

# Implementing Facial Recognition by Interfacing MATLAB Along with Arduino

E. Ramkumar, T. Guna, S.M. Dharshan, V.S. Ashok Ramanan

*Abstract: Facial recognition has become one of the recent trends in attracting abundant attention within the society of social media network. The face is flat and therefore needs plenty of mathematical computations. Facial knowledge has become one in every of the foremost necessary biometric, we tend to witness it from the day-to-day gadgets like mobile phones. Every transportable electronic device currently being discharged includes a camera embedded in it. Network access management via face recognition not solely makes hackers just about not possible to steal one's "password", however conjointly will increase the user-friendliness in human-computer interaction. For the applications of videophone and conference, the help of face recognition conjointly provides an additional economical secret writing theme. Face detection technologies are employed in an oversized kind of applications like advertising, diversion, video secret writing, digital cameras, CCTV police investigation, and even in military use. Totally different algorithms are used for biometric authentication. The Kanade-Lucas-Tomasi rule makes use of abstraction common intensity transformation to direct the deep explore for the position that shows the simplest match. Another common face detection rule is that the Viola-Jones rule that's the foremost wide used face detection rule. It's employed in most digital cameras and mobile phones to notice faces. It uses cascades to notice edges just like the nose, the ears, etc. Hence, during this paper, we've got planned the Viola-Jones rule because the best one supported our application. The rule is employed within the biometric authentication of individuals and also the pictures are kept during processing. The kept information is employed for recognizing the faces and if the information matches, an impression signal is given to the controller. The MATLAB software is employed to relinquish control signals to the motor, which is employed for gap and shutting the door. The input image is fed by a digital camera and also the image is processed within MATLAB. The output is given to the external controller interfaced with MATLAB. The image process field has several sub-fields, biometric authentication is one in each of them because it gains additional quality for security functions these days. The planned system can be employed in residential buildings, malls, and industrial sectors. Thus, this technique is helpful for homemakers to be safer in their homes.*

*Keywords: mobile phones, biometric authentication, monitoring, biometrics, controller, MATLAB, homemakers.*

## I. INTRODUCTION

The face is the most ordinarily used biometric to acknowledge folks.

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Face recognition has received substantial attention from researchers, thanks to human activities found in numerous applications of security like associate degree field, criminal detection, face trailing, forensic, etc. Compared to different biometric traits like palm print, iris, fingerprint, etc., face bioscience is often non-intrusive. The data can be taken even without the user's knowledge and any are often used for security-based applications like criminal detection, face trailing, field security, and rhetorical police investigation systems. Face recognition involves capturing face pictures from a video or a police investigation camera. They're compared within the available database. Facial-recognition involves the training of pictures, classify them with noted categories and then they're kept within the database. Once a take a look image is given to the system it's classified and compared with the database. The data associated with the facial features could be a difficult field of analysis with numerous limitations obligatory for a machine face recognition like variations in the head cause, amendment in illumination, countenance, aging, occlusion thanks to accessories, etc., numerous approaches were steered by researchers in overcoming the restrictions expressed. Automatic face recognition involves image acquisition, feature detection, extraction, and recognition.

The securities presently become an awfully necessary issue and this is often why loads of security systems are purpose victimization. A very important method like recognition particularly for building access controls [1]. The advantage of victimization face recognition rather than different identification processes like iris or fingerprint identification is as a result of it was absolutely least intrusive and safer. The method is started 1st by taking the input image which might be observed as a guide. This guide is compared to the guide within the available database, and if the guide matches at intervals a group tolerance, access can solely be granted if the matching options between each templates area unit at intervals the set of tolerance.

## II. VIOLA-JONES

The Viola-Jones formula is meant for the detection of faces from a picture. Its performance is obtained by Haar sort options, computed speedily by using integral pictures, feature choice exploitation of the AdaBoost formula (Adaptive Boost) associated face detection with a basic cognitive process cascade. The Viola-Jones object detector uses Haar-like options, that area unit corresponding to Haar basis functions, to coach the stage classifier for the cascaded classifier.



The Haar-like options area unit is predefined and computed directly on the integral image of the grey image.

## A. Feature Calculation

Starting from the common characteristics of the faces, such as the region around the eyes is darker than the cheeks or the region of the nose is brighter than those of the eyes, five Haar masks (Fig. 1) were chosen for determining the features, calculated at different positions and sizes. Haar features are calculated as the difference between the sum of the pixels from the white region and the sum of the pixels from the black region.

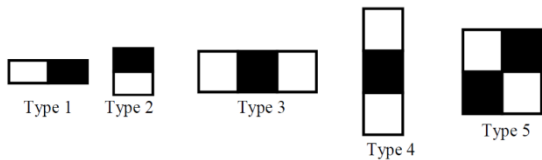


Fig. 1. Haar masks used

$$\sum_{1 \leq i \leq N} \sum_{1 \leq j \leq N} I(i,j)_{white} - I(i,j)_{black} \quad (1)$$

The features are extracted for windows with the dimensions of 24x24 pixels, which are moved on the image where we want to detect faces. For such a window, Haar masks are scaled and moved, resulting in 162,336 features [2]. To reduce the computation time of the Haar features, which vary depending on the size and type of the feature, the integral image was used. Fig. 2 is illustrated how an original image is obtained as the integral one and how it computed the sum of pixels within a rectangle region using an integral image.

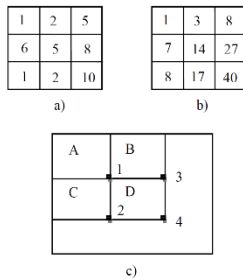


Fig. 2. Haar Internal Image: a) Original Image I; b) Internal Image II; c) Pixel computation from the region D using internal image

For the pixel  $(i, j)$ , the integral image  $II$  contains the total of the pixels on top of and to the left of  $(i, j)$ , inclusive:

$$II(i, j) = \sum_{1 \leq s \leq i} \sum_{1 \leq t \leq j} I(s, t), \quad 1 \leq i \leq N, 1 \leq j \leq N \quad (2)$$

The total worth of the pixels among the rectangle is calculated with four array references. The results of the integral image at location one is that the total of the pixels in rectangle A. the worth at location two may be  $A + C$ , at location three may be  $A + B$ , and at location four may be  $A + B + C + D$ . The total among D is computed as  $4 + 1 - (2 + 3)$ .

## III. KANADE-LUCAS TOMASI

### A. Algorithm

This algorithm is employed in feature extraction. The algorithm avoids tracing of pixels within the ensuing image, and among a given foreground object, only a restricted set of

feature points are tracked. Objects solely on a restricted set of feature points are tracked. Kanade-Lucas Tomasi (KLT) methodology has been as a basis for several algorithms. KLT has been used for the full set of options rather than following every feature individually. This algorithm is employed for human faces from a captured video frame. Foremost we tend to calculate the displacement of tracked points from one frame to a different frame [3]. This displacement calculation is simple to figure out for a person's head, then the feature points of an individual's face are tracked.

### B. Feature Tracking

The KLT tracks an object in two steps. It locates the traceable options within the initial frame, then tracks every one of the detected options within the remainder of the frames utilizing that its displacement. The displacement of the precise feature is then outlined because the displacement minimizes the total of variations. This is often done unendingly between serial pictures so all the options can be half-track. Kanade-Lucas Tomasi algorithmic rule uses spatial intensity information to guide the position yielding almost the foremost correct match [4]. It's a lot faster than standard ways for checking lesser probable matches between the images.

Table 1. Comparison of Viola Jones and KLT Algorithm

Looking Directions	Viola – Jones	Kanade-Lucas Tomasi
Straight	97%	90%
Up	80%	80%
Down	80%	80%
Left	90%	85%
Right	88%	83%

## IV. PRINCIPAL COMPONENT ANALYSIS

### A. PCA Algorithm

PCA or principal component analysis algorithm is one of the most effective techniques that have been used in the section of image compression. PCA is one of the statistical methods which is used as a biometric technique. Karl Pearson, an important and famous mathematician, created PCA in 1901. PCA is used in creating predictive models such as face recognition and in the exploratory data analysis system. PCA functions reduce the dimensions of the transformed data. It is accomplished by using simple principle components that can give the user a picture of the requested data but in smaller shadow-like images. PCA can be done by two main procedures [5]. The first is achieved by decomposition of the eigenvalue of a data covariance. On the other hand, the second method is done by decomposition of a singular value of a data matrix. In PCA, the training face vectors in a set of eigenfaces are computed by performing singular value decomposition (SVD) of the sample covariance matrix,  $C$  defined by

$$C = \sum_{i=1}^M (x_i - \mu)(x_i - \mu)^T \quad (1)$$

where  $\mu$  is the mean of the face sample set [6]. Since each eigenvalue represents the total variance in its dimension, we only need to retain the eigen vectors having the large eigen values.

$$w = U^T(x - \mu) \quad (2)$$

These weights act as points in the face space where classification is carried out. This approach has been a basis by many face recognition techniques but is limited to second-order dependencies and rely on only single level representation.

### B. DPCA Algorithm

In DPCA the approach applies a deep structure by hierarchically learning from layers of PCA, where the output from the first layer would be used for the second layer [7]. This would result in representation layers,  $z_1$  and  $z_2$  defined by

$$z_1 = (w_1)^T x \quad (3)$$

$$z_2 = w_2^T z_1 = (w_2 w_1)^T x \quad (4)$$

where  $W_1$  and  $W_2$  are projection matrices, obtained through PCA, from the first and second layer respectively.  $z_2$  makes use the first layer information. By applying two layers of PCA would only lead to a redundant linear projection.

$$z_1 = \hat{w}_1^T \hat{x}_1 \quad (5)$$

$$z_2 = \hat{w}_2^T z_1 = \hat{w}_2^T f(\hat{w}_1^T \hat{x}_1) \quad (6)$$

By using DPCA, each layer would have a new and distinct information that could contribute in the overall representation of the face image.

### V. LINEAR DISCRIMINANT ANALYSIS

The basic plan of LDA is to find linear transformation because LDA features clusters [8]. The LDA computes the scatter matrix among the categories. The scatter matrix is situated in the categories so, separating the pictures among categories increasing the popularity rate [9]. When scheming load matrix, geometric distance is calculated. The general steps for acting a linear discriminant analysis square measure are:

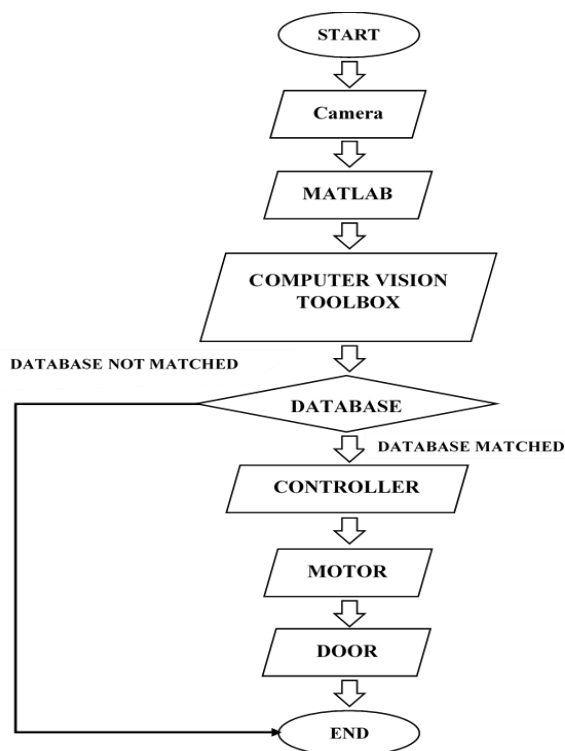
1. Computing the d-dimensional mean vectors for the various categories from the dataset.
2. Computing the scatter matrices (between-class and within-class scatter matrix).
3. Computing the eigenvectors ( $e_1, e_2, \dots, e_d$ ) and corresponding eigenvalues ( $\lambda_1, \lambda_2, \dots, \lambda_d$ ) for the scatter matrices. The goal is to maximize SB whereas minimizing southwest.
4. Sorting the eigenvectors by decreasing eigenvalues and opt for k eigenvectors with the most important eigenvalues.
5. The eigenvector matrix is employed to remodel the samples onto the new topological space [10].

Table 2. Accuracy of Algorithms

Algorithm	Accuracy
PCA	91 %

DPCA	92 %
LDA	95 %
KLT	94 %
Viola-Jones	97 %

### VI. FLOW CHART



### VII. COMPUTER VISION TOOLBOX

Computer Vision Toolbox provides algorithms, functions, apps for planning and testing Computer vision, 3D vision, and video processing systems. We can perform object detection similarly to feature detection, extraction, and processing. For 3D vision, the Toolbox supports single, stereo, and wide-angle camera calibration; stereo vision; 3D reconstruction; and measuring system and 3D purpose cloud process. Computer vision apps alter ground-truth labeling the camera activity workflows. We can train custom object detectors by utilizing deep learning and machine learning algorithms like YOLO v2, quicker R-CNN, and ACF. For linguistics segmentation, we can use deep learning algorithms like SegNet, U-Net, and Deep laboratory. Pretrained models allow us to discover faces, pedestrians, and different common objects. We can accelerate our algorithms by running them on multicore processors and GPUs. Most toolbox algorithms support C/C++ code generation for desegregation with existing code, desktop prototyping, and embedded vision system preparation.

#### A. Controller, Motor and Driver Circuit

The motor that we used in our project is a 12V DC 150 kg Torque Motor. The Arduino controller can give an output voltage of 5v, as it cannot run this motor.



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Also, the power from the controller drives the motor only in one direction. To overcome the direction and voltage problem, we are using an L293D driver circuit. The L293D driver circuit has an input control voltage of 5V from the Arduino board. To run the motor, an external power supply of 12V is given to the driver circuit. To change the direction of rotation, the control signals from the Arduino are changed and are sent to the H-Bridge circuit. The L293D driver circuit interchanges the direction of rotation of the motor.

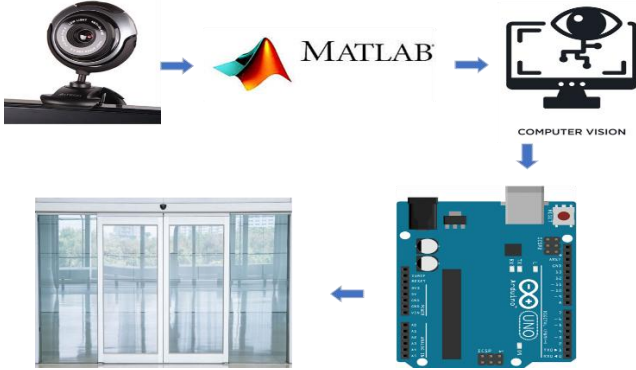


Fig. 3. Circuit diagram

## VIII. IMAGE PROCESSING

### A. Initializing Database

The proposed system allows a new user to take 10 photographs within the allocated time of 10 seconds. When the user is ready, the system captures images. The user has to vary his head positions by either looking at different directions or showing some facial expressions as either happy, sad, or excited. The proposed system captures these images and stores them in a database for comparing when the actual system is in work. The system stores the set of images in a Bitmap image file (BMP format). It is arranged in reverse chronological order. The images can be viewed in the designated folder and have access to those images.

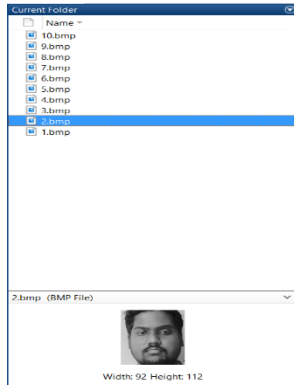


Fig. 4. Initializing database of user

### B. Facial Recognition

The facial recognition system is used to recognize the person in front of the camera as it does the required process. When the user is in front of the camera, the system captures the image and compares it with the available database.



Fig. 5. Face Recognition

### C. Controller

The controller program is for the Arduino UNO. Arduino Hardware packages are installed in the MATLAB software for the interfacing of the Computer Vision toolbox, MATLAB for the image processing process for the facial identification of the system.

## IX. IMPLEMENTATION

### A. Experimental Setup

This facial recognition system can be implemented in most of the residential buildings. The major factors are the positioning of the camera and the space for the installation of the door. The door has fewer physical components. The size occupied is less when compared to conventional security doors. As a part of the experimental setup, a product prototype has been developed by our team and has been installed the working model in one of our labs in our institution. Here the webcam is used as the camera takes the input image and gives it to the controller.



Fig. 6. Experimental setup door

### B. Hardware Arrangements

The hardware components of our facial recognition system are:

1. Logitech HD Webcam C270 (V-U0018)
2. Arduino UNO
3. 12V 100mm High Torque Motor
4. Sliding Door
5. Free Wheels
6. Aluminium Frames

The wooden door is framed with aluminium frames. The base of the door is arranged with freewheels for ease of movement. The whole door setup is placed on an aluminium frame which is stationary. The webcam is placed on this aluminium frame and the camera is still for receiving the input images.

The High torque motor is placed at the bottom centre of the door and it is wired to the controller. The controller is placed on a separate stand along with the power supply. Thus, the overall setup contains only fewer components.

## X. RESULTS

### A. Experimental Results

The experimental results of our project are represented in Fig.7. The image shows that the input image from the webcam is acquired with all the facial features. The next process is where these features are compared to the stored database. The MATLAB software uses the computer vision toolbox for the facial features and then compares the same features with the stored database. If the facial features match, the system returns the final expected face matching result

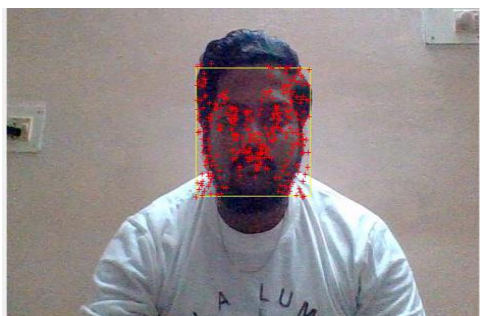


Fig. 7. Facial Features detected from webcam



Fig. 8. Face Detection

### B. Facial Features



Fig. 9. Facial Features in a stored database

## XI. CONCLUSION

An Intelligent Door Empowered with Computer Vision project has been completed and implemented in our institution laboratory. This project is a cost-efficient one as the face recognition system has been implemented in an Arduino controller in place of a raspberry pi. Thus, significantly the cost is lowered and it is very easy to setup. The system can accommodate a large database and has the ability to recognize the authorized personnel. The experiment was conducted with different persons and the analysis revealed that the present system shows excellent performance efficiency.

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