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A new pose invariant face recognition system using PCA and ANFIS

Reecha Sharma*, M.S. Patterh

Department of Electronics and Communication Engineering, Punjabi University, Patiala 147002, Punjab, India

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ABSTRACT

In this paper, an efficient pose invariant face recognition system using PCA and ANFIS (PCA–ANFIS) has been proposed. The features of an image under test have been extracted using PCA then neuro fuzzy based system ANFIS is used for recognition. The proposed system recognizes the face images under a variety of pose conditions by using ANFIS. The training face image dataset is processed by PCA technique to compute the score values, which are then utilized in the recognition process. The proposed face recognition technique with neuro-fuzzy system recognizes the input face images with high recognition ratio. The proposed approach is implemented in the MATLAB platform and it is evaluated by employing a variety of database images under various pose variant conditions.

1. Introduction

Face recognition is to identify or verify one or more persons in the given still or video images of a scene using a stored database of faces [1]. Face recognition can be classified into two categories; these are geometric feature-based and appearance-based [4]. The geometric feature-based methods, such as elastic bunch graph matching [5] and active appearance model [6] make use of the geometrical parameters that measure the facial parts; whereas the appearance-based methods use the intensity or intensity-derived parameters [1]. Face recognition system consists of two stages; these are face detection and the face identification [2]. In the face detection stage, facial images are localized in an input image. In the face identification stage, the localized faces are identified as individuals registered in the system. Therefore, developing both face detection algorithms and face identification algorithms is quite important [11].

The variations involved in face recognition, include illumination, pose, and identity [3], facial expression, hair style, aging, make-up, scale. It is very difficult for even humans to recognize faces correctly when the illumination varies severely, since the same person appears to be very much different [10]. A common solution to handling pose variations in face recognition is the view-based method. In this method, the face images of the individuals to be recognized are acquired from different view angles [13]. The images of the same view are used to construct an Eigen space representation for each view, and the view-specific Eigen space representations are then used for recognizing a person in different poses [12].

However the 2D image patterns of 3D face object can change dramatically due to lighting and viewing variations [7]. Recently there has been growing interest in face recognition from sets of images. Here, rather than supplying a single query image, the user supplies a set of images of the same unknown individual. In general the gallery also contains a set of images for each known individual, so the system must recover the individual whose gallery set is the best match for the given query set [9]. Recently face recognition using image-set or video sequence has attracted more and more attention within computer vision and pattern recognition community. More importantly, compared with single snapshot, a set or a sequence of images provides much more information about the variation in the appearance of the target subject [8].

The overall structure of the paper is organized as follows: Section 2 in which proposed face recognition system using PCA and ANFIS (PCA–ANFIS) is discussed. Section 3 gives the experimental results and discussions. Section 4 concludes the paper.

2. The proposed face recognition system using PCA–ANFIS

For the proposed work, the face images are taken from the ORL database. These images are first denoised using the adaptive median filter, before further processing. The denoised images are given to the next process in order to calculate the score values using principle component analysis (PCA) technique. The score values so obtained from the PCA techniques are then used by ANFIS classifier for accomplishing the training process. Based on the predefined threshold value the image under test is indicated as recognized or not recognized.

* Corresponding author. Tel.: +91 9501895500.
E-mail address: sharmareecha@gmail.com (R. Sharma).

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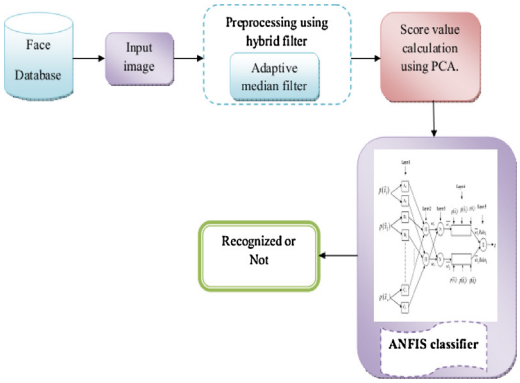

Fig. 1. Architecture of the proposed face recognition system.

The face database images are represented as

$$f_d(r,s) = \left\{ f_{d^1}(r,s), f_{d^2}(r,s) \ldots f_{d^i}(r,s) \right\}; \quad i = 1, 2, 3, \ldots, N, \qquad (1)$$

where N is the total number of images in the database D. These numbers of face images from the database D are utilized in the recognition process. The basic structure of our proposed face recognition system is given in Fig. 1.

The proposed face detection technique consists of three stages namely

(i) Preprocessing
- Adaptive median filter

(ii) Principle component analysis.
- Score value calculation

(iii) Classification using ANFIS.

2.1. Adaptive median filter

The adaptive median filter is applied to the images $f_d(r,s)$ which is affected by the (salt and pepper) noise and acquire a noise free image as an output. The process of adaptive median filtering in noise removal is given below:

Step 1: Initialize the window w size w_z.

Step 2: Check if the center pixel $p_{cen}(r,s)$ within w is noisy. If the pixel $p_{cen}(r,s)$ is noisy go to step 3. Otherwise slide the window to the next pixel and repeat step 1.

Step 3: Sort all pixels within the window w in an ascending order and find the minimum ($p_{min}(r,s)$), median ($p_{med}(r,s)$), and maximum ($p_{max}(r,s)$) values.

Step 4: Compute if $p_{med}(r,s)$ is noisy,

$$(i.e.) \quad p_{min}(r,s) < p_{med}(r,s) < p_{max}(r,s) \qquad (2)$$

If the median value range is in between the minimum and maximum means the pixel is not a noisy and go to step 5, otherwise $p_{med}(r,s)$ is a noisy pixel and go to step 6.

Step 5: Replace the corresponding centre pixel in output image with $p_{med}(r,s)$ and go to step 8.

Step 6: Check if all other pixels are noisy. If yes then expend the window size by 2 and go to step 3. Otherwise, go to step 7.

Step 7: Replace the center pixel of the image with the noise free pixel which is the closest one of the median pixel $p_{med}(r,s)$.

Step 8: Reset window size w_z and center of window to next pixel.

Step 9: Repeat the steps until all pixels are processed.

Using the above mentioned adaptive median filter algorithm the salt and pepper noise is removed. This denoised image is then given to the next process to calculate the score values using PCA technique.

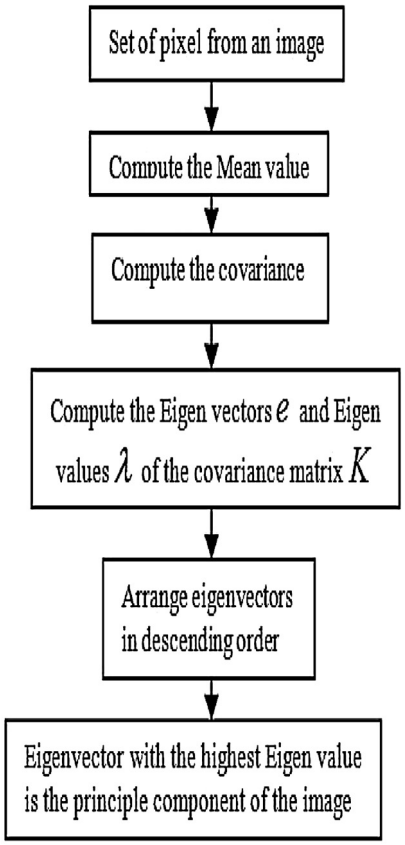

Fig. 2. Flow chart of the principle component analysis.

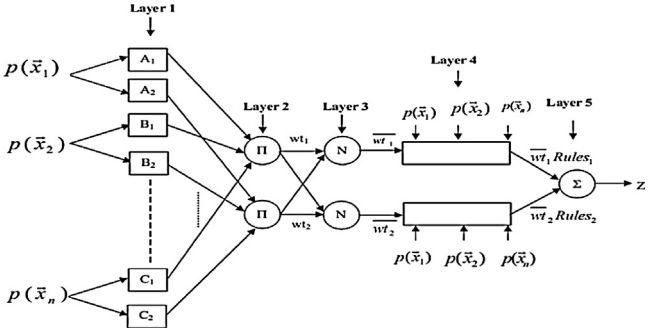

Fig. 3. Architecture of ANFIS.

2.2. Score value calculation using principle component analysis

The denoised image f'_d acquired from the adaptive median filter system is subjected to score values estimation utilizing principle component analysis [14]. Fig. 2 shows the flow chart of PCA.

In the last step of flow chart the score values $p(\vec{x}_1),\ p(\vec{x}_2) \ldots p(\vec{x}_n)$ obtained from the PCA process for different pose images are then passed into ANFIS based classification process.

2.3. Classification using ANFIS classifier

The score value $p(\vec{x}_1),\ p(\vec{x}_2) \ldots p(\vec{x}_n)$ obtained from the PCA are classified using the well known classifier named ANFIS which comprises five layers of nodes. Out of five layers, the first and the fourth layers possess adaptive nodes whereas the second, third and fifth layers possess fixed nodes. The architecture of the ANFIS is given in Fig. 3.