Face Recognition Using Multi-Classifier

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Abstract
In this paper, a new method has been proposed for face recognition. After a pre-processing and normalization stage to the image, PCA (Principle Components Analysis) is applied to recognize a specified face. If the face not recognized correctly, then more features are extracted face colour and moment invariant. The face is recognized again using Decision Tree. Applying two stage recognition process increased the recognition accuracy by 2%. Results showed 94% by applying PCA and 96% by adding face colour and moment invariant.

Keywords: Pattern recognition, Arabic handwriting, PCA, Recognition accuracy

1. Introduction

Biometrics is increasingly becoming important in our security-heightened world [1]. Computer face recognition promises to be a powerful tool, just like fingerprint scans. Automated face recognition is an interesting computer vision problem with many commercial and law enforcement applications [2]. Mugshot matching, user verification and user access control, crowd surveillance, enhanced human computer interaction all become possible if an effective face recognition system can be implemented [3]. However, face recognition is still an area of active research to solve the face recognition problem.

Face recognition is the ability to recognize people by their facial characteristics [4]. Just like human beings, computer algorithms to perform face analysis are also divided into detection, recognition and expression understanding [5].

In this research, a method is proposed to enhance the accuracy of recognizing faces of people available in Olivetti Research Laboratory (ORL) dataset. Our method attempts
to recognize face first by applying Principal Component Analysis (PCA). If face is correctly recognized, system stop and finish. But if it has not been recognized, moment invariant is applied, Hu's Equation combined a Decision Tree (DT) to classify the unrecognized faces by first attempt. In this way, the recognition is improved of high complexity on the method.

The method proposed in this research is the integration of PCA with (Moment Invariant + Face Colour) whereby this integration method is to improve the face recognition accuracy over PCA method with less complexity. Some methods such as Phiasai’s et al [6] apply moment invariant on some parts of the face, this means that they need to detect that certain part first and then apply the feature extraction on it. In this way, there is some difficulty in not detecting the certain part correctly and end up getting wrong result as well. In addition to that, the detection process increases complexity and time process. In our proposed method, there is no chance for difficulty in detection of certain parts correctly because we will not be using feature detection but instead we will be using face colour which reduces the complexity and also the time process.

The proposed method is compared with Phiasai’s et al. [1] method. Phiasai’s et al., 2001 method is using the integration of PCA and (Moment Invariant + Nose Feature). Phiasai’s et al., 2001 method for PCA has the recognition accuracy of 92% and for the integration of PCA and (Moment Invariant + Nose Feature) has the recognition accuracy of 96%. Our method is also based on this method and to enhance it.

2. Background and Methodology

Face recognition is a high dimensional pattern recognition problem. For large computational complexity and memory storage, this high dimensionality makes very difficult to obtain statistical models of input space using well-defined parametric models [4]. However, the intrinsic dimensionality of the face space is much lower than the dimensionality of the image space, since faces are similar in appearance and contain significant statistical regularities. The integration of PCA and moment invariants in this experiment corresponds to successful methodologies for the computational recognition of faces in digital images. In this experiment, ORL database is used to retrieve the images.

Integration of PCA and Moment Invariants method is used in this experiment to recognize faces. The PCA method is used to uncorrelate input data. It gives an insight information of input data (facial images), emphasizing the significant local and global features. Eigenfaces algorithm is a decomposition algorithm based on PCA that finds the vectors which best account for the distribution of facial images within the entire face database [7]. For the facial images that PCA cannot recognize, we use moment invariant and the face colour for better results.

In this experiment, two sets are used for training and testing sets. A pre-processing step for the data images is important as vector is normalized in the matrix. The
holdout method also known as simple validation, randomly partitions the database into two mutually exclusive datasets called a Training Set and a Test Set. In this experiment, 2/3 of the database is designated as training set and the remaining 1/3 as the test set. The training set is given to the inducer, and the induced classifier is tested on the test set to check if the knowledge gained from the training set is of general nature or not.

The images must be preprocessed to get rid of the confounding effect. Invariance to changes in illumination, scale, translations and small rotations in the image plane can be achieved through a process of normalization of face images. Normalization is a process that changes the range of pixel intensity values [8].

![Testing process diagram for face recognition](image)

Principal Component Analysis (PCA) networks are a mixture of unsupervised and supervised networks [9]. Principal component analysis is a linear procedure to find the direction in input space where most of the energy of the input lies. In other words, PCA performs feature extraction.

Moment invariants are a reliable and versatile way to construct a feature vector. Moments have been used as pattern features in a number of applications to recognize two-dimensional image patterns [2].

To extract face colour feature, we have drawn a gray level histogram of each image,
and select the intensity of the most frequent number of pixels. As said before, most of the image is the face, which means the largest number of frequent intensity of pixels should be for the face. To make the extraction of face intensity more reliable, the average of most frequent intensities is taken. Figure 2 shows a histogram of a sample image showing the intensities frequency.

Face colour is represented by the maximum number of pixels of a gray level histogram. A range of plus minus 5 is taken around the maximum number of pixels; for example the range value for Figure 2 is [45-55,130].

![Figure 2: A sample of gray level histogram for face image](image)

### 3. Proposed Method

The data input of human faces in the ORL database are in grayscale image. These images are in two-dimensional (2D) space and needs to be converted into one-dimensional vector.

All vectors are combined together in one matrix and it is called as A

\[
A = \begin{bmatrix}
\text{image 1} \\
\text{image 2} \\
\text{image 3} \\
\vdots \\
\text{image n}
\end{bmatrix}
\]

A preprocessing step for each of the data images is essential as each of the vectors in the matrix is normalized. The mean and standard deviation are calculated for each vector. Average mean and standard deviation are important for the normalization process is applied to normalize all vectors.
After normalization of all the vectors in Matrix A, Principle Component Analysis (PCA) is applied on A to get eigenvectors or eigenface and is called $E$, which contains the extracted features from face images. The weighted matrix $W$ are calculated in Equation 1.

$$\begin{align*}
W &= E^T \times A \\
\end{align*}$$

Recognition process is done by applying the nearest neighbour algorithm using Euclidean distance as a measurement in Equation 2.

$$Euc = \sqrt{(x_i - y_i)^2}$$

If the unknown face is recognized correctly, then process stopped and finish. But if the face has not been recognized, then other type of features are extracted for more investigation. The moment invariant seven Hu’s equations are applied for size and rotation invariance and extract the face colour as it may help to differentiate between dark and fair faces.

A second attempt to recognize the face is done by applying the nearest neighbour on the outcome of the moment invariant and the face colour intensity.

Recognizing the face means recognition accuracy is increased and by that additional features extracted, the recognition system process is improved.

### 4. Results and Discussion

The face recognition system consists of the integration of PCA and Moment Invariant. Varied-pose face recognition is a difficult problem due to the orientation and rotation of the face.

In this face recognition system, a test with PCA alone and with the proposed method which is the integration of PCA and Moment Invariant recognition rates are compared. All the images used in this system are from ORL database, which have variation of scale, illumination, expression and pose.

The experimental results of the proposed method improve the face recognition rate over PCA method by increasing approximately 4%. But some results cannot be classified because of variation of separated regions depends on varied structure of face image. If facial image is oriented too much and close to profile face, the recognition system can be improved due to local features loss.

In these experiments, PCA method is tested with images from the ORL database, which contains 40 subjects and a total of 400 images under various scale, light, pose and expressions. The system is trained using 7 images of each subject and tested it
using the remaining 3 images of each subject. Table 1 shows the recognition rate obtained by applying normalized PCA method during the experiment which gives 94%.

Table 1: Face recognition rate for PCA method

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<thead>
<tr>
<th>ORL FACE DATABASE</th>
<th>PCA method</th>
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<tr>
<td></td>
<td>94%</td>
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Table 2 shows the recognition rate obtained by applying our proposed method which is the integration of PCA and Moment Invariant with face colour on images from the ORL database. The recognition rate achieved is 96%.

By applying PCA, there are some face images that are not recognized correctly and. With our proposed method, the problem is managed to be solved for more face images. Earlier these images could not be recognized correctly, but with the proposed method and with the help of moment invariant and face colour, these images could recognize the right images. Moment invariant can solve the problem for images with different pose and face colour, can differentiate the images with different face colour. The other images are not recognized correctly due to the similarity in certain aspects such as pose variant, illumination, face colour or certain similar features. Face colour helped to recognize input images which is unrecognized by PCA.

Table 2: Face recognition rate for the proposed method.

<table>
<thead>
<tr>
<th>ORL FACE DATABASE</th>
<th>PCA + (Moment Invariant + face colour)</th>
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<tbody>
<tr>
<td></td>
<td>96%</td>
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The processing time is calculated by stating a stopwatch timer on the beginning of running the program and get out the elapsed time after the run finish. 120 face images has been tested on a PC Intel Centrino Dua 1.667 Mhz processor equipped with 512 MB DDR RAM and running a Win XP® operating system. Table 3 describes the processing time for Phiasai’s et al. method which is the integration of PCA and (Moment Invariant + Nose Detection) method. This method obtained 0.82965 seconds/image during the recognition process.

Table 3: Processing time for Phiasai’s et al. method

<table>
<thead>
<tr>
<th>ORL FACE DATABASE</th>
<th>Phiasai’s et al. method (PCA and Moment Invariant + Nose Detection) (seconds/image)</th>
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<td></td>
<td>99.558/120 = 0.82965</td>
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Table 4 describes the processing time for our proposed method which is the integration of PCA and (Moment Invariant + Face Colour) method. This method obtained 0.51167 seconds during the recognition process.

Table 4: Processing time for the proposed method.

<table>
<thead>
<tr>
<th>ORL FACE DATABASE</th>
<th>PCA + (Moment Invariant + face colour) (seconds/image)</th>
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<td>62/120 = 0.51167</td>
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Table 5 shows the comparison of processing time between Phiasai’s et al. method and proposed method. The total time process on 120 tested faces with applying Phiasai’s et al. [6], 2001 method is 99.558 seconds and 62 seconds when applying the proposed method. The processing time for Phiasai’s et al. method is 0.82965 seconds and the proposed method is 0.51167 seconds.

Table 5: Comparison of processing time between Phiasai’s et al. and the proposed method.

<table>
<thead>
<tr>
<th>ORL FACE DATABASE</th>
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Figure 3 compares the recognition rate of Phiasai’s et al. method and the proposed method. The recognition rate of Phiasai’s et al. method for PCA alone is 92% while proposed method, PCA with normalization is 94%. From this, the recognition rate is increased 2% with normalization. A local normalization technique which is applied to an image can effectively and efficiently eliminate the effect of uneven illuminations while keeping the local statistical properties of the processed image the same as in the corresponding image. Then, the processed images are used for face recognition.

Phiasai’s et al. method which is the integration of PCA and Moment Invariant with nose detection has the recognition rate of 96%. From previous studies, it is known that nose is a better feature for face recognition compare to other features.

The proposed method is the integration of PCA and (Moment Invariant + Face colour) which gives the recognition rate of 96%. Face colour intensity is very essential in improving the recognition rate. To extract face colour feature, the intensity of the most frequent number of pixels is selected.
Figure 3 is the histogram which explains the comparison between the proposed method and previous methods. From this histogram, we can see that integration of PCA and Moment Invariant (Phiasai’s et al. method) and our proposed method has the highest and the same recognition rate of 96% and PCA (Phiasai’s et. al method) has the lowest recognition rate of 92%.

In this paper, a method for face recognition is proposed. The proposed method integrates PCA and (Moment Invariant + Face Colour) for feature extraction and applied the nearest neighbor for recognition by using the Euclidean distance as a measurement. The proposed method is compared with a previous approach by Phiasai’s et. al. Our approach performs well with the same recognition accuracy but with less computational time process as Phiasai’s et. al. in addition to applying PCA, nose and eyes features are detected and then applying moment invariant upon them, while in our research, no need for nose and eyes detection, the face colour is just extracted which takes less computation.

The recognition accuracy may be increased by extracting more relevant features and by finding a better measurement for distance which leads to a more accurate recognition process.

Face recognition a research that is applied in a very important real life fields. Our aim is to achieve a very accurate recognition system which may be applied in real life applications and performs perfectly.

5. Conclusion

Face recognition attracts many researchers in these days. It is important to note that many applications of face recognition do not require perfect identification, although most require a low false positive rate. In this research, moment invariant is applied to
solve the problem of recognizing images with pose-invariance such as scaling, translation and rotation. Face colour has also been used to differentiate between images with different face colour. The approach of face recognition described in this paper meets the objectives of improving the recognition process with less computation and time-process. From the ORL database of face images, the results are promising and the system can recognize faces with the recognition accuracy of 96%. This system is implemented on images taken from ORL database of grayscale with varied pose.

The main technical contribution of this research is improving the recognition rate with less complexity and faster time-process. The recognition accuracy is increased a 2% when PCA with normalized method is applied compared to Phiasai’s et al., 2001 PCA method. Even though, our proposed method (PCA and Moment Invariant + face colour) and Phiasai’s et. al method (PCA and Moment Invariant with nose detection) has the same recognition accuracy which is 96%, an additional step is skipped that is the detection of the nose. The detection process increases the complexity and time-process.

6. Future Work and Extensions

There are many possible research directions and challenging problems involved in further improving the approach of face recognition.

One such to improve the recognition accuracy by using a different or improved technique rather than Euclidian distance and eigenface analysis only, which means not recognizing the nearest face but one of the 10 most nearest image because one of them may be the right image.

References


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