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Face Detection Using Automatic EyesLocalization Technique

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Abstract— *Eye localisation automatic technique is proposed for face recognition. The accuracy of this method is going to be evaluated using George Tech. Database (GT-database). AWGN distorts the database images to introduce some noise. The results show that >98.9% eye detection rate with eye localisation. Finally, the detection eye region tests a specific face with different properties with the same database's faces. Some encouraging results will be presented to show the efficiency of the proposed method. The system can be used in different applications such as security, communication systems, and education, to name a few.*

Keywords— *Automatic eye detection, Face detection, Pupil centre localization, RGB images, Segmentation.*

I. Introduction

Automatic face identification and detection has been a challenging problem in the area of computer vision and pattern recognition for many years. Automatic face identification has numerous applications including surveillance, security, gaze-based control, animation, video compression and affective computing. There are other methods for finding faces, but the eye technique seems to be the most useful in this area. Due to its significant role in nonverbal human-computer interactions, eye detection and tracking have become more advanced in recent years. Most of the time, the centre of the pupil is used to gauge the position of the eyes. [1],[2] and [3].

Identification of the face and eyes is crucial for face recognition. Eye detection serves three different objectives. The first is to recognise the presence of eyes, and the second is to precisely identify eye locations [3] and [4]. Lastly, recognising faces with the eye. This paper suggests the automatic-localization eye approach. To identify the face region, some segmentation based on skin tone is employed first. The GT database image is shown in the figure 1. Then, the results are converted into grey level then to binary image using some threshold. The automatic technique after that is employed to detect eyes-region. The technique localizes the pupil center, which means the status if the eyes are open or closed could be detected. Some images are presented to demonstrate the results. Then, the eyes-region templates are applied to the entire database and the tested image. Finally, the final decision is made based on five methods combined together. These features are Min error Mean, Min error Variance, Min error Covariance, Min Cross-Correlation, and Entropy.

II. Block Diagram of the Algorithm

To find the eyes in a face image, countless methods have been suggested [4]. The face detection operation began when the eye region, pupil centre, and iris boundary were located. An innovative method for detection using eye analysis is provided in this research, along with a simple method for pupil centre and iris boundary localization based on Eye Map and an automatic algorithm for eye state analysis. Figure 2 gives a summary of the suggested system and describes each phase in relation to relevant mechanisms.

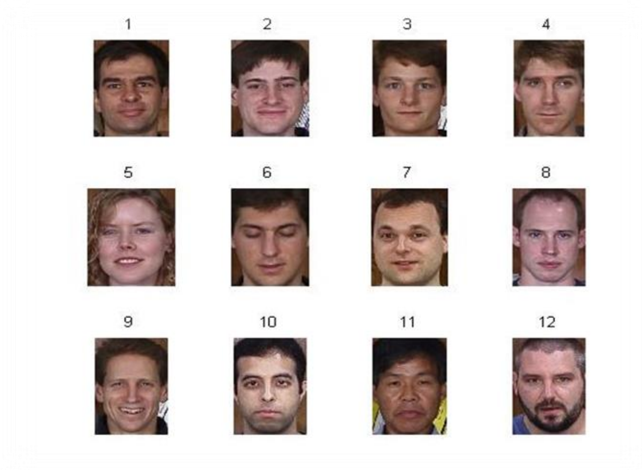

Fig. 1. Database GT images "Original RGB images".

Many proposed solutions used manual thresholds but nevertheless produced good results in their databases. The approach described in [5] and [6] demonstrated excellent performance for the detection of eye regions in various lighting conditions. It determined eye regions by creating an Eye Map. [6]

Through eye mapping, the suggested method first pinpoints the eye region. In order to determine if the eye is open or closed, it secondly locates the pupil's centre. Finally, it identifies the iris boundary and specifies the pupil centre. This automatic technique is computationally simple and doesn't need any training data, threshold selection by hand, or cropping of the ocular region [6].

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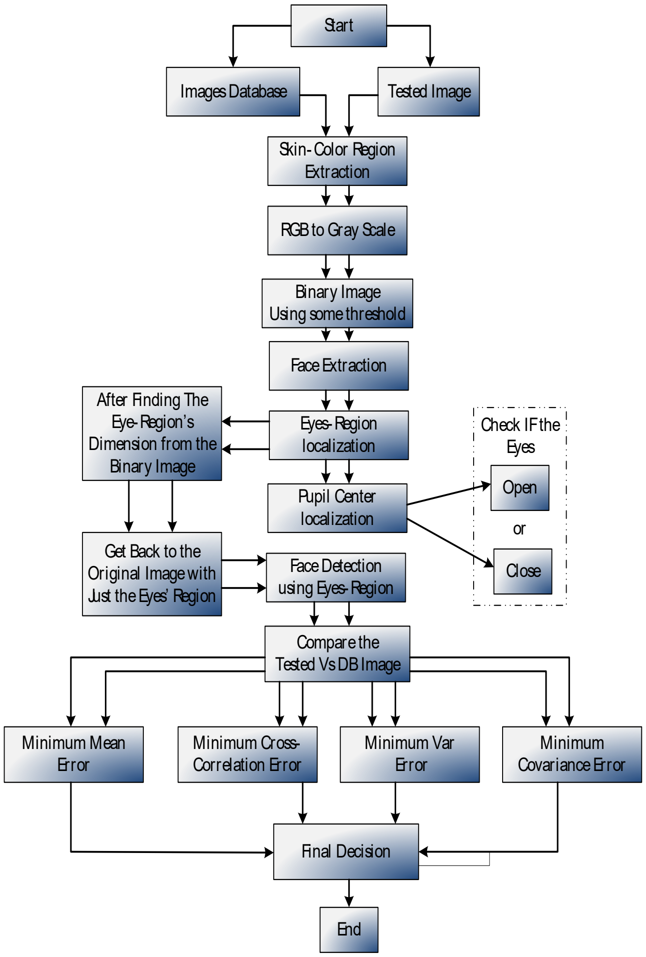

Fig. 2. Automatic localization block diagram

III. Skin Region Segmentation

In the suggested approach, colour space is first converted from RGB space to a normalized RGB model to reduce computing complexity in 2D and 3D as well as to lessen the sensitivity of RGB value to various lightings, as follows:

$$R = \frac{R}{R + G + B} \; ; \; G = \frac{G}{R + G + B}$$

In our instance, skin and non-skin pixels were taken into consideration. We need an accurate skin colour model that can be adjusted to persons with varied skin tones and under various lighting circumstances in order to divide human skin regions from non-skin regions based on colour. [7]-[12]. Using [8], we create a grey-level picture of the facial region.

$$I = 0.2989\, R + 0.587\, G + 0.114\, B$$

here, the "I" stands for a grayscale image. Figure 4 displays the outcomes of this procedure for two samples. Using the skin colour model previously stated, the primary objective of this segmentation procedure is to eliminate the picture background from skin regions. These normalized components are extracted during the segmentation process, which will later create these images. 4. As illustrated in Figure 3, each image is transformed into a binary image by using various thresholds on the normalized input image. As illustrated in Figure 5, we then apply an operation on these two black-and-white images, where white pixels represent skin and black pixels represent non-skin pixels. The colour information of some skin pixels behaves like a non-skin region due to the presence of AWGN noise in the input image, creating a fragmented skin tone region [9], and [10].

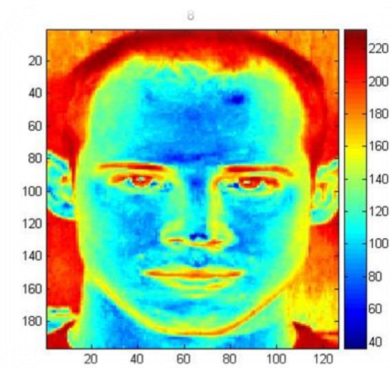

Fig. 3. Change an RGB to binary image using some threshold.

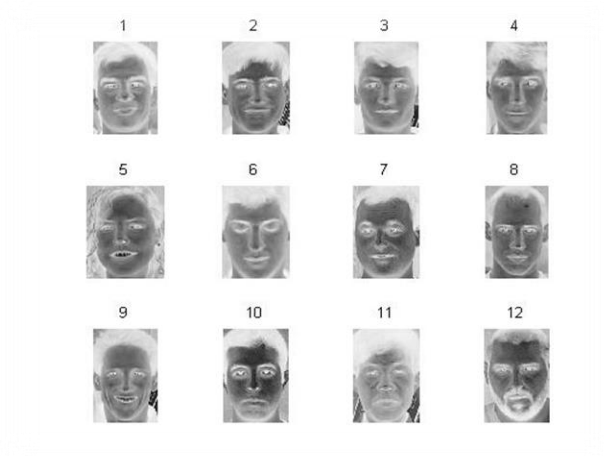

Fig. 4

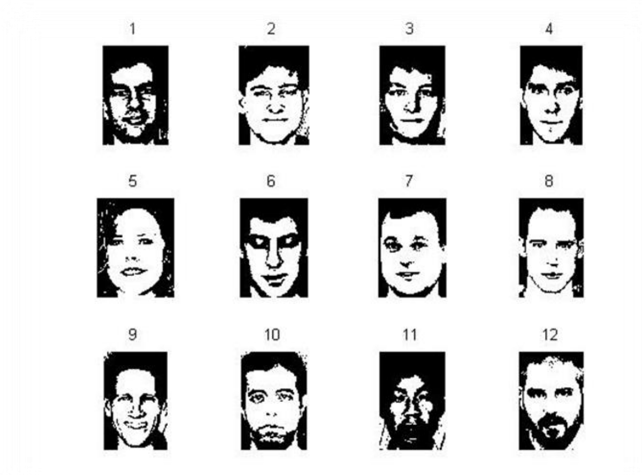

Fig. 5. Database images templates. “Binary-level images”.

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IV. Eyes Detection Automatic Algorithm

We now go on to the detection of the eyes within the face after generating a list of potential faces in the image. The eyelids, eyelashes, shade surrounding the eye's orbit, and the collection of features that make up the pupil, iris, and eyebrows are what are meant when the eyes are addressed in this section rather than the iris. As a whole, this universal area of the eye is a larger and more dominant structure than any of its constituent parts. As a result, it is simpler to recognize as a whole. Even while the method of incorporating the surrounding area enhances heftiness, it decreases accuracy since the brow and eye orbit shading may have contours with centres that are different from the centres of the pupils. Additionally, if a character is squinting or the image quality is poor, the iris will not be clearly discernible, and such high-accuracy algorithms that hunt out an iris or eyelids fully may fail.[11].

Many earlier methods created templates for the eye region by manually trimming the eye region, which were then converted to binary pictures. The suggested approach will identify the database's eyes-region templates. Many earlier methods created templates for the eye region by manually trimming the eye region, which were then converted to binary pictures. The suggested approach will identify the database's eyes-region templates. automatically using some technique which is explained later. The flow of the planned approach is shown in Figure.2. When an image is presented to the system, firstly, we use skin segmentation as explained before. Then, we extract the eye region by choosing a specific point at the centre of the face.

$$(\text{X\_axis})_{\text{Center}} = \text{Lenght}(\text{x})/2$$
$$(\text{Y\_axis})_{\text{Center}} = \text{Lenght}(\text{Y})/2$$

i) Beginning from the$(X_axis)_{Center}$of the model, we move up the principal axis by a distancedy_1, where one parallel line is formed that contains the band of interest.

(ii) The lengthdy_1 can be computed by programming a loop in Matlab, so the loop is stopped when we reach the hair. Then, the same step is repeated to extract the area of the face. (iii) Beginning form t $(Y\_axis)_{Center}$ of the model, we move right and left the principal axis by distance dx_1 and dx_2 , where two parallel lines are formed that contain the band of interest.

(iv) The length x_1 and dx_2 are computed by starting from the centre until we reach the hair on the right and left.

(v) The same operation is repeated to analyze several faces from a database.

This method actually generates a band that more than adequately covers the eyes. This operation operates perfectly when the eye spatial search is clear and can be obtained.

Figure 6 displays the outcomes of combining actions I to (V). The area around the eyes can be easily recognized from the face. The eye region extraction stage's goal is to roughly remove the two eyes' surrounding area from the face. The following eye-detecting algorithm will only be used on this area, as explained in section VI. Consequently, it raises system effectiveness.

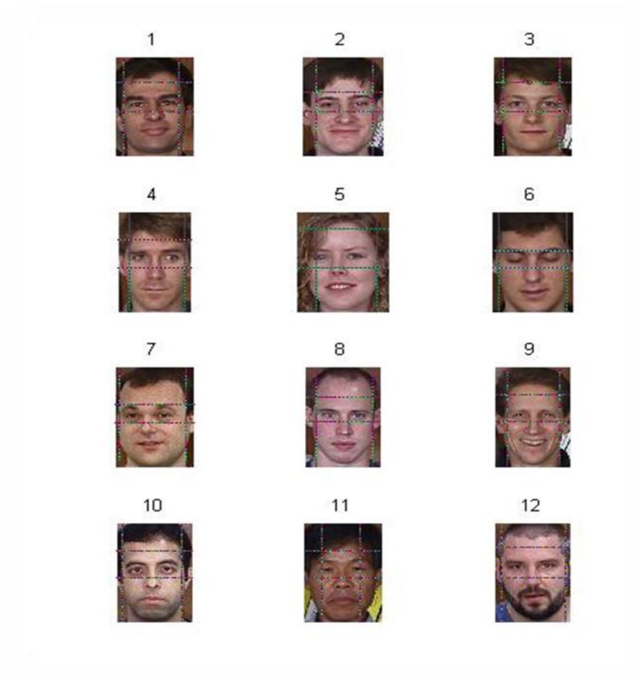

Fig. 6. Database Eyes-Region Detection for RGB Images.

It can be observed from Figure 6 that the eye region of the images does not have the same dimension. The reason for that is each face does have some features that are different from the others. As mentioned before, this has been applied this method on the converted binary images, as shown in Figure 7. Also, the edge of the eye region is computed as shown in figure.8 because it will help in further computation such as cross-correlation and face detection. Finally, the eyes-region is extracted from the original images using the obtaining eyes-region dimension. In other words, the algorithm is applied to binary images to detect the dimension of the eye area, and then the obtaining dimension is used to extract the region from the RGB database and tested images, as shown in Figure 9.

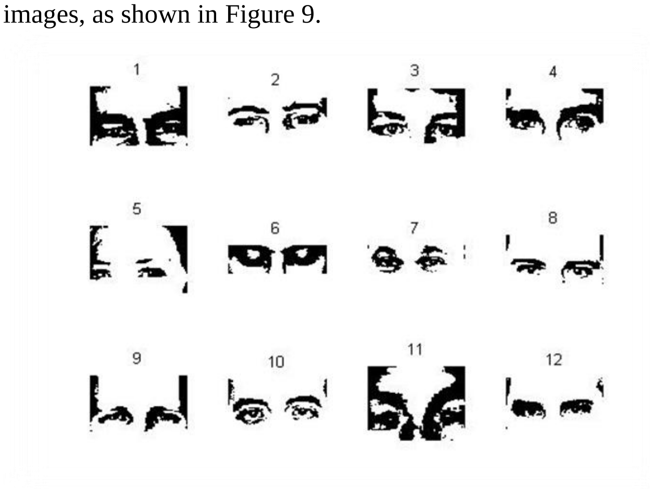

Fig. 7. Database Eyes-Region Detection for Binary Images.

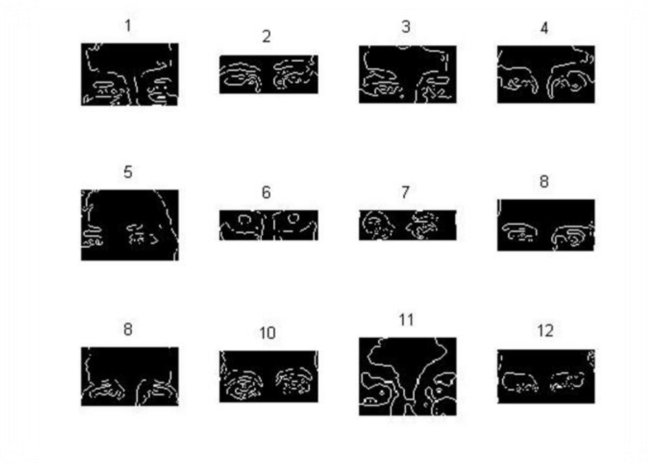

Fig. 8. DatabaseEyes-Region Detection for Edge Detected Images.

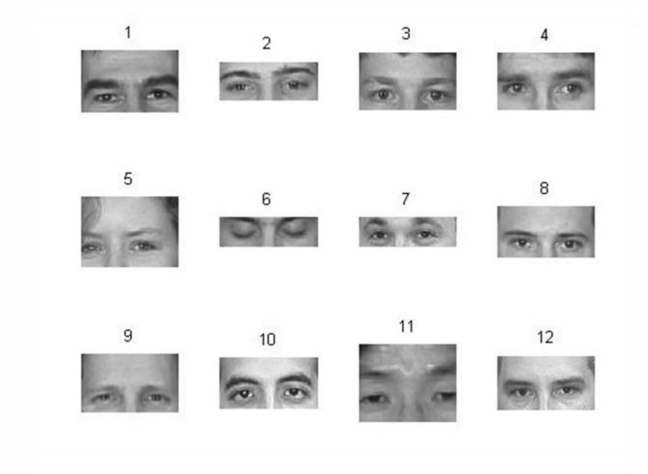

Fig. 9. Database Eyes-Region Detection for RGB Images.

V. Methodology of Localizing a Pupil Center and Iris Boundary

Personal classification based on biometrics has grown to be an option for security applications with the increasing stress of security in our daily lives. Along with the biometric family, iris and pupils are particularly useful for their steady, unique, and non-invasive features. They have quickly become hot areas for researchers. Iris and pupil localization are locating the suitable part of the iris and pupils for succeeding feature extraction modules. Even though state-of-the-art iris and pupil features are very successful for iris and pupil acknowledgement, their recognition presentation is seriously restricted by iris and pupil localization. The reason is the outcome of iris and pupil localization that defines the image contents used for feature extraction and matching. However, the location of the pupil center is not very accurate. Consequently, the error is going to be computed by comparing the simulated detection method with the manual method. Pupils are the center of mass of eye region. Pupil's center localization is obtained from eye region detection step [6].

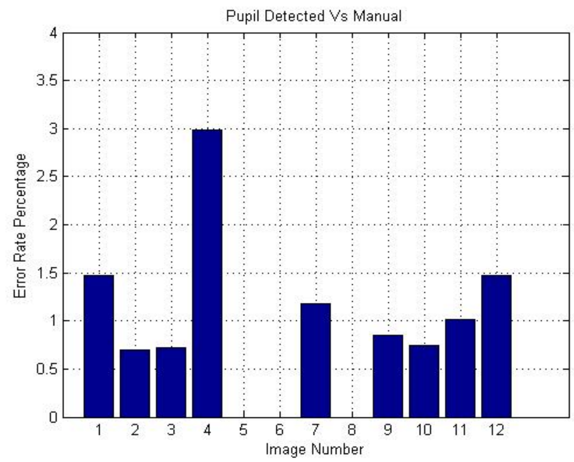

Fig. 10. the detected eye positions and manual eye positions error

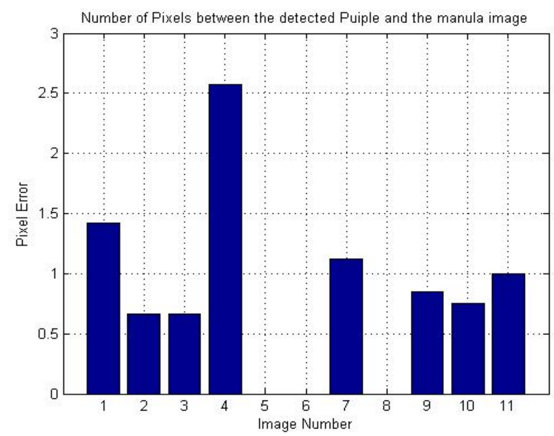

Fig. 11. the detected eye positions and manual eye position pixels' error

Two studies are conducted in order to quantitatively validate the effectiveness of the provided eye detection approach. A comparison of the detected eye locations and the manually labelled eye position methods was done in the first experiment. As illustrated in figure 10, the Euclidean distance between the detected eye positions and the manual eye positions will be used to compute the localization error rate performance for several image samples. Then, in Section VI, some eye traits will be used to improve the accuracy of face recognition in order to identify any particular face among the others. The GT database is utilized for both investigations. It is not possible to gauge the performance of our eye detector in terms of the distance between the manually provided eye positions and the detected eye positions because the correctness of manually provided eye positions has not been verified and no one knows where the actual eye positions are. Convincing. To further validate the performance of our eye detector, we decided to apply it to face detection and use the face detection accuracy to evaluate its performance.

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All of the 2D photos in the GT database use the eye detection technique. About 94.0 percent of frontal faces are detected. The lost faces are typically brought on by some illumination. It obtains a rate of detection of the observed faces for eye detection alone of roughly 98.97%. We now have a general eye detection rate for the GT database of 98.97 percent [3].

The pupil centre and iris boundary for both the manual method and the detected method are shown in Figure 12. Figure 10 also displays the total error as well as the obtained errors. According to Figure 11, there is a maximum Euclidean distance of 2.6 pixels between each image's automatic eyes and the ground truth, accounting for an error of 2.9 per cent.

The typical overall error rate is around 1.079 percent. Figures 12 and demonstrate the distribution of the detected eyeballs' Euclidean distances in relation to the real world. 13. Figure.13 displays the outcome of identifying the pupil centre and iris boundary for the entire GT-database.

Fig. 12. Detected pupil and iris region method "blue" Vs manual method "Red".

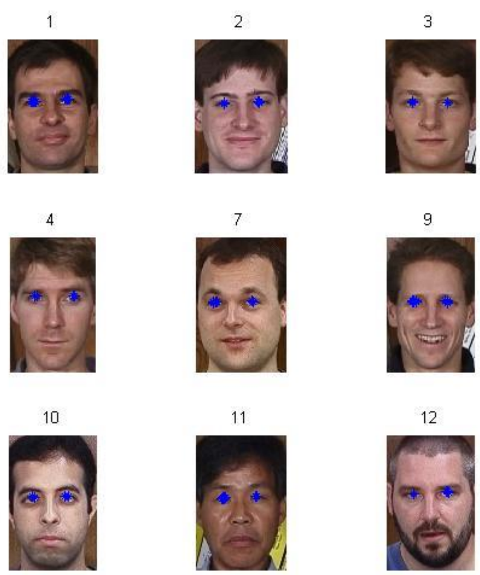

Fig. 13. Detected pupil and iris region method "blue area" for all database images

The algorithm can also detect if the eye is open or close. Figure.14 shows that pupil and iris region cannot be detected because the both eyes were closing. If one eye is open and the other one is close the algorithm can detect that. It can also detect the face even the eyes were close "see section VI."

Fig. 14. Detected pupil and iris region method, Not found for close eyes.

VI. FACE DETECTION USING EYE TEMPLATE METHODOLOGY

Here, face recognition is accomplished using the eyes template function. The eyeballs template is initially created as previously described. The template is then compared to the image's extracted window to determine where the eyes are most likely to be. This can be done specifically by combining the minimum error mean, minimum error variance, minimum error covariance, minimum cross correlation, and minimum entropy to determine which faces among the others have the greatest number of matches. Figure.15 displays the outcomes.. In order to evaluate the proposed system, two experiments were proposed. The first set of experiments was detecting eye regions for all the faces in the database as explained in section IV. This GT database is made up of 12 different individuals.

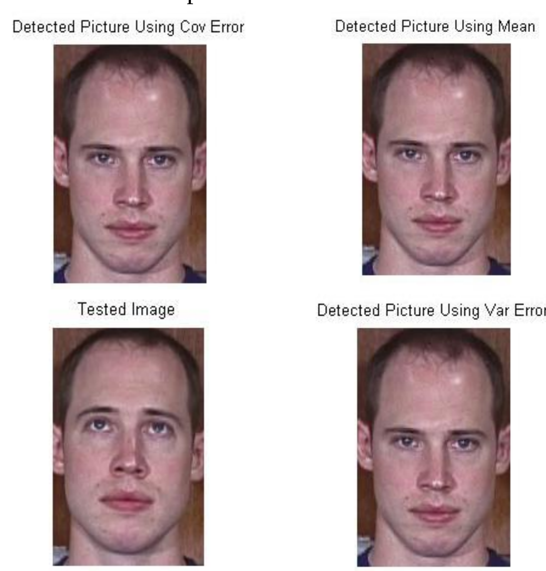

Fig. 15. Detect the tested image face with different glaze direction.

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Facial expressions, lighting conditions and eyes' movements in different directions test the tested images of each individual. The second experiment is implemented by using the results from the first experiment as presented in section VI that is shown in figure.15. The method of detecting the face was based on combined minimum error mean, variance, covariance, entropy, and cross correlation.

$$M.E.M = \frac{E\left(X_{Tested\ Image}\right) - E\left(X_{Data-Base-Image}\right)}{E\left(X_{Tested\ Image}\right)}$$

Where
$M.E.M$: *is the minimum error mean.*
$E\left(X_{Tested\ Image}\right)$: *is the expected value of the tested image.*
$E\left(X_{Data-Base-Image}\right)$: *is the expected value for each DB image*

The results presented in figure 16 show how the image number 8 can be detected using the minmum error mean method. The yellow part from the pie graphrepresents the image the match the tested image from the database with minum error mean.

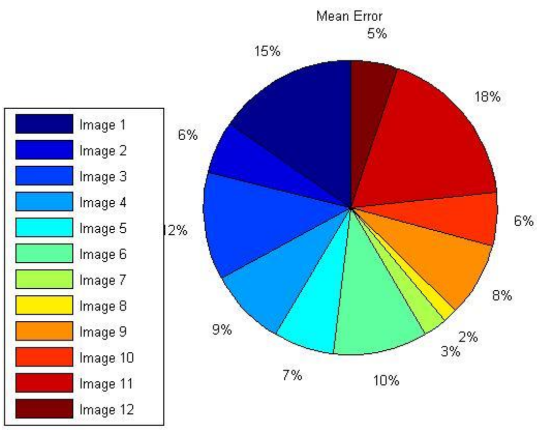

Fig. 16. Detect the tested image face by comparing the minimum mean errors.

$$M.E.V = \frac{Var\left(X_{Tested\ Image}\right) - Var\left(X_{Data-Base-Image}\right)}{Var\left(X_{Tested\ Image}\right)}$$

Where
$M.E.V$: *is the minimum variance error.*
$Var\left(X_{Tested\ Image}\right)$: *is the variance. value of the tested image.*
$Var\left(X_{Data-Base-Image}\right)$: *is the variance. value for each DB image*

Again, the same results in figure 17 and 18 confirm that tested image number as shown in figure.15 is the same face that it has been tested. That proves that these chosen features are excellent to test our algorithm to detect faces using eye localization.

$$M.E.C = \frac{Cov\left(X_{Tested\ Image}\right) - Cov\left(X_{Data-Base-Image}\right)}{Cov\left(X_{Tested\ Image}\right)}$$

Where
$M.E.M$: *is the minimum* $Cov.$ *error.*
$C\left(X_{Tested\ Image}\right)$: *is the* $Cov.$ *value of the tested image.*
$C\left(X_{Data-Base-Image}\right)$: *is the* $Cov.$ *value for each DB image*

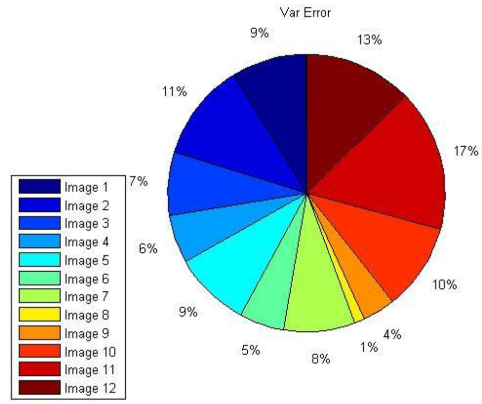

Fig. 17. Detect the tested image face by comparing the minimum variance errors.

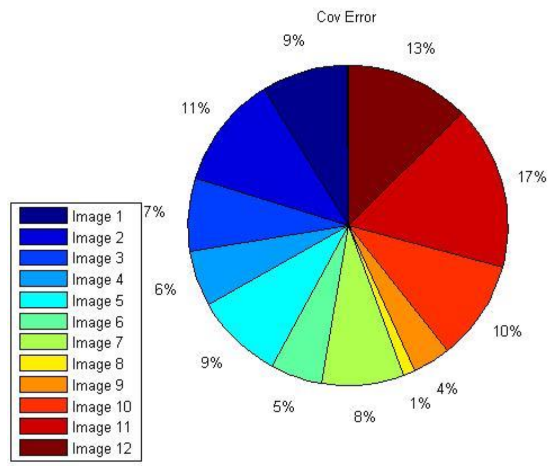

Fig. 18. Detect the tested image face by comparing the minimum covariance errors.

VII. CONCLUSION

In this paper, eye localization automatic technique was proposed for face recognition. The accuracy of this method is going to be evaluated using George Tech. Database (GT-Database) plus AWGN. The results showed>98.9% eye detection rate with eyes localization. Finally, the detection eye-region was used to test a specific face with different properties with the same database' faces.

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