Face Detection at the Low Light Environments

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Abstract

Today, with the advancement of technology, the use of tools for extracting information from video are much wider in terms of both visual power and the processing power. High-speed car, perfect detection accuracy, business diversity in the fields of medical, home appliances, smart cars, humanoid robots, military systems and the commercialization makes these systems cost effective. Among the most widely used image processing tools are detection systems and investigate the faces of people. Change the brightness is one of the challenges in face recognition under complex lighting conditions. There are multiple various methods for removing lighting changes. In this study, it is used of the methods, the non-local means, non-local adaptive means; Retinex single comparative scale and the PCA method input data was provided by using calculated Eigen-face and finally, the face Detection was conducted using the PCA. It should be noted that the used image bases include Extended Yale B and CMU PIE database, which contains a variety of images along with the different lighting intensities and angles. The obtained results show the proposed method that the maximum recognition achieved in a space of 360 dimensional PCA is about 97.5 percent, and detection speed is equal to 2.55 milliseconds that is very impressive compared to the high volume of used database.

Keywords: face recognition, non-local means, non-local adaptive means, Retinex single comparative scale.

1. Introduction

Researches in the field of facial recognition and facial recognition have been interested in researchers for many years. As of today, the face recognition face is widely used in different fields, including public security, identity identification, critical location protection, access control, video monitoring, and so on. In addition, face detection systems are more likely to be used in new areas such as the human-computer relationship (HCI), Internet services such as Internet shopping, etc. [1-2]. Lighting changes are one of the challenging facets in complex lighting conditions. In reference [2], the goal is to identify faces in many images. The most influential parameter in this field is the response time of the system. In this regard, using the extraction and composition approach of properties, the most important properties are firstly determined and then by combining two methods of clustering and Naïve bayes, it is developing a classifier for face recognition in a large data set. In reference [3], the application of neural networks is the development of real-time facial recognition operating systems. This system guides the search process on the areas where it represents the characteristics of human skin color (skin tone). In reference [4], a method for selecting and combining facial features is proposed to improve the accuracy of the classification of facial recognition systems. The proposed method is about the process of selecting and integrating the feature. This technology uses neural networks and genetic algorithms to select and classify facial features. There are five different ways to eliminate lighting changes such as out-of-field image methods, non-local meanings, non-localizable comparative averages, Impact Wave Detection, and Retinex Single Adjustment Scales applied on Extended Yale B and CMU PIE image bases. Each of these methods has advantages and disadvantages. To evaluate and surveying the performance of each of these methods, functional parameters are described such as incorrect acceptance rate, incorrect rate of incorrect acceptance, incorrect zero rate, zero incorrect rate, equal error rate, etc. [5].

2. Face Recognition

Face recognition is a pattern recognition action that is specifically performed on faces. This act contains categorizing a face as "known" and "unknown" after comparing with saved well-known faces [6]. Computational models of face recognition should be difficult to answer for several issues. This difficulty comes from the fact that faces should be presented in such a way that the facial information is best used to distinguish a particular face from other faces. In this case, faces cause a difficult problem because all faces are similar to each other since they have the same set of features as eyes, noses and mouths [6-7].

A common face detection system includes the following three steps:

1. Face Detection
2. Feature Extraction
3. Face Recognition

The challenges ahead face recognition in terms of image recording conditions, such as face-to-face, lighting, facial expressions and number of pixels in the face, as well as the aging process can make many changes to the person's face. Other changes may also be made through the appearance of coatings such as hats or sunglasses and facial hair and, aging in some people increases or decreases weight. There are many different facial recognition algorithms, most commonly called PCA - ICA - LFDA - EBGM – SVM, The algorithm used in this study is the PCA algorithm [8-12].

3. PCA Algorithm

This method was proposed by Torque and Pentland in 1991, which used the analysis of the main elements of the PCA to reduce the dimension can find a sub space with orthogonal vectors in which shows the space dispersion of the data for best reflect the data. This space is called space when applied to face events. After the vectors are identified, all the images are transmitted to this sub space to achieve the weights that represent the image underneath it [13]. By comparing the similarity of existing weights with the new image weighs to this sub space, we can identify the input image. By portraying the human face that is achieved by putting together the matrix rows of the image, it is possible to take human face into a high-dimensional space. Given the similar characteristics of the faces, it can be concluded that the vector of faces is located below a lower dimensional space. By mapping the face to this sub space, you can create new base images that each face is described with the help of these base vectors [14]. In fact, each face is a linear combination of these base images. The coefficients of this linear combination are used as a feature vector. In this method, an image with dimension n * m becomes a vector with component nm. That is, you can imagine a picture as a point in the next nm space. PCA's goal is to find vectors that can identify sub space well. These vectors define the face space. These vectors define the face space. Since these vectors are a special vector of correlation matrix related to facial images, they are called Eigen-face because of their similarity to the human face [15].

3.1. Calculating of Eigen-face

If we consider the following matrices as a set of input images

$$S = \{\Gamma_1, \Gamma_2, \Gamma_3, ..., \Gamma_m\} \quad (1)$$

The average faces are calculated as follows:

$$\psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n \quad (2)$$

Of course, as in the previous section, in this method, an image with dimension n * m becomes a vector with component nm. That is, we consider a photo as a vector row or column with component nm. All the formulas mentioned in this algorithm are based on the assumption that we consider the image matrix as a column vector [16].

The difference between each image from the mean is calculated as follows:

$$\Phi_i = \Gamma_i - \psi \quad (3)$$

The vector u_k is chosen to maximize λ_k:

$$\lambda_k = \frac{1}{M}\sum_{n=1}^{M}\left(u_k^T\Phi_n\right)^2 \quad (4)$$

Of course, with the following assumption:

$$u_k^T u_k = \delta_u = \begin{cases} 1 & if \quad l = k \\ 0 & otherwise \end{cases} \quad (5)$$

The u_k and λ_k vectors are respectively special vectors and special values of correlation matrices. The correlation matrix is calculated from the following equation:

$$\begin{aligned} C &= \frac{1}{M}\sum_{n=1}^{M}\left(\Phi_n\Phi_n^T\right)^2 \\ &= AA^T \\ A &= \{\Phi_1, \Phi_2, \Phi_3, ..., \Phi_n\} \end{aligned} \quad (6)$$

That is, it can also be achieved by using a covariance matrix.

3.2. Feature Extraction

To determine if a new photo is related to which of the photos that the system was practicing with. We have to map all the photos that the system has been practiced with, as well as the new image to the face, if we call any of the images Γ, then the following formula can be mapped to the face of the image [17].

$$\omega_k = u_k^T\left(\Gamma - \psi\right) \quad (7)$$

We then construct the weights vector:

$$\Omega^T = [\omega_1, \omega_2, \omega_2, ..., \omega_M] \quad (8)$$

Now we can determine which entry picture belongs to which class. One of the ways to do this is to compare the vector of weights of the input image with the vector of the weights of the photos previously trained by the system. To do this, we can use Euclidean distance as below:

$$\varepsilon_k = \|\Omega - \Omega_k\|^2 \quad (9)$$

That is, we have ε for the number of photos that the system has been practiced with. If the value of ε was less than a predetermined value, then the picture entry of the image has been known. If it was more and it was less than the second then an incident image is an unknown person. But if it was larger than both, it was not an image of the incoming face! [18].

But after recognizing that the picture entry of an image would have been known, to find out who this photo is, we have to compare the values of εs together. Obviously, the input image is related to a photo whose distance (ε) is less than the other image.

3.3. proposed method

A general flowchart of the suggested method is presented in Figure 1. As shown, the present study is carried out in three separate sections: the first stage, which includes the image preprocessing and in that nonlinear mean, non-linear, and Retinex methods are used in order to improve the image quality. In the next step, using the PCA algorithm, face detection will be performed and eventually the face and the image will be determined. It should be noted that with the use of Extended Yale B and CMU PIE video bases, imagery contains about 3600 images.

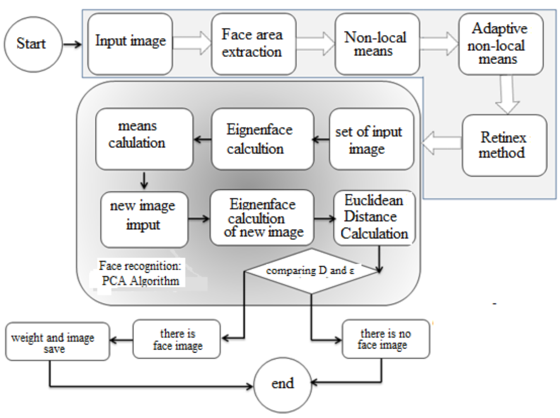

Fig. 1. Flowchart of Proposed Method

3.4. Image Preprocessing

In the preprocessor, it has been tried to improve the lighting with a help of the histogram technique. Results of the implementation of the histogram improvement technique are presented in Figure 2. Also, in Fig. 3, the histogram results of the base images are presented for further investigation.

3.5. Adverse non-linear mean

In the next study, adaptive non-localized mean technique is used for noise removal and image enhancement. As previously mentioned in Chapter 3, non-local comparative averages are: Recovering each pixel in the image by computing the weighted average of the surrounding pixels by measuring the strong similarities between the neighboring pixels around the desired pixel. In the present study, half windows of pixels around 4 pixels are considered, in other words, the actual window of the surrounding pixels (2 × 4 + 1) is considered. The results of implementing Adaptive non-linear means on the database images are presented in Figure 6.

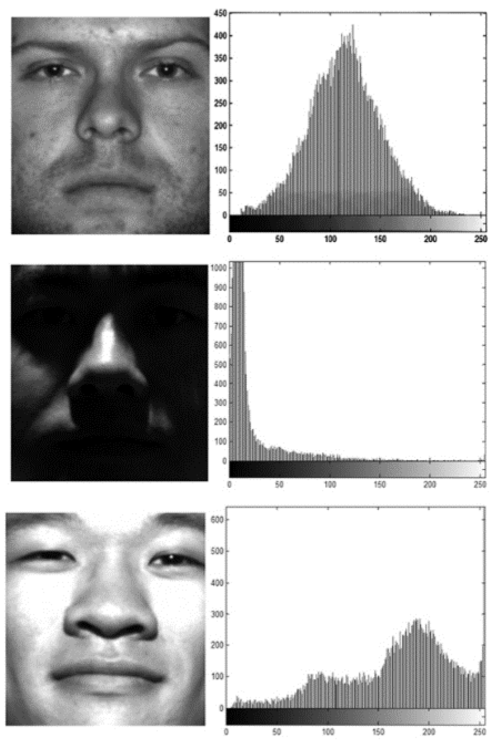

Fig. 2. Histogram of base images

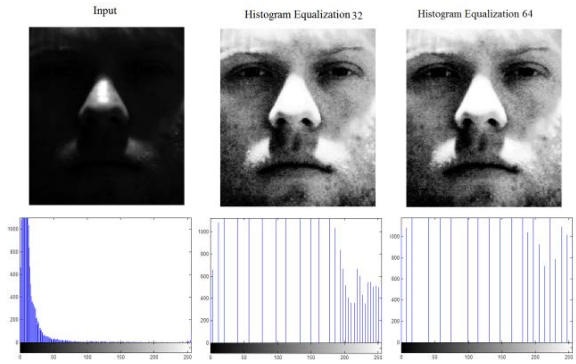

Fig. 3. Improved Histogram|

As illustrated in Figure 4, image enhancement images have been significantly boosted with improved histograms. And the face that is almost unclear in the initial image is clear after the improvement of the histogram of the face. The histogram improvement is part of the preprocessing stages. In the following, the gradient calculation technique has also been used to better define the facial features, as the results of the gradient calculation is shown in Figure 5. It should be noted that the gradient of the image is considered to be 7, less than 7, more than 7.

As seen in Figure 6, Gaussian White Noise Database was first introduced then mean noise removal is done using an adaptive non-linear. it can be seen from the de-duplication results which in this way, the noise reduction is well done when the light of image is much.

3.6. Retinex method

Further, the methods of de-dysfunction and image recovery are utilized by the Retinex method. The results of implementing the Retinex method are presented in Figure 7. A total of 12 images from the collection of database images have been implemented in this section, given the size of the number of images, this is enough. In the third chapter, the principles of the Retinex method were discussed. According to the above, it can be seen that brightness improvements have been improved and image clarity has dramatically increased. Pictures provided under the heading Shading are estimated images that ultimately result, in the final image of the difference between these images and the original images have been obtained. For example, the image of the left column of the fifth row in the initial state of the eyes was not recognizable at all; however, after the implementation of the Retinex method, the facial features of the eye, nose, and lip are marked and recognizable. It should be noted that in the above image the lighting has been taken from above, so the eyebrow shadow completely covers the eyes.

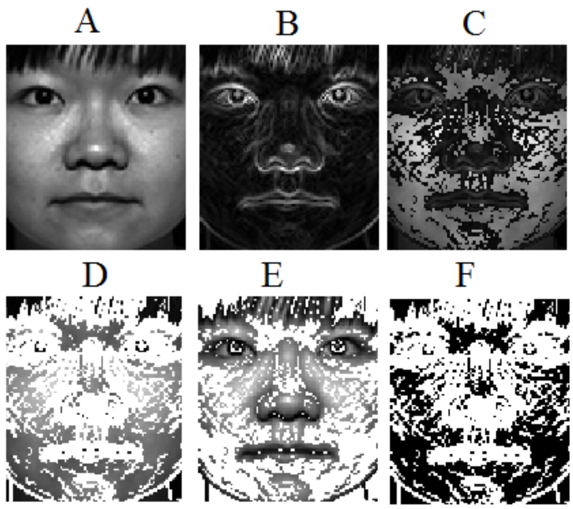

Fig. 4. Calculation of Image Gradient

In the rest of the study, by using the Retinex method, two imaginations in the database were compared including light-intensive images and very low light-intensity images to evaluate the performance of the Retinex method. According to the results presented in Figure 8, it is clearly possible to see the performance of the Retinex method in improving the images. Of course, as expected, when the base image has enough light, the result of the Retinex method is better than that in which the light is extremely low.

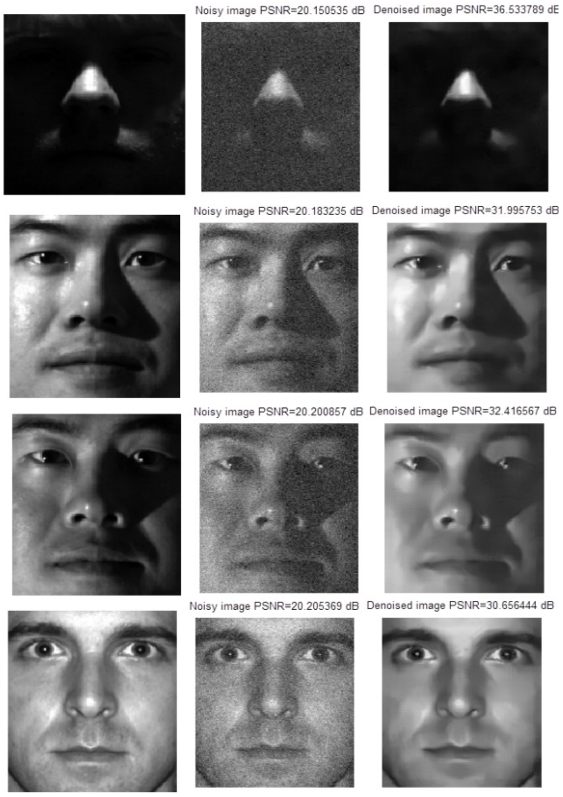

Fig. 5. Results From the Implementation of Adaptive Non-Linear Mean on Base Images

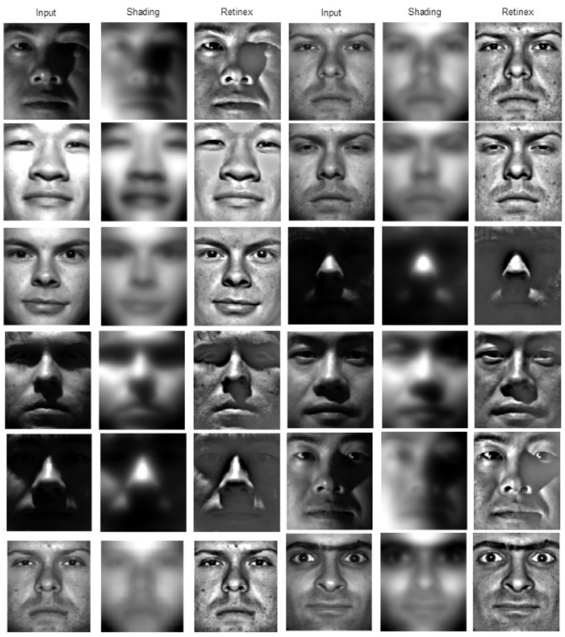

Fig. 6 . Retinex Implementation Results on the Database

3.7. Calculate the results of Eigen-faces

The results of computing the Eigen-faces are presented in Fig. 9. It should be noted that a total of 65 Eigen-faces have been calculated, with only 25 of them presented here

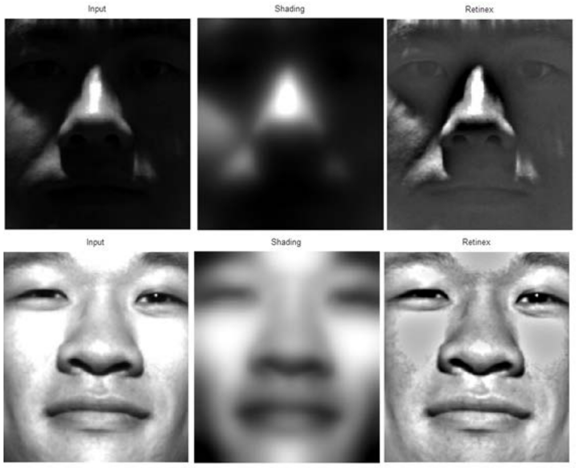

Fig. 7. Compare Two High and Low Light Photos in the Retinex Method

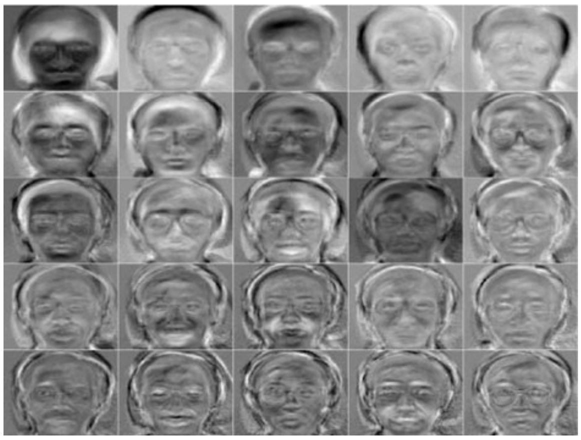

Fig. 8. Eigen Face Images

4. Face Detection with PCA Algorithm

So far, all facial recognition processes have been implemented with the PCA algorithm and now the final stage of the proposed method is presented in this section. The results of the detection percentage are presented in terms of the number of dimensions of the PCA in Figure 4-10.

According to the graph, it can be seen that when the number of dimensions of the PCA reaches 10, the detection rate is increased by about 90, however, with a further increase in PCA dimensions, the percentage of detection varies between 94% and 98% and In the best case, the detection rate is 97/5. This 360-dimensional process continues to exceed 95%, which is evidence of the high-performance feature of face recognition is in different light conditions.

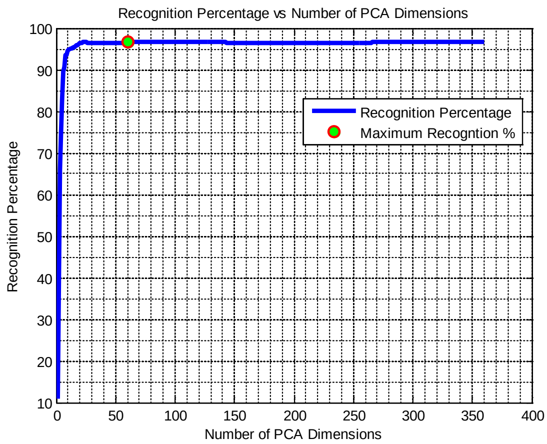

Fig. 9. Detection Percent **B**ased on the Number of PCA Dimensions

In order to demonstrate the ability of the proposed method, the computational time required to recognize each image in terms of the number of dimensions of the PCA is presented in Figure 10. According to the results, it can be clearly seen that in most cases, the detection speed is approximately 2.52 milliseconds and the minimum detection time is 5.1 milliseconds and the maximum detection time is 6.3 msec, which is recorded in dimensions 1 and 173, respectively. Another point that clearly emerges from Figure 10 is that, with increasing PCA dimensions, the detection speed has slightly increased.

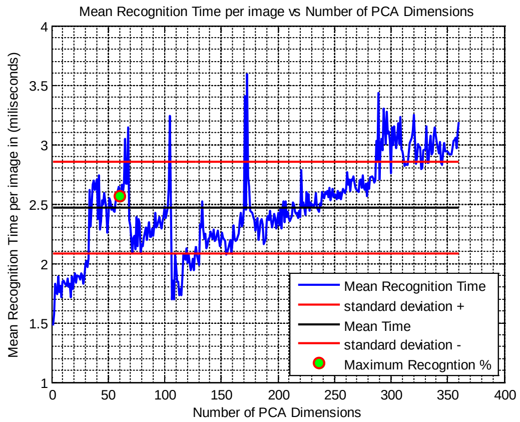

Fig. 10. Average Detection Time in Terms of PCA Dimensions

5. Conclusion

One of the most important recognition and identification technologies used by biometric users is the Identification System based on Face Detection, which is one of the most important biometric recognition technologies after the success of the fingerprint identification system over the past few years. These importance and application development are two main reasons. First, this system deserves to be used in various security applications, "image processing", is a quick, automatic identification without any person interfering and speeds up the processing and reduces the error. and despite reliable biometric systems such as fingerprint recognition and eye iris, the face recognition system creates a more emotional relationship with the user and takes place without a full body member with the diagnostic system and of course, the development of advanced digital camera applications has been a major factor in the development and advancement of fans of the system. The image processing trace is observed in many sciences and industries, and some of these applications are so dependent on image processing that they remain free of their goals. The application of image processing in every field is very extensive, image processing is done in ways that can help to understand the meaning and content of the images. There are several different methods for removing lighting variations. In the present study, we use nonlinear averages, Adaptive non-local means, Retinex single adaptive scale. In the next step, using the calculated Eigen-faces, the input data was prepared for the PCA method and finally, using the Face Detection PCA. It should be noted that the applied image bases include the Extended Yale B and CMU PIE databases, which include different types of images with lighting of varying intensity and angles. The results of the proposed method show that the maximum detection in a 360-dimention-space of PCA is about 97.5% and the detection speed is 2.55 ms which is very impressive compared to the high volume of the database.

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