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RESEARCH ARTICLE

Improved Facial Identification Using Adaptive Neuro-Fuzzy Logic Inference System

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Abstract

Objectives: To suggest an efficient pose invariant face recognition system (PCA-ANFIS) based on PCA and ANFIS**. Methods:** Using a dual-tree complex wavelet transform technique, face image improvement is obtained. ORL and YALE B data sets are used in this process. To train and test the network to recognize the person, two sets of photos were used. The system will return recognized if the test image matches one of the image's training sets. The system will report not recognized if the test image does not match one of the image's training sets. Accuracy, specificity, sensitivity, precision, and recall are the criteria taken into account. The suggested approach is then evaluated and compared to other known, gold standard facial recognition algorithms, including PCA, WP&LDA, GOBER WAVELET, SVM, and Bayesian Classifier methods. **Findings:** The study results indicated that the image accuracy, specificity, sensitivity, precision, and recall are enhanced toa level of 90, 85, 95, 86, and 95 per cent respectively when compared with the test results of other known gold standard facial recognition algorithms viz., PCA, WP &LDA, GOBET WAVELET, SVM and Bayesian Classifier approaches by which it can be concluded that it is an efficient approach for facial identification. **Novelty :** Both the feature extraction strategy and the classification approach play a strong emphasis on these factors. Principal component analysis is used for feature extraction, while an Adaptive Neuro Fuzzy Inference System is used for classification. The study proposed a novel neuro-fuzzy system-based face recognition method that is proposed in this study correctly that identifies the input face photos with a higher recognition rate Compared to the existing reports.

Keywords: Facial Recognition; Image Processing; Biometric Technology; Facial Image Enhancement; Accuracy; Sensitivity

1 Introduction

Face recognition(FR) has recently emerged as a significant research problem in the domains of artificial intelligence and pattern recognition. The primary goal of the face recognition system is to find one or more persons in the given video, which includes

a scene preserved inside the data set such as YALE B and ORL or raspberry pi set. The facial identification system is improved in the first phase by using the Dual-Tree Complex Wavelet Transform method (DTCWT). When compared to previous procedures, this methodology can produce findings with more precision and less delay[(1)].

FR is a pattern recognition method that is connected to the notion of artificial intelligence. It is a difficult challenging topic of research since real-time face pictures are created by the merging of numerous components under different settings such as changes in lighting, interference of background, facial position fluctuation, and so on[(2–5)]. The two most crucial processes in our automated FR system are feature extraction and classification[(6–8)]. Individual face pictures are converted into vectors that are highly dimensional in the categorization system. It is necessary to change the picture space from high to low dimensions. There is now a variety of dimensionality reduction approaches available in the FR system to alleviate the ”dimensionality curse.” Some fundamental approaches for acquiring this aspect include Linear Discriminate Analysis (LDA), Support Vector Machines (SVM), and Independent Component Analysis (ICA), among others. The effectiveness of such FR techniques is highly determined by the sample quantity per individual in the training data set. When the sample size is small, the learn sub-space project may be defective[(9)], and these are the study gaps reported in the literature.

To address these inadequacies, the recommended technique in this study is divided into three sections. In the first step, the input facial pictures are preprocessed using DTCWT, since it allows for a smaller data set size for the identification of test pictures. Secondly, the pre-processed images are used for feature extraction by employing the PCA technique. Finally, after obtaining the feature values, face categorization is carried out using the ANFIS classifier. The current study's goals are to improve measurables such as accuracy, specificity, sensitivity, precision, and recall.

2 Methodology

2.1 Procedure steps

1. Begin the procedure
2. GUI process will be used initially for human-machine interaction
3. After that, facial samples will be submitted in order to train the system using feature extraction.
4. Following that, the picture sample normalisation will happen
5. Feature vectors are extracted using PCA and expressed as Eigen values (Principal component analysis)
6. Following that, the feature vector will be saved in the database
7. Use an adaptive neurofuzzy inference system to perform classification
8. Assessment of the system's effectiveness in terms of positive and negative rates, sensitivity, specificity, and recognition accuracy
9. Stop

2.2 Adaptive Neuro-Fuzzy Inference System

ANFIS is a hybrid approach that combines ANN and fuzzy logic. ANFIS uses IF-THEN fuzzy rules (FRs) to describe the knowledge between a modeling problem's input and target datasets[(10–12)]. The block diagram of the ANFIS controller has presented in Figure 1. The Takagi-Sugeno inference technique is crucial in this model for producing the if-then rules and the range from input to output.

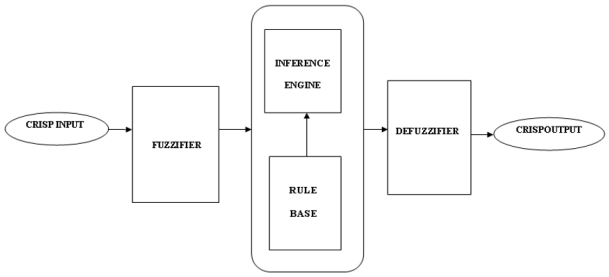

Fig 1. Block diagram of ANFIS controller

2.3 Technique Utilized

The FR issue has incorporated itself as a powerful technique among alternative strategies. The proposed face recognition considers upgraded PCA calculation, ICA, and LDA with ripple chunks and bend lets, and exploratory findings suggest that the combination of such procedures improves the proficiency of the acknowledged method and will improve the current frameworks. The primary purpose of the proposed model is to update the use of PCA computation for boosting the facial recognition approach. The facial identification technique generally has four related stages. Confront location is the first stage, standardization is the second stage and highlight extraction is the third stage and the last stage is confront acknowledgment. In picture and PC vision preparation, a component is a data snippet that is trivial for tackling the computational assignment that is identified with a particular application. The key points may likewise be the sequence of a basic neighborhood recognition that is connected with the image[13,14].

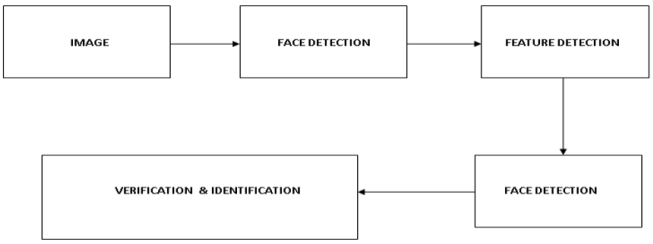

Fig 2. Adaptive neuro fuzzy interference system

2.4 Categorization of utilizing ANFIS classifier

The esteemed score p (_x_1), p (_x_2) . . . p (_x_n) that is gained from the PCA are placed in order by using the classifier which is termed as ANFIS that com-acclaims five nodes of layers. As the features are extracted, a relatable classifier should be chosen and the number of classifiers is utilized and every individual classifier is identified as a suitable one to categorize a specific kind of feature vector based on their properties. The Nearest Neighbor classifiers are basically used classifiers and the closest neighbor classifier is used to look at the component vector of the model with image highlight vectors that keep away within the database and this aspect is acquired by identifying the distance between the image prototyping and the database. ANFIS is utilized as a classification to analyze the emotions of humans depending on their features[15].

2.5 Work Flow

In this study, the ANFIS classifier effectively classified the PCA characteristics after the completion of the feature extraction process.

- To take a fuzzy deduction framework in which the enrollment capacities are iteratively balanced by a furnished arrangement of yield and data information.
- The ANFIS structure is apparent as that of a neural network and it maps through the input membership functions (MF) and connection parameters. Likewise, external mapping is done via output membership functions and connection parameters. For instance, x and y are the two sorts of inputs and z is the output.
- The Takagi-Sugeno inference technique is crucial in this model for producing the if-then rules and the range from input to output.
- The first-order IF-THEN rules of fuzzy logic can be furnished as below

1. Rule 1: IF x=A1 and y=B1, THEN f1= p1x + q1y + r1
2. Rule 2: IF x=A2 and y=B2, THEN f2= p2x + q2y + r2

Where A_1, A_2, and B_1, B_2 are the MFs for inputs x and y respectively.

The symbols p_1, q_1, r_1& p_2,q_2,r_3 are the connection parameters of functions of the output. The fuzzy reasoning mechanism for the Mamdani fuzzy model type is to obtain output function f from the given input vector [x,y].

The 5-layered ANFIS architecture

- Layer 1: Individual node is allocated to a fuzzy membership value utilizing membership functions to create a fuzzy set
- Layer 2: Individual node multiplies the signals of the input
- Layer 3: It contains nodes averaging and is labeled as "N"
- Layer 4: The function of the node within this layer is to calculate the contribution of every i^{th} rule towards the function and the total output.
- Layer 5: It consists of a single output node where the overall output of ANFIS is calculated. The extracted feature values of PCA are utilized to produce input triangular membership functions and addition of the fuzzy rules and furnish an output MF which depends on the database picture and featured extract values.
- The fuzzy rules number and optimal parameter numbers that are essential to define the FIS for the best possible output are decided depending on the input numbers that are utilized as well as their type along with fuzzy membership functions deployed within the model. After the creation of fuzzy rules, the file is imported and saved that file in the present folder.
- After this, a fuzzy file read as (.fis file) and fuzzy interference system is evaluated by utilizing the feature extracted and fuzzy values. Later it will evaluate them and recognize and classify them automatically.

2.6 Sensitivity & Accuracy

- After classification, it is essential to analyze tp,fp,fn,tn to estimate accuracy and sensitivity, etc., These two values finding are essential based on true positive, false positive, true negative, and false negative values.
- The aspect of sensitivity depends on true positive values, if the value of true positive is enhanced, the high sensitivity enhances.
- Image identification gets positive in more numbers of sensitivity gets enhanced.
- In this study, many images of persons are utilized for the purpose of facial recognition
- Facial recognition is done for every individual image of a person and some of the images are identified correctly which is termed as true positive.
- In this study:

In this study, 40 images with each of 10 with different angles and lighting conditions are tested and different parameters are calculated.

As per the formula,

Sensitivity =tp/tp+fn; eq(1)

=39/39+2*100;

=39/42*100;

Sensitivity =95%

The test accuracy is the ability to differentiate the correct and incorrect pictures of the persons. The aspects such as sensitivity and accuracy are achieved based on the correctness and incorrectness of the images of the persons that are utilized for the classifier that classifies automatically.

Accuracy = (TP+TN)/(TP+TN+FP+FN)

The values of TP, TN, FP, and FN are furnished below

TP=39

TN=35

FP=6

FN=2

As per the formula,

Accuracy = (39+35)/(39+35+6+2)*100

= (74/82)*100

= 90

2.7 Process of Classifier Working

1. In this study, the ANFIS classifier effectively classifies the PCA features that are obtained after the process of feature extraction
2. PCA depends on the eigenvector that decomposes the co-variance matrix variables
3. The fundamental idea of this study starts by analyzing the practically obtained values of PCA features that are procured after various facial images

4. In this study, the basic component analysis (PCA) is utilized to extract feature values of individual images and they are utilized for image testing
5. Fuzzy classification is the grouping process of elements within a fuzzy set
6. The extracted feature values are utilized to create a triangular membership function and the addition of the fuzzy rules and provide output MF depends on the images of the database.
7. A fuzzy system of inference is indulged to adjust the given set of output and input data
8. As an output, the ANFIS classifies the face recognition automatically

3 Results and Discussion

Table 1. Comparing Parameters of Various Algorithms

Algorithm	Accuracy	Specificity	Sensitivity	Precision	Recall
PCA, WP&LDA	55%	50%	65%	55%	50%
GOBER WAVELET	65%	65%	68%	70%	62%
SVM	87%	81%	74%	78%	76%
Bayesian Classifier	88%	83%	80%	81%	79%
ANFIS(Now)	90%	85%	95%	86%	95%

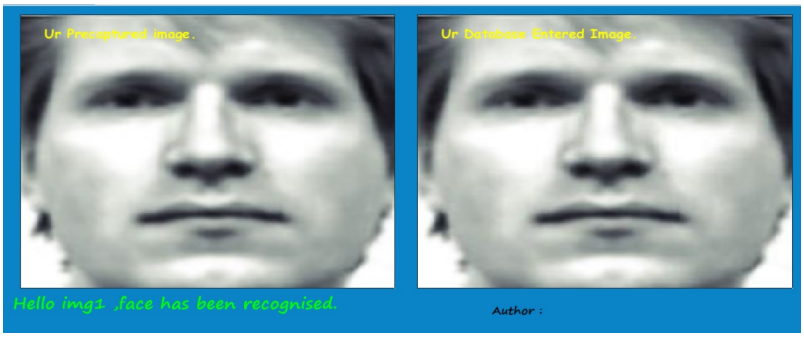

Fig 3. Recaptured vs Entered Image

From Table 1, it is evident that when compared with the other algorithms like PCA, WP & LDA, GOBER WAVELET, SVM, and Bayesian Classifier the algorithm that is utilized in the present study i.e., ANFIS shows enhanced accuracy, specificity, sensitivity, precision, and recall.

The percentage enhancement of the ANFIS algorithm approach with various approaches in terms of sensitivity is in the order of 63%,38%,3.4%,2.2% respectively, 70%, 23%, 4.9%,2.4% respectively for specificity, 46.1%, 39.7%,28.3%, 18.7% respectively for sensitivity, 56.3%, 22.8%, 10.25%, 6.1% respectively for precision and 90%, 53.22%, 25%, 20.2% respectively for recall.

3.1 Sensitivity

- The aspect of sensitivity depends on true positive values, if the value of true positive is enhanced, the high sensitivity enhances.
- Image identification gets positive in more numbers of sensitivity gets enhanced.
- In this study, many images of persons are utilized for the purpose of facial recognition
- Facial recognition is done for every individual image of a person and some of the images are identified correctly which is termed as true positive.

3.2 Specificity

- The negative proportion in a binary test classification that is correctly identified
- The aspect of specificity relates to the test's ability to exact rejection of the images from the mismatching of the person's images

- Specificity =(TN/TN+FP)
- The mismatched person's image which is correctly recognized by the test is termed as a true negative
- The mismatched person's image which is incorrectly recognized by the test is termed a false positive

1. In this study, for facial recognition, many images of people are utilized in which every individual who is having various poses, and now the specificity is calculated.
2. While the calculation of true negative which means the mismatched pictures of a person is tested on the 19 persons' images and the result obtained was mismatched.
3. If the mismatched images of a person are tested on to the 19 images of the person which the result will be mismatched and it is regarded as a false positive.
4. In this study, the result is 19/19 and it concludes that 19 is the exactly identified number (true positive), 19 is the total member and 0 is the incorrectly identified number (false negative) and the result is 100%.

As per the formula,

Specificity =(TN/TN+FP)*100 –eq(2)

= (35/35+06)*100

=85%

3.3 Precision

The repeatability level of measurements furnishes the closeness of the results of each measurement. It is not the same as accuracy.

Precision = (TP/TP+FP)

The values are furnished as below

TP=39

FP=06

As per the formula,

Precision = (39/39+6) =86

3.4 F-Score

In binary statistical analysis of classification, the F1 score is the measurement of accuracy and it can be interpreted as a weighted average of the recall and precision and its best value is 1 and its worse is 0.

F- Score= (2TP/2TP+FP+FN)

The values are furnished as below

TP=39

FP=6

FN=2

As per the formula

F-Score= (2*39/(2*39+6+2))

=78/86

=90

4 Conclusion

PCA is an effective pattern identification tool. PCA-ANFIS combination improves performance by acquiring the accuracy and specificity values of the image in terms of facial recognition at about 90% and 85% respectively. Precision, sensitivity, recall, F-score, and time are all improved (provide values in the percentages of 90, 85, 86, 95, and 95 per cents respectively, and F-score in the order of 90 % when compared to the same values by other approaches performance indicators (mention them). The performance indicators are consistent with real-world experiences, and this research may be expanded as a future scope of research to be used in public locations and also for real-time security systems in public meetings, among other things.

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