = CP \tag{5}$$

$$C = (C_1, C_2, \dots, C_i, C_i \in \{o.1\} \tag{6}$$

$$P = L + R + N + M \tag{7}$$

where C is a single chromosome and C_i is a gene in the chromosome. L is the length of the chromosome, which is the same as the input set P. Testing time on separate feature sets from each face region P represents a set of separate features. As mentioned in the previous section, the size of the left eye feature set is 20 L, the right eye feature set is 20 R, the nose feature set is 20 N, and the mouth feature set is 30 M. After combining this set of features, the size of the set of features becomes 90 P, which is the equation of the set of features P mentioned above. The input feature vector F was transferred to ANN for classification. ANN with only one hidden layer was used in this technique. The classification error of the test was used to calculate the suitability of the relevant individual in the genetic algorithm. In copying, the most suitable person who has achieved the best level of test classification is reproduced. The chromosomes of each generation of the genetic algorithm that achieved the best classification rate are recorded. These chromosomes indicate which traits are selected and which are not. After all generations, the total number of times each feature has been selected. The areas that have a feature with rank n are the important areas. In this experiment, n is defined as 3.

5. Database

In the implementation of this method, the FERET database has been used, and we have used a small set of this database for preliminary tests. This subset of 200 includes 50 classes (50 distinct people) and there are 4 faces in each class. In each of the classes, there are pictures with different poses of a person to measure the flexibility of the algorithm with respect to the disturbances. Fig. 1 shows an example of the images of this database.

Fig. 1. Data base FERET

6. Simulation Result

Our main experiment is based on the combination of PCA with genetics and the database contains 50 classes, each class represents a distinct person. In this database, there are 4 face images in each class. Three of them were randomly selected for training and one for testing. Experiments on the location of significant spaces using GA_ANN have been done on each relevant area separately. The features of the gray level value of each corresponding area form the input feature vector for that area. The size of the extracted feature set L from the left eye area is 20, the same size is set for the extracted feature set R from the right eye area and the extracted feature set N from the nose area. The feature sets extracted from the facial parts including eyes, nose, and mouth go to GA_ANN separately for selection and classification. The purpose of the experiment is to check the proposed method and compare it with other existing methods. All test data were selected from the comprehensive FERET dataset. The comparison of the classification rate of training and test data for the category of specific facial features can be seen in Fig. 2. diagram 1 for the left eye, diagram 2 for the right eye, diagram 3 for the nose, diagram 4 for the mouth, and diagram 5 shows their combination. The gray column is the classification rate of the training data and the blue column is the test data. As can be seen in the diagram combination of features leads to better classification. Fig. 3 shows the comparison of the classification performance in our face recognition method with other methods for 4 images per class, respectively, which shows that the accuracy and precision of the classification in our proposed method is 94%. This number is high compared to other methods.

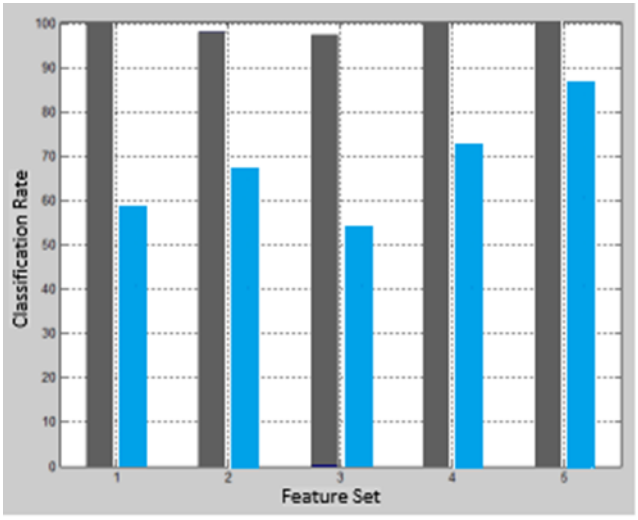

Fig. 2. Comparison of classification rates between feature categories

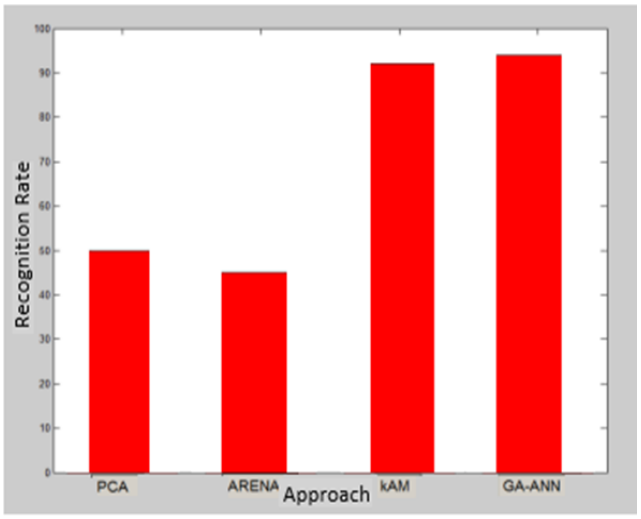

Fig. 3. Performance comparison with other methods

7. Conclusion

In this article, a new feature selection and integration technique for face recognition was presented. In the proposed technique of the algorithm Genetics was used for feature selection and artificial neural network was used for classification. Technique presented in a collection Separate features from each face region were tested and compared to the combined feature set. A subset of 220 of FERET database images were used for the test. In this research, the genetic algorithm was used to find potential important features that would create more recognition. Areas that contain these important features were considered as important areas. Chromosomes represent important selectable traits. The results showed that the selection of face features and the combined method improve the classification accuracy of face recognition systems using genetic algorithm.

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References

[1] T. Kamyab, A. Delrish, H. Daealhaq, A. M. Ghahfarokhi, and F. Beheshtinejad, "Comparison and Review of Face Recognition Methods Based on Gabor and Boosting Algorithms," *International Journal of Robotics and Control Systems*, vol. 2, no. 4, pp. 610-617, 2022, https://doi.org/10.31763/ijrcs.v2i4.759.

[2] E. Gumus, N. Kilic, A. Sertbas, and O. N. Ucan, "Evaluation of face recognition techniques using PCA, wavelets and SVM," *Expert Systems with Applications*, vol. 37, no. 9, pp. 6404-6408, 2010, https://doi.org/10.1016/j.eswa.2010.02.079.

[3] A. Yousefiankalareh, T. Kamyab, A. M. Ghahfarokhi, F. Beheshtinejad, H. Mirzanejad, and S. Seddighi, "Utilizing Multi-Agent Systems Approach in Firefly Algorithm," in *2021 International Conference of Modern Trends in Information and Communication Technology Industry (MTICTI)*, pp. 1-6, 2021, https://doi.org/10.1109/MTICTI53925.2021.9664757.

[4] A. Yousefiankalareh, T. Kamyab, F. Shahabi, E. Salajegheh, H. Mirzanejad, and M. M. Masouleh, "Face recognition based on sparse coding using support vector machine classifier," in *2021 International Conference on Intelligent Technology, System and Service for Internet of Everything (ITSS-IoE)*, pp. 1-5, 2021, https://doi.org/10.1109/MTICTI53925.2021.9664757.

[5] C. Liu and H. Wechsler, "Evolutionary pursuit and its application to face recognition," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 22, no. 6, pp. 570-582, 2000, https://doi.org/10.1109/34.862196.

[6] L.-L. Huang, A. Shimizu, Y. Hagihara, and H. Kobatake, "Face detection from cluttered images using a polynomial neural network," *Neurocomputing*, vol. 51, pp. 197-211, 2003, https://doi.org/10.1016/S0925-2312(02)00616-1.

[7] H. Kobayashi and F. Hara, "Recognition of six basic facial expression and their strength by neural network," in *[1992] Proceedings IEEE International Workshop on Robot and Human Communication*, *IEEE*, pp. 381-386, 1992, https://doi.org/10.1109/ROMAN.1992.253857.

[8] Y. Fang, T. Tan, and Y. Wang, "Fusion of global and local features for face verification," in *2002 International Conference on Pattern Recognition*, pp. 382-385, 2022, https://doi.org/10.1109/ICPR.2002.1048319.

[9] J. Bala, K. DeJong, J. Huang, H. Vafaie, and H. Wechsler, "Hybrid Learning Using Genetic Algorithms and Decision Tress for Pattern Classification," *14th Int Joint Conf. on Artifical Intelligence (IJCAI)*, vol. 1, 1995, https://cs.gmu.edu/~eclab/papers/ijcai95.pdf.

[10] Y. Sun and L. Yin, "A genetic algorithm based approach for 3D face recognition," *3D Imaging for Safety and Security*, pp. 95-118, 2007, https://doi.org/10.1007/978-1-4020-6182-0_4.

[11] D. E. Golberg, *Genetic algorithms in Search, Optimization, and Machine Learning*. Addion-Wesley, 1989, https://dl.acm.org/doi/10.5555/534133.

[12] M. Mitchell, *An Introduction to Genetic Algorithms*. MIT Press, 1998, https://doi.org/10.7551/mitpress/3927.001.0001.

[13] M. Li, W. Du, and L. Yuan, "Feature selection of face recognition based on improved chaos genetic algorithm," in *2010 Third International Symposium on Electronic Commerce and Security*, pp. 74-78, 2010, https://doi.org/10.1109/ISECS.2010.25.

[14] A. Nazari and S. B. Shouraki, "A constructive genetic algorithm for LBP in face recognition," in *2017 3rd International Conference on Pattern Recognition and Image Analysis (IPRIA)*, pp. 182-188, 2017, https://doi.org/10.1109/PRIA.2017.7983043.

[15] F. Mahmud, M. E. Haque, S. T. Zuhori, and B. Pal, "Human face recognition using PCA based Genetic Algorithm," in *2014 International Conference on Electrical Engineering and Information & Communication Technology*, pp. 1-5, 2014, https://doi.org/10.1109/ICEEICT.2014.6919046.

[16] S. Ravi, D. P. Mankame and S. Nayeem, "Face recognition using PCA and LDA: Analysis and comparison," *Fifth International Conference on Advances in Recent Technologies in Communication and Computing (ARTCom 2013)*, pp. 6-16, 2013, https://doi.org/10.1049/cp.2013.2202.

[17] P. Sukhija, S. Behal, and P. Singh, "Face recognition system using genetic algorithm," *Procedia Computer Science*, vol. 85, pp. 410-417, 2016, https://doi.org/10.1016/j.procs.2016.05.183.

[18] R. N. Verma, K. Jain, and M. Rizvi, "Efficient face recognition method using RBF kernel and genetic algorithm," in *2015 International Conference on Computer, Communication and Control (IC4)*, pp. 1-5, 2015, https://doi.org/10.1109/IC4.2015.7375674.