

# Hybrid Features Extraction based on Master Eye Block for Face Recognition

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**Abstract**— As technology is advancing, the demand of face recognition which is one of the biometric technologies is increasing day by day. During the last years, many researchers had introduced different techniques and different algorithms for accurate and reliable face patterns recognition. In this paper, a new face recognition system is presented. The system work flow passes through two main phases the enrollment phase and the recognition phase. The two phases share the two main modules of the system (preprocessing module and feature extraction module).The preprocessing include three stages; face clip detection, eye block detection and edge detection. After read face image as bmp file, the face detection stage pass through these steps; convert to HSV color space for skin color modeling, segmentation process is done for detect the skin area, noise removal, face localization. The eyes blocks detection stage include these steps; image smoothing, convert to gray scale, contrast enhancement and extract master eye cutouts block. The third stage consists of applying canny edge detection and thinning. All these steps to obtain the main edges of eye block. In this research the features vector that represent the face attributes consists of fifteenth feature obtained by applying moment invariant, color moment and geometric features. Probabilistic neural networks (PNN) have been used to make a decision in matching stage. The system was tested over a dataset collected from 30 volunteers, where 10 images for each person were collected in different pose, expression and orientation. The achieved training rate was 100% and an excellent recognition rate 88.5% was achieved.

**Index Terms**— Face Recognition, Moment Invariant, Color Moment, HSV color space, Probabilistic Neural Network.

## 1 INTRODUCTION

Face is the index of mind, it is our first center of attention in social life and it is playing a main role in carrying identity. [1]. Face recognition has received a great deal of attention over the last few years because of its many applications in security, surveillance, general identity verification and image database investigations in various domains. Face recognition is a biometric based technique which has risen as the most promising option for perceiving people, instead of authenticating people and granting them access to physical and virtual domains based on passwords, PINs, smart cards, and plastic cards. Biometric based techniques are essentially pattern recognition applications that acquire certain biometric attributes from an individual, extract a salient feature set from that attributes, compare this feature set against the feature set(s) enrolled in the database, and finally produce a final decision that based on the result of the comparison. A generic biometric system can be viewed as having four main modules: sensor, quality assessment and feature extraction, matching and a database [2].

## 2 FACE RECOGNITION APPROACHES

Generally, there are three types of approaches in the face recognition process.

### 2.1 Feature Based Approach

In feature based, the local features of the face like nose, mouth, eyes are found. Then these features are segmented and it can be used as the input data for structural classifier. During the research it have been studied that center of eyes, mouth, nose, distance between the eyes, width of the nose, depth of the eye sockets, the shape of the cheekbones and the length of the jaw line are the most important features for face recognition. These nodal points are measured creating a numerical code, called a face print (features vector), representing the face in the database [3, 6].

### 2.2 Holistic Based Approach

Holistic approaches attempt to identify faces using global representations of face image, its descriptions based on the entire image rather than on local features of the face. There are techniques like Eigenfaces, fisherfaces, moment invariants and independent component analysis ICA which can be used in the holistic approach [4, 7].

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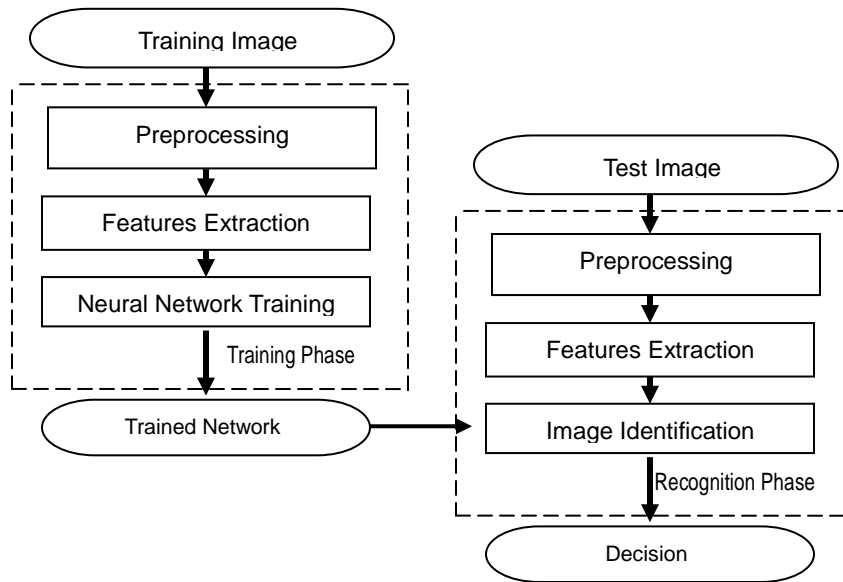


Fig. 1. Primary structure of proposed recognition system

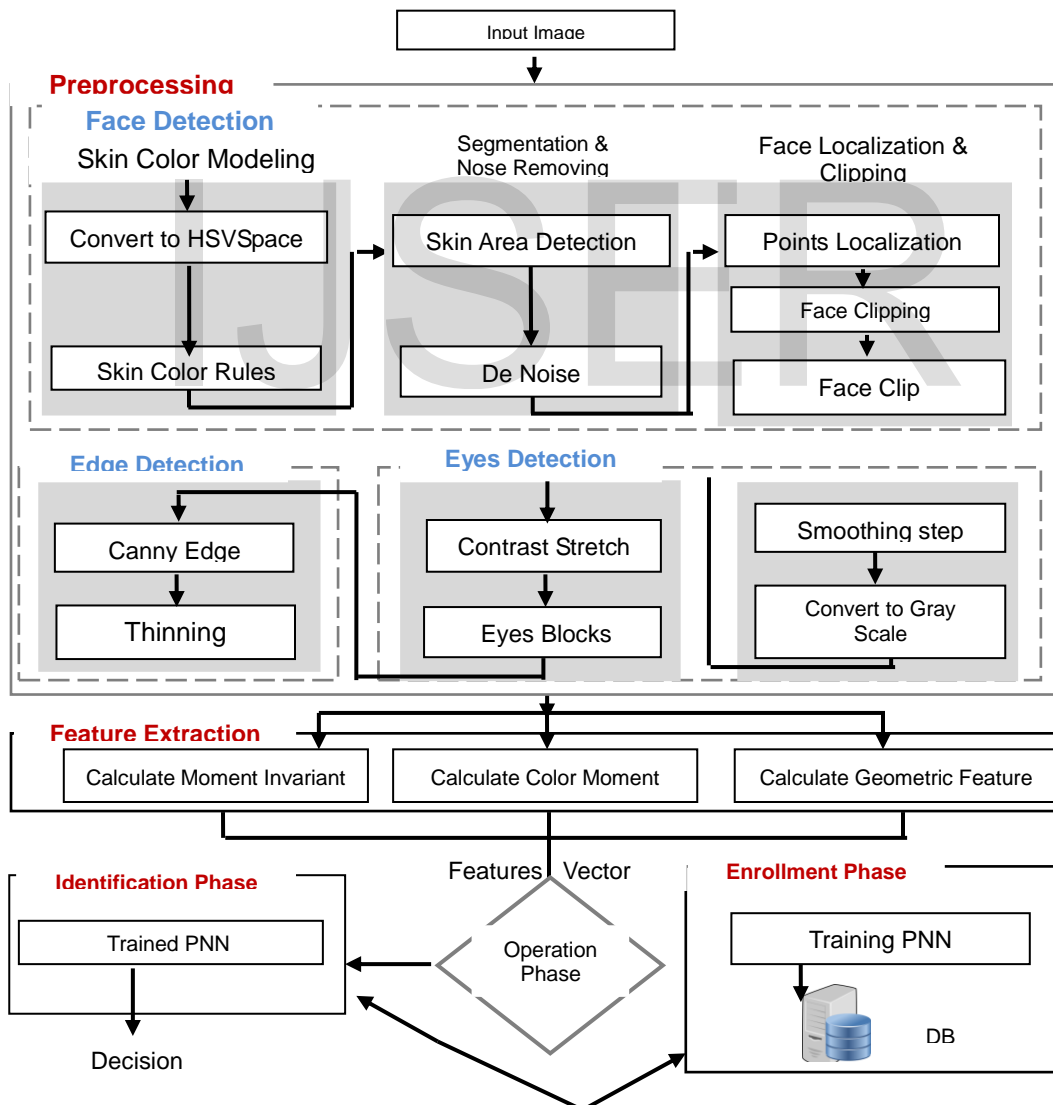


Fig. 2. layout of two phases of the proposed system

### 2.3 Hybrid Based Approach

This method is the combination of holistic approach and feature based approach. The idea of this method comes from how human vision system perceives both local feature and whole face. [4,7].

## 3 PREPROCESSING MODULE

The first module in the proposed system is preprocessing. The main focus of this module is to detect skin area in face image, localize and extract each of face clip and eyes blocks. This module is considered crucial task for both features extraction and recognition tasks. This module consists of three main stages; each stage includes many steps, as follows:

### 3.1 Face Detection Stage

The efficiency recognitions heavily dependent on the accuracy of face detection technique used [5]. In this work, feature based approach based on skin color and pixel based model are utilized. This is done by applying the following steps:

#### 3.1.1 Skin Color Modeling Step

In RGB color space too great change in color values might not be detected by a human observer as in fig 3. Therefore, this color space is not suitable for skin detection, for this reason, HSV color space which is suitable for representing human skin color is used.

Hue saturation value (HSV) based color spaces were presented when there was a need to indicate color properties numerically; they describe color with intuitive values, based on the concept of tint, saturation and tone. Hue defines the dominant color (such as red, green, blue and yellow) of an area; saturation measures the colorfulness of an area in proportion to its brightness. The intensity, lightness or value is related to the color luminance. The intuitiveness of the color space components and explicit discrimination between luminance and chrominance properties made these color spaces popular in the works on skin color segmentation. The equations (1), (2), and (3) represent transformation rules to obtain the (H, S, V) values from RGB color space [6].

$$H = \begin{cases} \left(\frac{G-B}{Max-Min}\right) / 6 & \text{if } R = Max \\ \left(2 + \frac{B-R}{Max-Min}\right) / 6 & \text{if } G = Max \\ \left(4 + \frac{B-R}{Max-Min}\right) / 6 & \text{if } B = Max \end{cases} \quad (1)$$

$$S = \left(\frac{Max-Min}{Max}\right) \quad (2)$$

$$V = Max \quad (3)$$

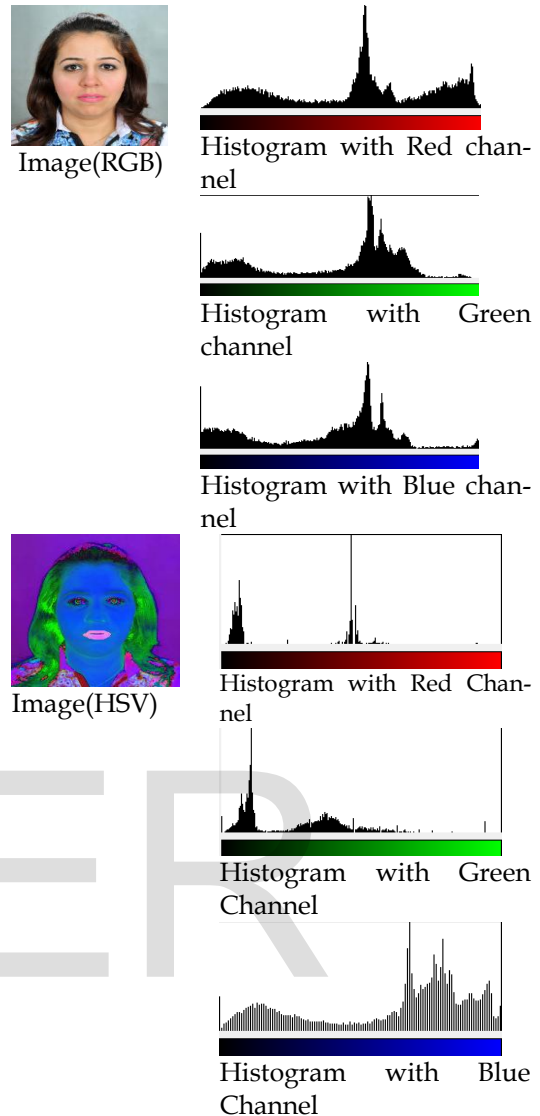
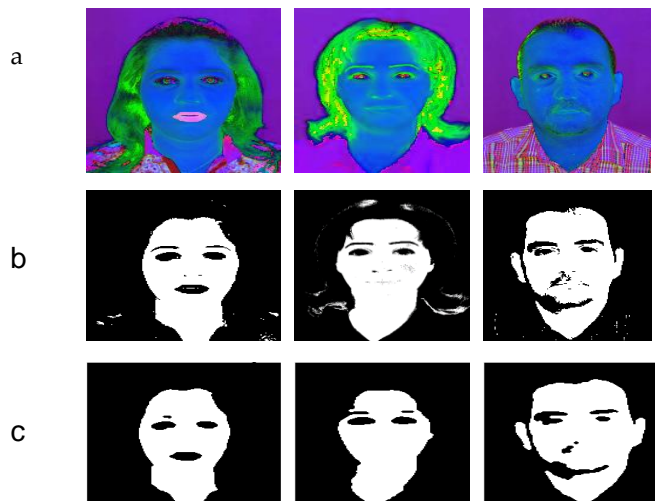


Fig. 3. Histogram Distribution in RGB and HSV color space

From the skin color subspace examination, a set of range rules is gotten from the HSV color space, in light of trying numerous samples. All range rules are derived for intensity values between (0 and 255), depend on the observation that the HSV subspace is a strong differentiates of skin color; the blue values exhibit the most detectable split the skin and non-skin areas as shown in figure (3). Each of H, S and V cutoff levels skin boundaries was assessed, and three range rules which encased HSV skin color area are formed, as below:

$$\begin{aligned} &(H > 0) \text{ and } (H < 40) \text{ and} \\ &(S > 30) \text{ and } (S < 160) \text{ and} \\ &(V > 150) \text{ and } (V < 255) \end{aligned} \quad (4)$$

Therefore, each pixel that fulfills equation (4) is classified as a skin color pixel; figure (4) shows examples of face skin color detection.



**Fig. 4. Face Skin Area Segmentation**  
 (a) After convert face image to HVS color space  
 (b) After face skin region detection  
 (c) After apply median filter

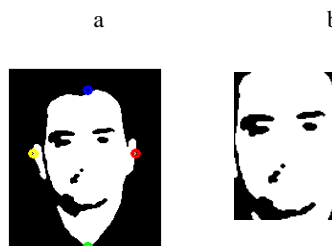
### 3.1.2 De-Noise Step

Medium filter used to remove the noise pixels that may appear after classifying the pixels that are not skin. The median is just the middle value after ascending all the values of the pixels in the neighborhood; the median has half the values in the neighborhood larger and half smaller [8]. Figure 4 shows samples of the input noisy images and the produced smooth images, the size of applied median filter is (3x3), and is applied three times to obtain an acceptable result.

### 3.1.3 Face Localization Step

The aim of this step is determine and extract the position of face clip in the face image. This is done by:

1. Determine main points: determine the position of skin area in order to localize interest clip in test face image, which based on checking the skin area coordinates arrays in order to find the minimum and maximum points. In this scanning, the minimum and maximum values of x and y-coordinates (the margins of the skin area) are registering, the minimum and maximum x values represent the left and right margin, while minimum and maximum y values represents the top and bottom margins, respectively, figure (5) presents a sample explain the localization of face skin area.
2. Clipping face: the purpose of this step is to obtain face clip, without unnecessary parts like right ear, left ear, neck and Palate as in figure (5) below. The process of removing all unnecessary parts from the face depending on computing the percentage of white to black, the minimum ratio of white value to the black value for all pixels in the area. The minimum ratio from left to remove left ear and from right to remove right ear, also from bottom to remove neck and palate. This result is necessary to determine the required face clip.



**Fig. 5. Face clip Localization and Clipping**

- Point (MinTopX, MinTopY)
- Point (MaxBottomX, MaxBottomY)
- Point (MinRighthX, MinRighthY)
- Point (MaxLeftX, MaxLeftY)

## 3.2 EYES DETECTION STAGE

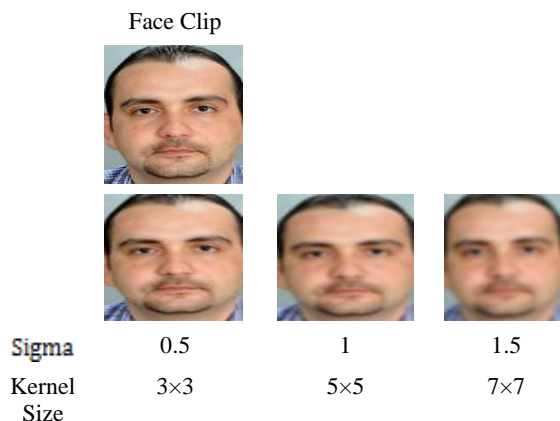
After the stage of extracting face clip from the face image with necessary details, the purpose of this stage is to obtain eyes shape and extract its blocks, by done the following steps:

### 3.2.1 Image Smoothing Step

The purpose of this step is to reduce the existing noise and improve the shape of face details. Gaussian filter [9] as expressed in equation (5), is apply in this step.

$$f(x, y) = \frac{1}{2\pi\sigma^2} \exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \quad (5)$$

In the figure (6), explain of applying Gaussian filtering with kernel size (3x3, 5x5, 7x7) and sigma values (0.5, 1, and 1.5). The sigma equal to (0.8) and kernel size (3x3) have been chosen in the proposed system. The smoothing step is processed to achieve better edge extraction results.

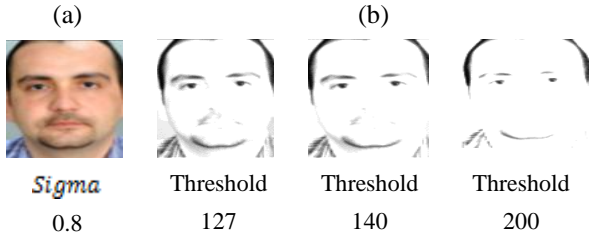


**Fig. 6. Explain the effect of applying Gaussian filter**

### 3.2.2 Convert to Gray Scale Step

In the proposed system, the proper threshold value is assessed after applying different thresholds value on image that result from smoothing step the test results indicated that the best

value for the threshold is 140.



**Fig. 7. An example result of applying different thresholds**  
 (a) face clip after Gaussian filter  
 (b) face clip after convert to Gray-Scale

**3.2.3 Contrast Enhancement Step**

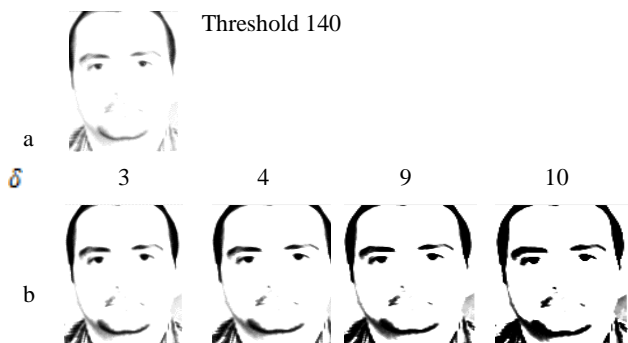
Contrast enhancement step is important to make the image data more usable for the next stages of the proposed system [10]. In order to accomplish this goal, contrast stretching has been made for gray value. The applied contrast stretching comprises of several steps; the first is to calculate the mean and standard deviation and consequently the min and max parameters values could be determined using equations (6) & (7). Then, linear stretching is applied; it shifts the low intensity values that are less than the determined (min) value toward 0, and the high level values higher than (max) value is shifted toward 255. The color level values lay between min and max values are linearly mapped (using equation 2.7). As a result, the range of intensity levels is stretched to the full range (0-255). As shown in figure (8)

$$\text{Min} = \mu - \alpha \sigma \tag{6}$$

$$\text{Max} = \mu + \alpha \sigma \tag{7}$$

$$\text{Img}(x, y) = \text{round} \left( \frac{(\text{img}(x, y) - \text{Min})}{(\text{Max} - \text{Min})} \alpha * 255 \right) \tag{8}$$

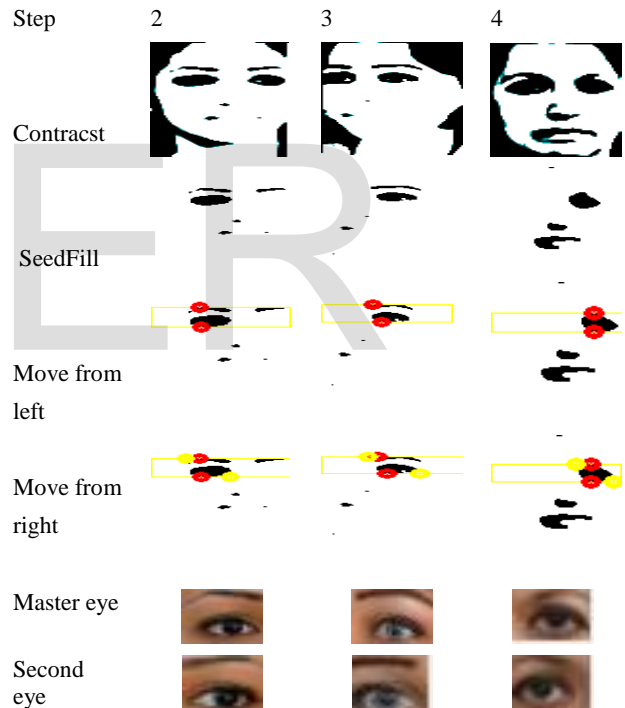
Where  
 Min: is the minimum value of the input image  
 Max: is the maximum value of the input image  
 $\mu$ : is the mean value  
 $\sigma$ : is the standard deviation value.



**Fig. 8. An example of contrast enhancement**  
 (a) Image in grayscale  
 (b) Image after contrast Enhancement

**3.2.4 Extract Master Eye Block Step**

The proposed system developed to recognize face image in many cases (front view, left and right orientation, more than one expression). The main issue characterizing this work is avoidance the effect of partial loss of eyes in the cases when the face is not front view. The purpose of this stage is extracting one cutouts block of eye (master eye). In this step, many holes in image were filled in. Seed filling algorithm used for filling these holes. After apply filling algorithm, one eye remain none filled in (still with black color). This eye called master eye (which refer to eye that have complete details) and the second one called second eye (which have partial loss). In case of face rotate to right side the block of left eye will stay the most clear, and when the rotation to left side the block of right eye will stay clear more than the left eye. Recognize depend on master eye cutouts block is tested with many samples to find that is lead to best recognition rate. In the figure (9) explain the detect of master and second eye for different person. This eye block will used in next step to extract its features to use in training and recognition phase.



**Fig. 9. Examples for different persons explain the determination and extraction of master and second eye**

**3.3 Edge Detection Stage**

The main purpose of this stage is detect the main edge in eye block, This stage including two steps, apply canny edge detection and thinning process.

**3.3.1 Canny Edge Detection**

The motivation behind edge detection in general is to significantly reduce the amount of data in an image, while protecting the main structural to be utilized for further image processing [11]. In the figure (10) explain the applying of canny filter with the values  $\delta = 3, 4, 6, 9, 10$  and explain the edges de-

tection according to each value from values chosen. According to the proposed system the suitable value is  $\delta = 9$  which given best results.

### 3.3.2 Thinning Step

Thinning operation is a powerful step for representing objects shape description, because it useful to capture both the boundary and region information of the shape [12]. The image which obtained from canny edge detection with value (0) and (1), value (1) represents the edges. In the figure below clarification edges detection through applying the previous algorithm with thinning process.

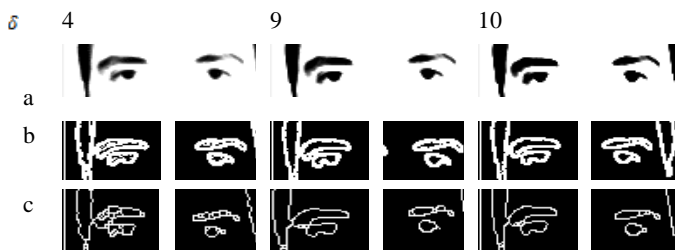


Fig. 10. Explain the effect of thinning (a) contracts with different  $\delta$  values (b) after canny filter (c) after thinning

## 4 FEATURE EXTRACTION MODULE

Any object possesses a number of discriminatory properties or features. The process of extracting these essential properties from an input image is referred to as a feature extraction or (data reduction). In the proposed system, three features extraction techniques used to extract fifteenth features and tested by fed them to the PNN. These features are the seven moments invariant values plus six color moment features which obtains by apply color moment on color master eye block and two geometrical features.

### 4.1 Moment Invariant

Moment invariants have been widely applied to image pattern recognition in a variety of applications due to its invariant features on image translation, scaling and rotation [13]. The two dimensional geometric moment of order  $(p + q)$  of a function  $f(x, y)$  defined in equation (2).

$$m_{pq} = \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} x^p y^q f(x, y) \tag{9}$$

Where

$p, q = 0, 1, 2, \dots, \infty$

N: is the number of columns

M: is the number of rows.

The moments that have the property of translation invariance are called central moments and are denoted by  $\mu_{pq}$  it is defined as in equation (10):

$$\mu_{pq} = \sum_{x=0}^{N-1} \sum_{y=0}^{M-1} (x - \bar{x})^p \cdot (y - \bar{y})^q f(x, y) \tag{10}$$

Where  $\bar{x}$  and  $\bar{y}$  are the coordinates of the centered and they are calculated using (11) and (12).

$$\bar{x} = \frac{m_{10}}{m_{00}} \tag{11}$$

$$\bar{y} = \frac{m_{01}}{m_{00}} \tag{12}$$

It can be easily verified that the central moments up to the order  $p + q \leq 3$  may be computed by the following formulas, equations (13) - (22):

It can be easily verified that the central moments up to the order  $p + q \leq 3$  may be computed by the following formulas, equations (13) - (22):

$$\begin{aligned} \mu_{00} &= m_{00} \\ \mu_{10} &= 0 \end{aligned} \tag{13}$$

$$\mu_{01} = 0$$

$$\begin{aligned} \mu_{20} &= m_{20} - \bar{x}^2 m_{00} \\ \mu_{02} &= m_{02} - \bar{y}^2 m_{00} \\ \mu_{11} &= m_{11} - \bar{x} \bar{y} m_{00} \\ \mu_{30} &= m_{30} - 3 \bar{x}^2 m_{10} + 2 \bar{x} \bar{y}^2 m_{01} \\ \mu_{12} &= m_{12} - 2 \bar{x} \bar{y} m_{11} - \bar{x}^2 m_{02} + 2 \bar{y}^2 m_{10} \\ \mu_{21} &= m_{21} - 2 \bar{x} \bar{y} m_{11} - \bar{y}^2 m_{20} + 2 \bar{x}^2 m_{01} \\ \mu_{03} &= m_{03} - 3 \bar{y}^2 m_{02} + 2 \bar{x} \bar{y}^2 m_{01} \end{aligned} \tag{22}$$

Scale invariance can be obtained by using normalized central moments  $\eta_{pq}$ , as equations (23) and (24).

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^\gamma} \tag{23}$$

Where

$$\gamma = \left\lceil \frac{(p + q)}{2} \right\rceil + 1 \tag{24}$$

A seven non-linear absolute moment invariants, calculated from normalizing central moments through order three are given as equations (25) to (32):

$$\begin{aligned} \phi_1 &= \eta_{20} + \eta_{02} \\ \phi_2 &= (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2 \\ \phi_3 &= (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - \eta_{03})^2 \\ \phi_4 &= (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2 \\ \phi_5 &= (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12}) \\ &\quad [(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] \\ &\quad + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03}) \\ &\quad [3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\ \phi_6 &= (\eta_{20} - \eta_{02}) [(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] \\ &\quad + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}) \end{aligned} \tag{25}$$

$$\phi_7 = \frac{(3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})}{[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2]} + \frac{(3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})}{[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]} \quad (32)$$

#### 4.2 Typical geometrical features

Two geometrical features are used in this research plus to moment invariant and color moment, which are aspect ratio and eccentricity. Aspect Ratio which is the ratio of image's width-to-height, it is computed by using equation (33) and eccentricity is computed by using equation (34) [14]:

$$\text{Aspect Ratio} = \frac{W}{H} \quad (33)$$

$$\text{Eccentricity} = \frac{W^2 - H^2}{W^2} \quad (34)$$

Where:

W: Width of the object, and H: Height of the object.

#### 4.3 Color moments

It is one of measures that used to extract features depend on image color, which can be used differentiate images based on their features of color. Once calculated, these moments provide a measurement for color similarity between images. These values of similarity can then be compared to the values of images indexed in a database. The basis of color moments lays in the assumption that the distribution of color in an image can be interpreted as a probability distribution. Probability distributions are characterized by a number of unique moments (e.g. Normal distributions are differentiated by their mean and variance). It therefore follows that if the color in an image follows a certain probability distribution, the moments of that distribution can then be used as features to identify that image based on color [15]. Three central moments of an image's color distribution. They are Mean, Standard deviation and Skewness. The three color moments can then be defined as following equations:

$$E_i = \sum_N^{j=1} \frac{1}{N} P_{ij} \quad (35)$$

Where

$E_i$ : can be understood as (mean), the average color value in the image.

$i$ : represent color channel at the  $j$ th image pixel as  $p_{ij}$ .

$N$ : is the number of pixel.

$$\sigma_i = \sqrt{\frac{1}{N} \sum_N^{j=1} (P_{ij} - E_i)^2} \quad (36)$$

Where

$\sigma_i$ : is the square root of the variance of the distribution.

$$S_i = \sqrt[3]{\frac{1}{N} \sum_N^{j=1} (P_{ij} - E_i)^3} \quad (37)$$

$S_i$ : can be understood as a measure of the degree of asymmetry in the distribution.

### 5 PROBABILISTIC NEURAL NETWORK

Probabilistic Neural Networks (PNN) is a kind of radial basis network suitable for classification problems, it is based upon the Bayes classification rule for decision making which minimizes the expected error of classification, also based on Parzen window estimation which estimate the probability density function (PDF) for each class based on the training samples [16]. In 1990, PNN was introduced by Donald Specht. Who was showed that the Bayes Parzen classifier, could be separated into a large number of simple processes implemented as a multilayer neural network and each of these process unit could be run independently in parallel [17]. The performance of PNN in object identification characteristics with reduced complexity, it has a very fast training speed, and the PNN can easily add new pattern neurons to pattern layer. Unfortunately PNN requires large memory because the pattern node in pattern layer is just equal to the total number of training samples, which normally depends on the sample size and substantially causing high network complexity [18].

### 6 ARCHITECTURE OF PROBABILISTIC NEURAL NETWORK

The PNN architecture is like multilayered feed forward network with four layers: an input layer, a pattern layer, a summation layer, and an output layer as shown in figure (10). It is utilize a supervised learning training algorithm [19].

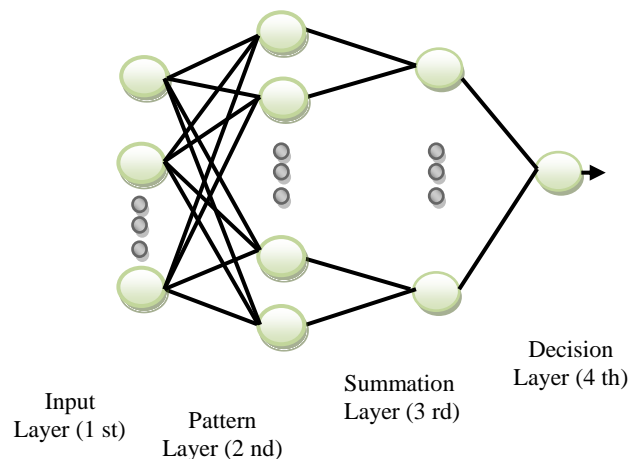


Fig. 11. PNN Structure

In the input layer which is fully connected to the pattern layer, the input features vector ( $x$ ) are distributes to all neural node in pattern layer. The pattern layer contains one neuron for each training sample. In the pattern layer, each neuron node computes the distances between the input features vector and the training samples, and produces a vector whose elements indicate how close the input to a training sample, any distance metric like Euclidean distance, squared Euclidean distance

and Manhattan distance can be used for computing the distance [20]. Each neuron performs a Gaussian function (radial transfer function) which can be simplified as follows:

$$G(x) = \exp\left(-\frac{D}{2\sigma^2}\right) \quad (38)$$

Where

- G: represent the output of a neuron pattern node.
- X: is the input features vector to be assigned into class  $C_i$
- D: is the distance between the input features vector and the pattern vector that belongs to specific class, (Euclidean distance has been used in this thesis).
- $\sigma$ : is smoothing factor

The pattern layer neurons which belong to the same class are connected to the same summation neuron node. In the summation layer, there is one neuron node for each class, sums the outputs of pattern layer for each class and produces outputs which represent the probabilities of that class (obtain and estimate probability density function of the class), as equation (39).

$$G(x) = \exp\left(-\frac{D}{2\sigma^2}\right) \quad (40)$$

Where

- $O(x)$ : the output of summation node  $i$  for class  $C_i$
- $n_j$ : the number of samples in pattern layer of class  $C_i$
- $G(x)$ : represent the output of pattern node  $i$

Finally, the output layer (decision layer) picks the maximum of these probabilities, and provides the target class for the input features vector [19], as equation (41).

$$\text{Targetclass}(x) = \text{maximum}\left(\frac{1}{n_j} \sum_{i=1}^{n_j} G(x)\right) \quad (41)$$

It remains the decision of which standard deviation  $\sigma$  to assign to the Gaussians. The value of  $\sigma$  affects the recognition results of PNN classifies, and should be chosen with care. More than one algorithm can be used to determine the range of smoothing element. In this research the minimum and maximum standard deviation value after compute the mean vector of each class are used to determine  $\sigma$  range.

In this research the description of each layer are:

1. Input Layer: consists of (15) neuron input nodes, represent the length of features vector.
2. Pattern Layer: consists of (240) neuron pattern nodes. There is one pattern node for each training sample. For each class (8) training samples, these training samples are the features vectors sequentially extracted from master eye cutouts block with its inverse and second eye block with its inverse (face in front view), master eye with its inverse (face rotate to right), master eye with its inverse (face rotate to left).
3. Summation Layer: consists of (30) neuron nodes (number of classes). Each summation node receives the outputs from pattern nodes associated with a given class, i.e. there is one neuron for each class, these neurons sum the values of the

pattern layer neurons corresponding to that class in order to obtain and estimate probability density function (PDF) of that class.

4. Output Layer: consists of one node (classes largest). As shown in figure (12).

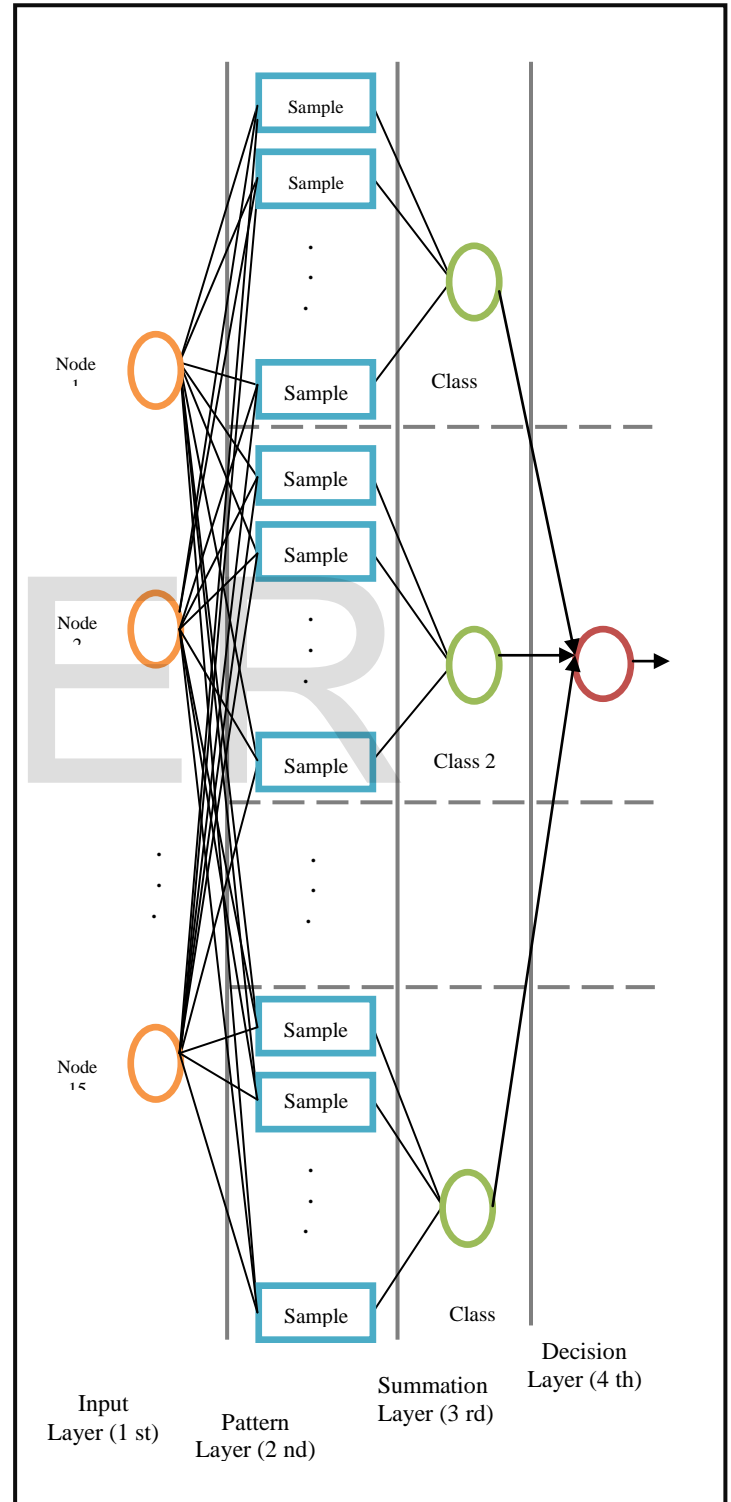


Fig. 12. The Design of PNN of this work



## 7 DATASET

The dataset that collected from 30 volunteers consists of different samples; ten samples for each person. The images were taken with varying of pose, orientation (tilting and rotation about to 30 degrees in two directions left and right), and expressions (surprising, sadness, look up/down and smiling/non-smiling). Not all images are taken with the same background; the face is in frontal position. The face images are a BMP 24 bit/pixel (bit depth), the size of each image used is 320×500 pixels. For training purpose, training face image set which refers to a set of entire face images extracted from the dataset to be used for training neural network, the training set is used to generate training pattern set, three samples for each person is used (front view, rotate to left and rotate to right) to extract master eye cutouts block with its inverse and second eye with its inverse from front view sample, and master eye cutouts block with its inverse form sample rotate to left and sample rotate to right. So the total number of cutouts block that used in the pattern layer is (8) for each person.

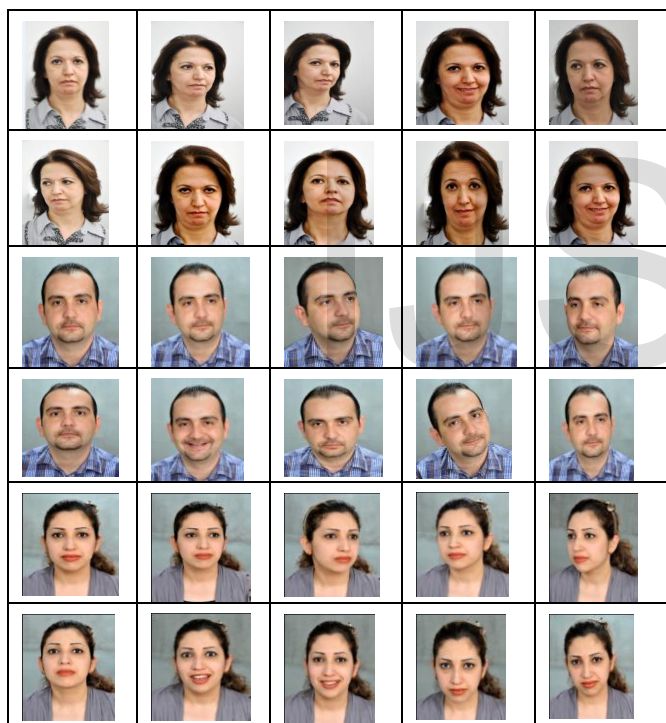


Fig. 13. some face images chooses from the dataset

## 8 EVALUATION CRITERIA

To test the performance of the established face recognition system, first it is tested on the training samples and then on testing samples. The analysis was aimed to find out the best set of system parameters that led to best recognition rate upon the training set of samples. the evaluating performance of the system is calculated by two measures called False Alarm Rate (FAR) and Recognition Rate (RR). The formula for calculating these measures are given as in equations (42) and (43) respectively.

- **FAR:** is defined as the ratio between the numbers of false recognition decision to the total number of attempts.

$$FRR = \frac{\text{Number of false recognition attempts}}{\text{Total number of attempts}} \times 100 \quad (42)$$

- **Recognition Rate:** is defined as the ratio between the numbers of correct recognition decision to the total number of attempts.

$$RR = \frac{\text{Number of correct attempts}}{\text{Total number of attempts}} \times 100 \quad (43)$$

The features vectors for all persons are determined during the enrollment phase and stored in a dedicated database (file); such that each features vector is stored with the person number (class number and sample number) for example (C1\_S3). Each sample is preprocessed starting with get RGB, skin color modeling, applying median filter with kernel size (3×3) and algorithms to localize and extract face clip, then applying the following control parameter: (1) Gaussian filter using  $\sigma$  equal to 0.8 and kernel size (3×3), (2) convert to gray scale with threshold equal to 140, (3) contrast enhancement using sigma equal to 9, (4) canny edge detection with minimum threshold equal to 40 and maximum threshold equal to 200, (5) finally applying thinning algorithm.

This set of control system parameters may affect the recognition behavior of the proposed method. The most effective parameters are the followings:

**TABLE 1**  
DIFFERENT SIZE AND VALUES OF GAUSSIAN FILTER PARAMETER WITH FIXED VALUES OF OTHERS PARAMETERS

Recognition Rate							
Control Parameter		Evaluation Criteria					
Gaussian Filter		Training			Testing		
$\sigma$	Kernel size	Total Attempts	False Attempts	RR	Total Attempts	False Attempts	RR
0.5	3×3	90	12	86.6%	210	60	71.4%
0.8	3×3	90	0	100%	210	24	88.5%
1	5×5	90	8	91.1%	210	45	78.5%

in this set of tests the thresholds of convert to gray scale, maximum and minimum thresholds of canny edge and contrast sigma is kept fixed.

**TABLE 2**  
**DIFFERENT THRESHOLDS PARAMETER OF GRAY SCALE**

Recognition Rate						
Threshold	Evaluation Criteria					
	Training			Testing		
	Total Attempts	False Attempts	RR	Total Attempts	False Attempts	RR
110	90	21	76.6%	210	79	62.3%
120	90	10	88.8%	210	49	76.4%
130	90	7	93.3%	210	41	80.4%
140	90	0	100%	210	24	88.5%
150	90	8	91.1%	210	56	73.3%
160	90	15	83.3%	210	64	69.3%

in this set of tests the sigma of Gaussain filter and kernel size is fixed, also, the maximum and minimum thresholds of canny edge and contrast sigma is kept fixed.

**TABLE 3**  
**DIFFERENT SIGMA OF CONTRAST ENHANCEMENT**

Recognition Rate						
Contract Sigma	Evaluation Criteria					
	Training			Testing		
	Total Attempts	False Attempts	RR	Total Attempts	False Attempts	RR
1.5	90	17	81.1%	210	59	71.9%
8.5	90	5	94.4%	210	34	83.8%
9	90	0	100%	210	24	88.3%

in this set of tests the sigma of Gaussain filter and kernel size is fixed, also, the maximum and minimum thresholds of canny edge and thresholds convert to gray scale is kept fixed.

**TABLE 4**  
**DIFFERENT THRESHOLDS OF CANNY EDGE DETECTION**

Recognition Rate		
Control Parameter	Evaluation Criteria	
	Training	Testing
Thresholds		

Min	Max	Total Attempts	False Attempts	RR	Total Attempts	False Attempts	RR
40	100	90	29	67.7%	210	92	56.1%
40	150	90	14	84.4%	210	59	76.8%
40	200	90	0	100%	210	24	88.5%
40	210	90	9	90%	210	49	76.6%
10	200	90	12	86.6%	210	56	73.3%
30	200	90	6	93.3%	210	39	81.3%
60	200	90	14	84.4%	210	64	69.5%
80	200	90	21	76.6%	210	77	63.3%

Also, in this tests, all other parameter is kept fixed.

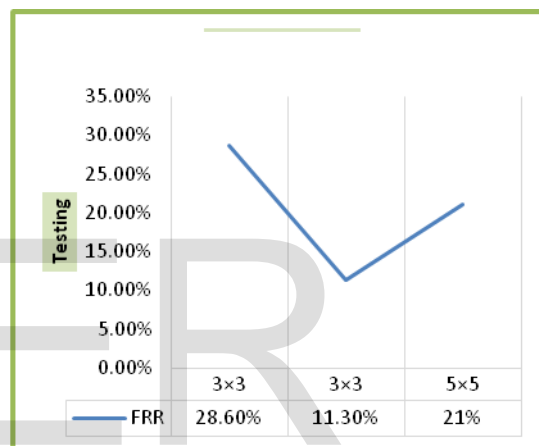


Fig. 14. The effect of applying Gaussian kernel on FAR

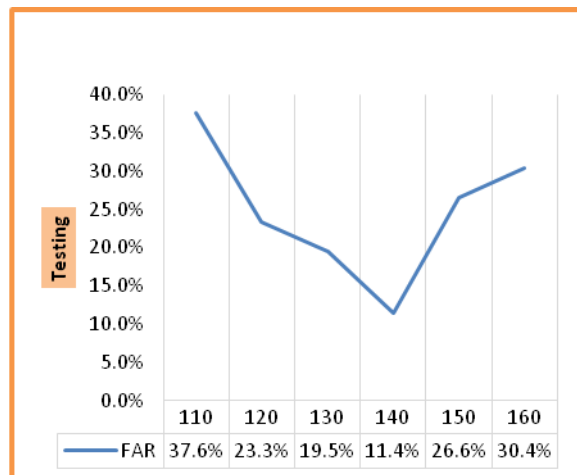


Fig. 15. The effect of converting to Gray Scale on FAR

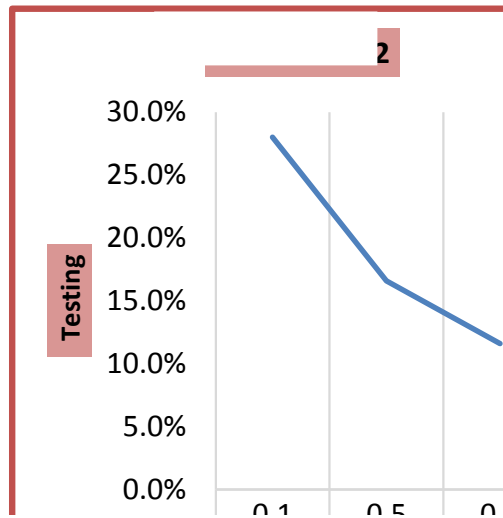


Fig. 16. The effect of Contrast Enhancement on FAR

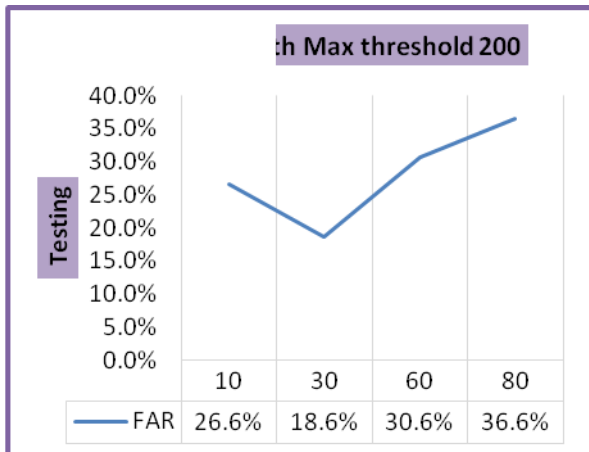
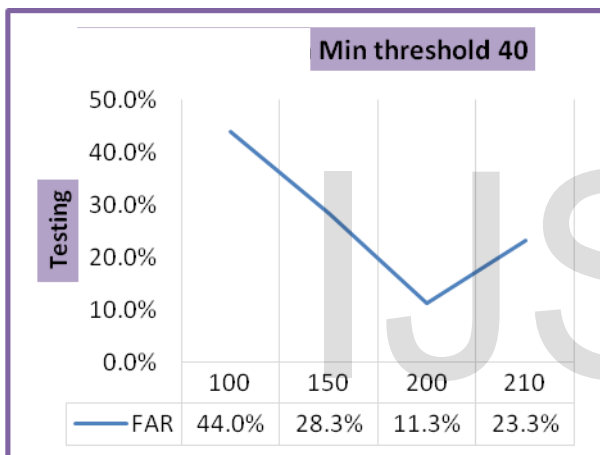


Fig. 17. The effect of Canny Edge Detection on FAR

## 9 CONCLUSIONS

Some important conclusions can be drawn from this work:

1. For face detection stage based on color features; indicate that the use of HSV color space for skin color modeling led to higher detection results.
2. The proposed algorithms for localize and extract face clip shows best result; even though the variant of pose, orientation and expression.
3. If lighting conditions are not controlled there will be some shadow on the face, which makes face detection process difficult, thus when an image is picked there should not be any shadow on the face (controlling lighting conditions).
4. The proposed algorithms for detect and extract master and second eye cutouts block from the face clip shows best results; even though the variant of pose, orientation, and expression.
5. The results of the conducted tests on data set samples indicated that the best achieved recognition rate occurred when using: The value of control parameters are: kernel size of Gaussian filter equal to (3x3) and its sigma equal to (0.8), threshold of gray scale equal to (140), sigma value for contrast enhancement equal to (9), and finally the value of maximum and minimum thresholds of canny filter are equal to (40) and (200).
6. This work has demonstrated that the effect of control parameters is indeed a practical solution to generate proper features vector from feature extraction stage.
7. The work presented achieves 88.5% recognition rate.

This work can be extended in different directions. In the followings some suggested ideas are given:

1. Partitioning the master eye cutouts block as matrix 3x3, compute the moment invariant for each cell in the matrix and make feature analysis to obtain the best features which lead to best recognition rate.
2. Trying to detect and extract mouth and nose blocks cutouts plus eye block and applied the same features extraction techniques to obtain three features vectors, make features analysis to obtain (features have better discrimination power) that fed to the PNN with same structure to improve the recognition rate.
3. Trying to use face images with size larger than one used in this work, for possibility of obtain the iris trait and use it for extract more discriminations features vectors to improve the recognition decision.

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