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Research paper

An efficient Real Time Multi View Face Recognition System

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Abstract

In recent years, the biometrics environment has received considerable attention at the global level. One of the most important biometrics is the face recognition. Viola and Jones algorithm is used for front face detection. Facial side images detected through the skin detection methodology. For features extraction step, Histogram oriented gradient (HOG) algorithm is used. This paper suggested using Raspberry pi3 platform in the real time multi-face recognition system to connect three cameras. In the recognition step, Support Vector Machine (SVM) used and compared with the performance of the principal component analysis algorithm (PCA). The system is tested on multiple images of the FEI database.

Keyword: *Face Recognition, Euclidean Distance, Viola and jones's, HOG, PCA.*

1. Introduction

Analysis of human faces is very challenging research area, and it was gain much attention during the last years. The face recognition used in law enforcement and commercial crowd surveillance applications ,such as surveillance systems, smart homes, or any application deals with identifying people from images or videos[1] [2] .The art of recognizing human face is completely difficult as it is exhibits the characteristics like the variations in expressions, pose or even occlusion [3]. All of these variation affected on Feature extraction step in face recognition operation [4] .Feature representation have to performed well to maximize the difference between persons [4].

The proposed methodology implemented into two stages face detection and face recognition [5]. Different techniques used for face recognition. Among those, Neural Networks, Algebraic Moment, Elastic Template Matching, Local Binary Pattern, Principle component analysis [6] . For the fast detection step the Viola and Jones algorithm used, by using rectangular features that can be computed from the integral image [7]. Since the human face identified by the detection step, the relevant features are extracted from facial image [8].

This paper foxes on comparing between two methods in the recognition step. The front view face detected by the Viola and Jones algorithm. While the right and left sides views faces detected using skin color detection. Then the two use the same feature extraction algorithm (HOG) to the multi view system for face recognition. The Principle Component Analysis (PCA) algorithm moreover, Support Vector Machine (SVM) algorithm used again for the recognition step. All this steps implemented by MATLAB programing language. The three images captured by three cameras connected to raspberry pi3 when the ultrasonic sensor sensed the motion. The capturing steps and the sensing implemented by PYTHON programing language in the raspberry pi3.Then the three images send to the PC by the TCP/IP protocol using three port and specified IP .The images receiving done by JAVA programing language in the PC. Section 1displayed the recent techniques. In section 2, we describe our methods working. Then in section3, the experimental results displayed.

2. Related Works

In [1], the author proposed automatic face detection system by using Deformable Template algorithm. The Eigen faces approach utilized for face recognition and the recognition rates 73% achieved. In [2], proposed new approach by using of three appearance based stastical methods principle component analysis (PCA), Independent component analysis (ICA) and Linear Discriminant Analysis (LDA) algorithms for face recognition and the performance measurement evaluated between them. In [3], generated side view image from 2D face image by creating mirror image. For the detection phase, the Viola and Jones algorithm is used and Local Binary Pattern for feature enhancement is utilize. In [5], the author proposed facial expressions recognizer system. For region of interest detection, the Viola and Jones algorithm is used. In addition, for features extraction Histogram Oriented Gradients (HOG) is used. To make dimensionality reduction ICA, LDA or PCA used. In [6], proposed implementing the system in two stages. Detection by Viola and Jones algorithm is the first stage. Moreover, for face recognition PCA with feed forward Neural Network used in the second stage. The BIO ID Face-Database used to test the system. In [7], for the face, recognition used Support Vector Machine (SVM) and Eigen faces algorithms for the front view image, and Support Vector Regression implements the Pose estimator for face detection. In [8] the author proposed using Viola and Jones algorithm for the detection step and fusion of principle component a Principle Component Analysis and Artificial Neural Network for the recognition step. In [9] the author proposed using a skin detection method as a primary step, and made comparison between different color spaces to explore it is effect on the detection by using Multi-layer perceptron spaces Neural Network MLP. In [10] the author proposed outdoor security system by using the raspberry pi for door unlocking and the GSM to send the security alert. For the face recognition and detection PCA used through video camera controlled by the Raspberry pi.

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3. Proposed System

The proposed method implementation used efficient techniques for face detection and recognition, which is independent with the variations in features like expressions, hairstyle and using of the glasses on the eyes. The proposed system consists of two parts the client and the server. The client part consist of hardware components, Ultrasonic, Raspberry pi3, PC and three cameras as shown in the Figure 1.

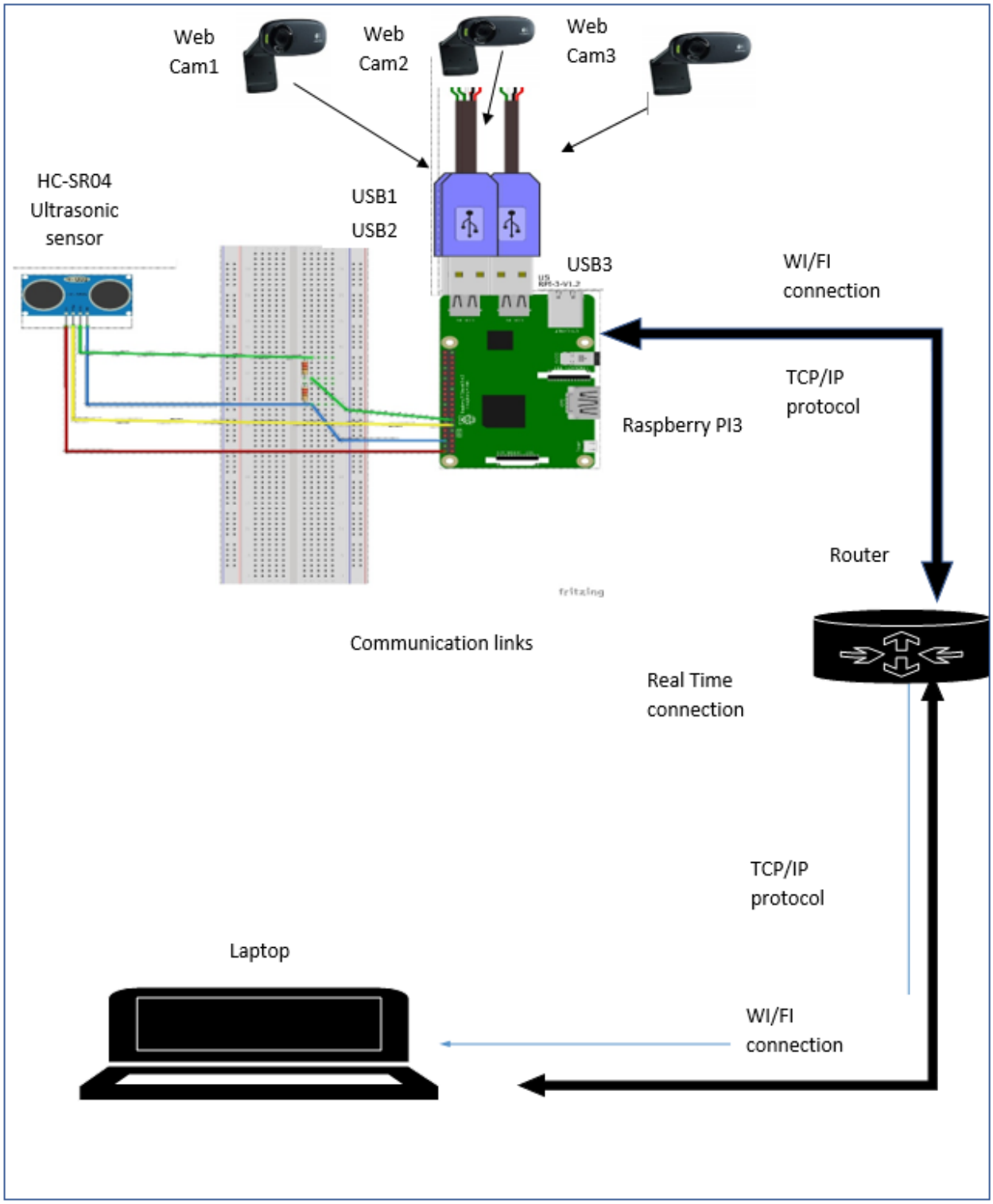


Figure 1: The Proposed System Diagram

3.1 The Client Part

It is consist of Raspberry pi3 interfacing with HC-SR04 ultrasonic sensor. The raspberry pi3 used to connect the three cameras to the system. In addition, HC-SR04 ultrasonic sensor used to sense the new person presence in front of the cameras to take pictures. The HC-SR04 ultrasonic sensor device used for measuring the distance to an object by the sound waves the shown in the Figure (2). It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object. Since it is known that sound travels through air at about 344 m/s (1129 ft./s), you can take the time for the sound wave to return and multiply it by 344 meters to find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes

the 'trip' from the sonar sensor to the object AND the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced Distance=speed of sound × time taken÷2 off the object). To find the distance to the object, simply divide the round-trip distance in half.



Figure 2: The HC-SR04 Ultra sonic sensor

The Ultrasonic sensor have to be interface to Raspberry Pi3.Since the Raspberry Pi3 works at 3.3V while the HC-SR04 Ultrasonic Sensor works at 5.So the connection needs to use two series resistance .The Raspberry Pi3 have to read the Echo pin to calculate the time. The GPIO 27 pin on the Raspberry Pi must be configured as Input. Therefore, the Trigger Pin of the HC-SR04 Ultrasonic Sensor connected to GPIO 17 pin of the Raspberry Pi3.The +5V and GND provided to connect the Ultrasonic Sensor from the Raspberry Pi3 Pins. A voltage divider consists of two resistors (R1 and R2) in series connected to an input voltage (Vin), which needs to be reduced to output voltage (Vout). In our circuit, Vin will be ECHO, which needs to be decreased from 5V to our Vout of 3.3V. A combination of 470Ω and 330 KΩ Resistor used to convert the Echo pin to 3.3V Logic (approximately). A simple calculation program is written in Python to detect the HIGH on Echo Pin and produce an equivalent distance.

$$VO=R1\div R1+R2\times Vin,\ VO=470\div 470+330\times 5=2.9\ V=3V$$

The Fig.3 shows the voltage divider connection and Figure (4) shows the Raspberry pi3 interfacing with the HC-SR04 Ultra sonic sensor.

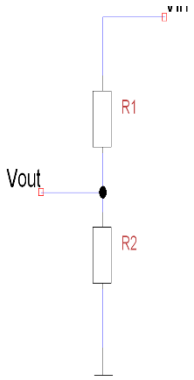


Figure 3: The resistance connection

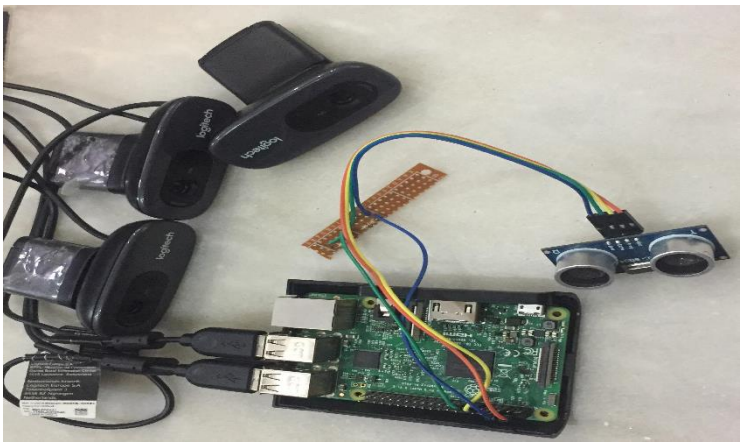


Figure 4: The Raspberry pi3 interfacing

The three cameras still open for a half hour until the ultrasonic sensor sensed the human motion. Then it take pictures to the human face in JPG format type to resultant high-resolution pictures. The three images send to the PC using the raspberry pi3 Python program. By the TCP/IP protocol, the three images are send as stream of bits. The port1 (11000), port2 (12000) and port3 (13000) for the PC and it specified IP address used in the sending process .WI/FI used to making PC receive from raspberry pi3 the detected face images by using Java program. Moreover, make raspberry pi3 and PC connected with the router.

3.2 The server part

It is consist of set of steps shown in the Figure (5).The listener used to listen for new pictures and load it automatically in the system. The pictures will be displayed for a half hour with the date of the capture. Until new picture come then the old pictures will be deleted .The incoming three images to the PC converted from RGB color space to grey color space. Because the grey level have one channel of color and this reduced the number of bit that represent the image leading to made the processing more easy as shown in the Figure (6) the face image for FEI data set and in Figure (7) one of the persons that took part on the system testing . The front view face image pass to Viola Jones detection algorithm and the side view pass to skin detection method. Moreover, the features will be extracted and finally, the three images will be recognized as follows.

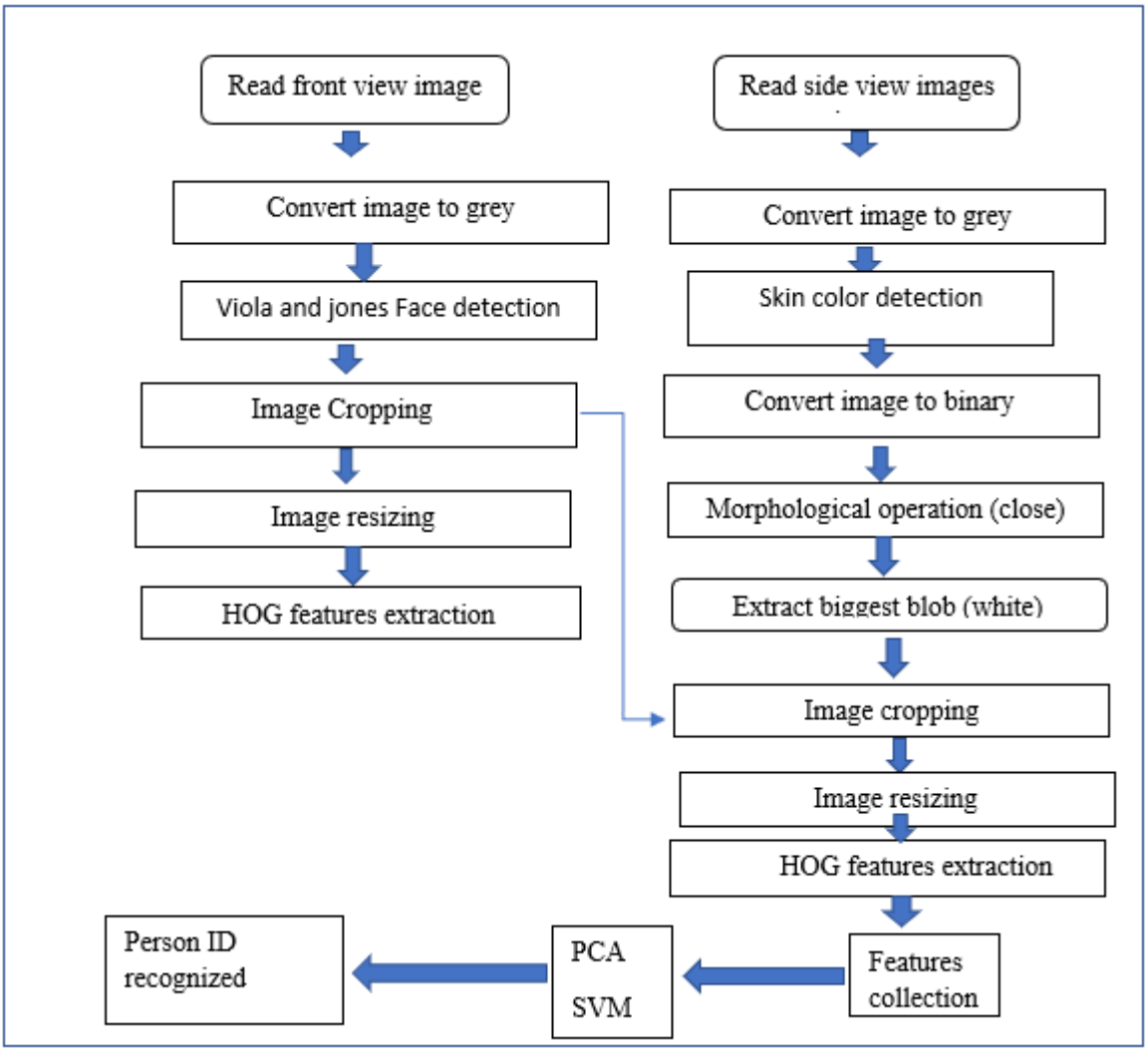


Figure 5: The server part structure



Figure 6: The front image and one of the lateral image

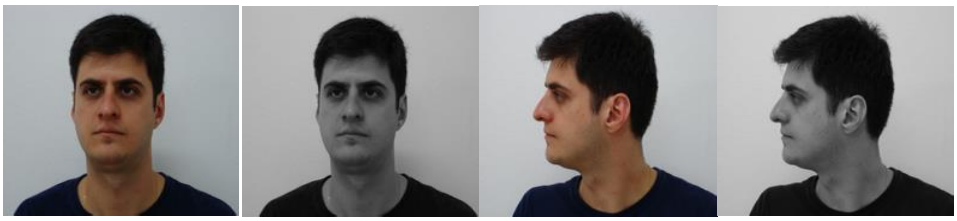


Figure 7: The front image and one of the lateral image

The server part is executed in several steps as follows:

3.2.1 Viola and jones frontal face detection

For the front view image, the detection implemented by Viola Jones algorithm. It is more effective, and is can cope with 45˚ face rotation for both around the vertical and horizontal axis. As it known, there is some similarities in human faces. The concept to detecting the face from the front view camera. If this features found in the image the algorithm pass the candidate to the next stage. Which this candidate is not whole the image but sub window have specific size. Viola Jones algorithm works in four stages Haar features, creating an integral image Adaboost learning and cascade classifier. The detection for each object shown by (bounding box on identified object) as shown in Figure (8) for FEI database and Figure (9) for the person involved in the test of the system.



Figure 8: The front face detection

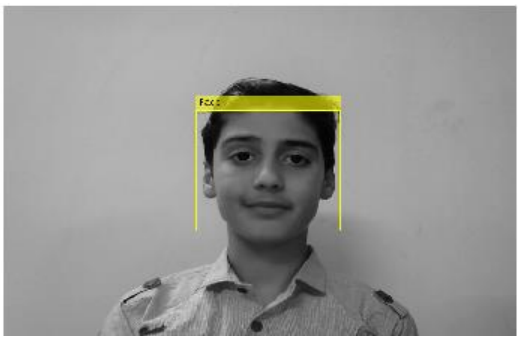


Figure 9: The front face detection

3.2.2 Side view face detection

Side view detection in proposed system on skin color detection depend on Ycbcr color space. The criteria of detection skin is as follow the luminance (Y) should be greater than (eighty) the (CB) band should be greater than eighty five and less than 135.While (CR) band should be greater than 135 less than 180. Has high separation of chrominance and luminance component make it high efficient in skin detection. The skin color map used on chrominance components of the input image for detecting pixels that seems to be skin. The skin-color reference map are:

$77 \leq Cb \leq 127$ and $133 \leq Cr \leq 173$

Skin detection helps in human torso, limbo or face skin detector and it proved to be useful and robust method for face detection as shown in Figure (10) and (11).

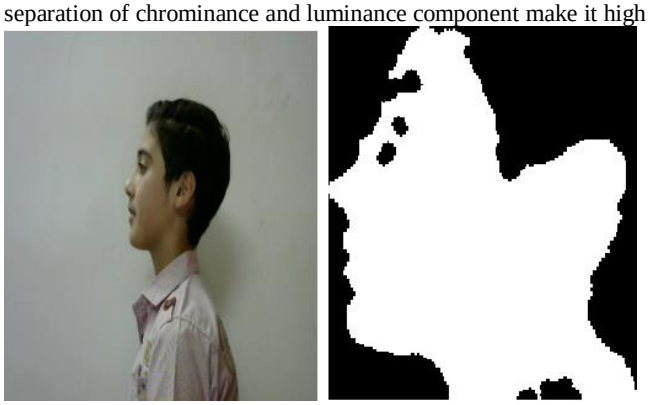


Figure 10: The side face detection



Figure 11: The side face detection

3.2.3 Objects Cropping

The size of captured image in three camera (left, right and front) is 640 ×480 .The detected face cropped in size 167×167 and resized to 128×128 pixels .The side view detected face depend on skin color detection. In addition, the coordinate of face in the front view. There are post processing on skin color to front only face skin. These steps done on binary mask result from skin detection operation. Close morphological operation apply on the mask and find the biggest blob that present on the side view face. Depend on last mask (biggest blob) the original image will cropped and resized to (128×128) as shown in Figure (12) and (13).

3.3 HOG features extraction

Extract HOG features from each cropped and resized object. Where main features of the face are identified by Voila-Jones algorithm marked by a bounding box from the previous step. HOG algorithm is very simple to understand because it is used to extract ”global” feature rather than “local” features and it represented the entire person by a single feature vector. HOG is extracted 8100 features from each image; this number depends on the image dimensions. The summation of all images features will be 24300. Then collect all features from the front and the side view image separately to store them in the features database. Then the image pass through two algorithms, once across PCA and another in SVM .To making classification and recognition step.



Figure 12: Image cropping



Figure 13: Image cropping

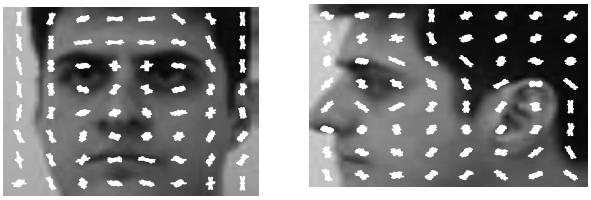


Figure (14): Image cropping

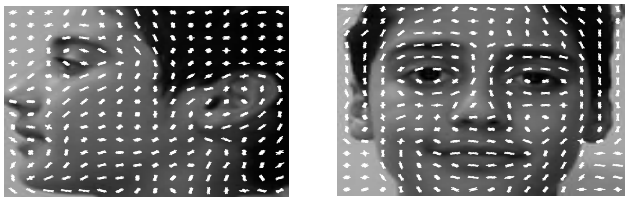


Figure (15): Image cropping

3.4 Dimension Reduction by principle component analysis (PCA)

Face recognition for the three sides' images executed once by PCA algorithm, and again by support vector machine (SVM) to compare the performance for both cases. Feature reduction and classification step done by PCA .Which one of mathematical procedure It is reduce the features value dimensionality that contain many variables correlated with each other to uncorrelated variables called the Eigen faces. The PCA retain the maximum variation that present in the original components [2]. After determining Eigen faces each image in training set will be represent by a linear combination of Eigen faces and can represented as vectors. The input image features will compared with all features in the database for recognition result. Moreover, the decision will made by Euclidean Distance

3.5 Classification and recognition by multi Support Vector Machine (multi SVM)

To train our SVM algorithm, we formulate the problem in a difference space, which explicitly captures the dissimilarities between two facial images. In difference space, we are interested in the following two classes: the dissimilarities between images of the same individual, and dissimilarities between images of different people. These two classes are the input to a SVM algorithm. A SVM algorithm generates a decision surface separating the two classes. For face recognition, we re-interpret the decision surface to produce a similarity metric between two facial images. This allows us to construct face-recognition algorithms .To provide a benchmark for comparison, we compared our algorithm with a principal component analysis (PCA) based algorithm.

4. Testing and Training stage the system in the offline

To evaluate the performance of face detection and recognition the FEI face database.are used [9]. It is a face database in Brazil, includes a group of face images. Which have tacked from June 2005 to March 2006, at the Artificial Intelligence Laboratory of FEI located in São Bernardo do Campo, São Paulo, Brazil. In this dataset, there are (10 images) belong to each one of (50 persons), with 500 images as a total to detect human face. Fifty views images used for each 20 person to testing the performance of the method. For the training stage, twelve images used as a total, three images from front, left and the right side for each person. In addition, three image used for the testing in each direction for each person. The original image size is 200×200, the face detected by the previous detection methods. Then each image resized by 64×64 pixels and the features extracted by the HOG. The accuracy achieved 90% for PCA and 95% for SVM.

4.1 Testing and training Stage the system in the real time

In this step, new data set built to operate the system in a real time. It consist of ten people each one picked up to him sixteen pictures as total for the training for each person. Twenty face images from front, left and right direction. The picture size (640 ×480) BMB type. The camera used to build the database is Logitech C270 HD Web camera as shown in Figure (1). At first, the system will get the input image then the face will be detect by using viola and jones algorithm for the front view image and skin color detection method for the two side views images. The next step is cropping each face image and resizing by 128×128 pixels. Then Extract the HOG features for each detected object. The reduction in size made ones in PCA and again with SVM .In the PCA algorithm produce the covariance matrix and put the features in one vector. The last step is comparing between extracting vector from tested images and all the vectors that stored in database. By using the Euclidean distance algorithm, the minimum distance produced. In addition, this leads to returning the person ID.

4.2 Experimental Results

The proposed system implemented using MATLAB 2017 and the tests conducted on a HP PC with core i7 processor. The first step detect the front view face by viola and jones algorithm. In addition, the side view image detected by the skin color. The side view image cropping depends on the front face length, and the side view biggest blob image coordinates are measured. Then the images cropped and resized by 128×128 to make all images have the same size. The features numbers from each image is 8100 depending on the image size. It extracted by the HOG algorithm. The summation of the features will be 24300. Moreover, all the features from training images is stored in data base to be compared with the input image and for make the features reduction and recognition step by PCA once and the classification and recognition by SVM another time. The features reduction helps for increase the system processing speed. Each person have 20 views for each side, for 10 persons the number of images will be 60×10=600 for the training stage. The incoming three input images from the client passed into the same steps for training images and their features compared with the features stored in the database. The covariance matrix for PCA will be reduced the size of features for training images to [600×600] instead of [600×24300].The returned person ID depends on the minimum distance between features measure by Euclidean distance algorithm. Moreover, the tested images features passed to SVM algorithm to produce the recognition ID result.
In Figure (16) displays the images entering the system and the result of the distinguished person represented by its ID.
The result evaluated for the FEI database and for the ten peoples in real time as shown in the Table (1) and Table (2) by changing the detected face size for the three images. This leads to change the features number by HOG algorithm. Then the accuracy rate for the recognition effected by the PCA and SVM once again.

Table (1): FEI data set result

Image Size	Features number	Accuracy in PCA	Accuracy in SVM
32×32	1764	80%	95%
48×48	2700	85%	95%
64×64	5292	90%	95%

Table (2): Real time result

Image Size	Features number	Accuracy in PCA	Accuracy in SVM
64×64	1764	73%	89%
96×96	4356	81.23%	91.4%
128×128	8100	87%	92.12%

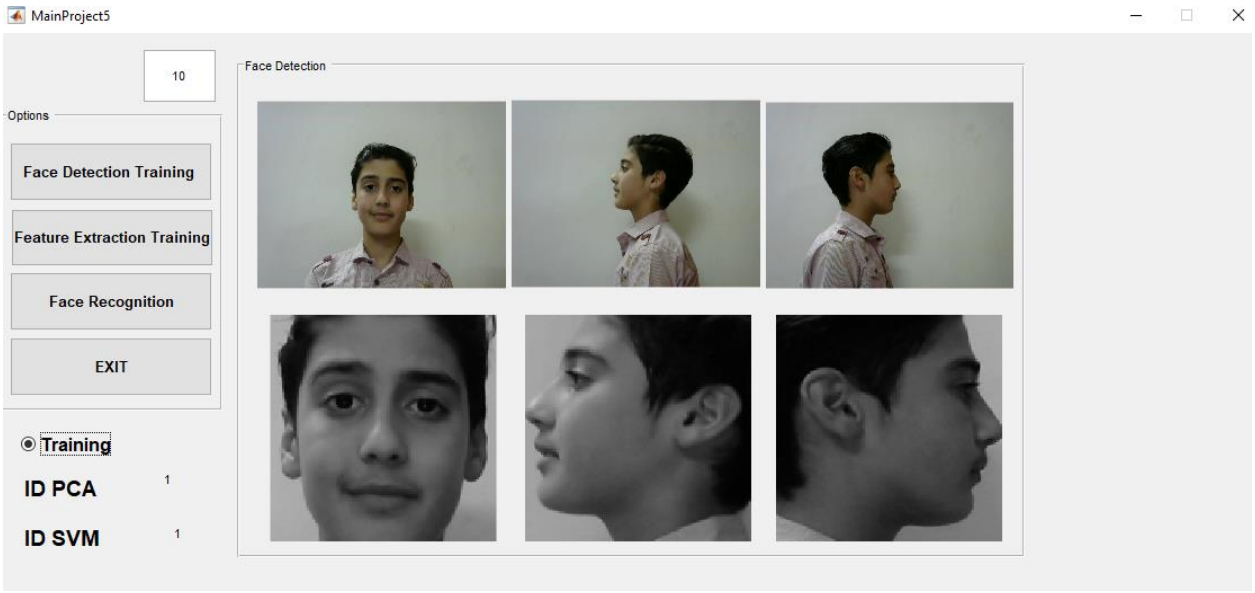


Figure (16): The test image ID.

5. Conclusion

The purpose of this project is to implement the Viola and Jones face detection algorithm and to obtain reasonable performance. The results that we are test meet our expectations. In terms of the processing time of our final detector, or for feature extraction time. Surprisingly the time bottleneck are not at the AdaBoost learning phase but the Haar-like rectangular feature extraction phase. The methods was evaluated in MATLAB environment using 300-image containing multi views for 20 person from FEI data base for the testing and training. The highest accuracy rate obtained 95% in SVM method when the image size 64×64. Moreover, 90% for in PCA recognition method for 20 consecutive trials. The using of Euclidean distance is very efficiency and increase the speed of matching with the database.

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