# MatlabSoftware in PC to Replace an Embedded System Used for Face Recognition

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***Abstract*—Currently in the European and American markets are highly developed systems of fingerprint recognition which commercial cost is in the range of one hundred to five hundred thousand dollars. The human faces recognition in digital images is very useful in environments where it is impossible monitoring of people, facilitating the detection of persons who are in a database of suspects. Face identification is also a good biometric method which can be used in access control and restricted areas. The use of artificial neural networks to solve the problem of face recognition and the need for a priori knowledge of the statistical distribution of the data, inherent parallelism, rapid classification and the most important thing is fault tolerance. This proposal is developed to Practice to users, small businesses, industry and government to promote compliance with standards, knowledge and development of biometrics. Therefore, in this paper a series of algorithms that run on a personal computer, are written in Matlab code, to date, this software is rapidly gaining users to solve problems as presented, is presented because the costs will be reduced drastically.**

***Index Terms*—face recognition, Matlab, neural networks**

## I. Introduction

From the beginning of time, the search for a means of unambiguous identification has been one of the goals of humanity.

In everyday life and in the technological world, the importance of privacy and data security force to establish identification and authentication measures to ensure that no other person access to outside information or private services. Until then done on paper they have come to be by applications.

Biometrics is the study of automated methods for recognizing humans based only on one or more intrinsic physical features (fingerprint, face, retina, iris) and behavioral (gait or signature) Fig. 1.

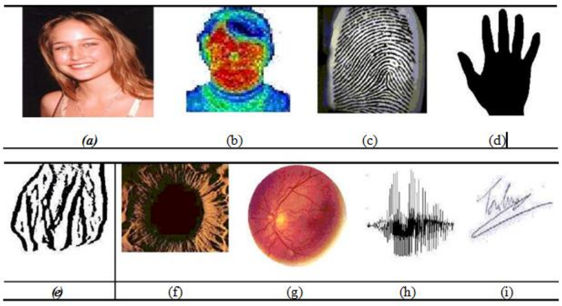

Figure 1. Biometric indicators. (a) Face (b) Facial thermogram, (c) fingerprint (d) hand geometry, (e) veins of the hand, (f) iris, (g) patterns of the retina, (h) voice (i) signature.

A biometric system identifies or verifies the identity of people, but you must collect biometric data.

The system requires two steps. The first is the process of collecting your biometric trait and is known as registration or enrollment. The second step is when the system checks the mark in its database, and it may verify or identify your identity.

A biometric indicator is a feature with which you can make biometrics. Whatever the indicator, must meet the following requirements [1]:

1) Universality: anyone has that characteristic;
2) Uniqueness: the existence of two people with identical feature has a very small chance;
3) Permanence: the characteristic does not change over time;
4) Quantification: the characteristic can be measured quantitatively.

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The recognition of human faces in digital images are composed of a set of techniques for preparing images and pattern recognition, and also face learning methods.

To recognize a face in a digital image, you must first prepare, simplifying, this is achieved by converting it to a format grayscale or applying the method of Eigen faces.

After simplifying the image, you must locate the face in the image, is part requires the use of algorithms that recognize patterns such as contour descriptors.

The learning phase is the most critical part of the process of face recognition, because in it, you must store information on the face, which then will be used for recognition. At this stage the faces are processed, making them invariant to the size and contrast changes, using learning algorithms and face recognition, nonlinear classifiers patterns are used, which can be calculated by simulation methods or some non-mathematical method in this case, neural networks and genetic algorithms.

## II. Methodology

Biometric devices have three basic components: the first a biometric indicator analog or digital, as the acquisition of the image of a human face using a camera. The second handles compression, processing, storage and comparison of the acquired data with the stored data and the third component interfaces with applications on the same or another system. The architecture of a biometric system can be understood conceptually as two modules; Module Registration and Identification Module Fig. 2.

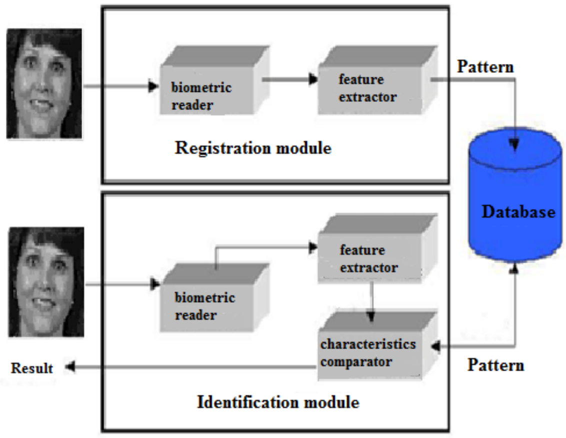


Figure 2. Architecture of a biometric system.

### A. Face Recognition

#### 1) Facial patterns

In pattern recognition, an important premise: the objects can be correctly classified if the variability within instances of a given class is less than the variability between two different classes. Taking the example of face recognition (Fig. 3), it very difficult to locate the eyes, nose, mouth, and others are presented. And also gestures, grimaces that the time change the pattern identification [2].

The recognition of a person's face is one of the most accepted by users, along with fingerprint methods.

The method of facial patterns is often used in robots to detect people and to differentiate them.

However, it is a method that is difficult to implement, and has the disadvantage that it is not a fixed characteristic, but the face of a person varies with age.

#### 2) Eigen faces

Method used to process an image that is based on Eigen vectors, which are used for various linear algebra calculations related to nature.

The main idea is to decompose a facial image in a small set of images with facial features, called Eigen faces (Eigenfaces), which arguably are the main characteristic components of the original image [3].

These Eigen faces function as orthogonal basis vectors (eigenvector) of a sub-linear space called "Facial Space". Facial recognition is performed by projecting a new image of a face in a face space and comparing its position in face space with a face known to the system.

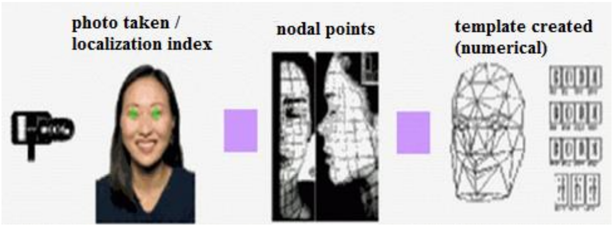


Figure 3. Facial recognition system.

Fig. 3 shows a comparison of fifteen images that has been applied algorithm and the resulting Eigen face facial space is observed.

#### 3) Construction of a facial space

The basis eigenstates of a face is the construction of a facial image. Then a mathematical definition of the construction of the facial space is given. The vectors used for the calculation of these spaces are called eigenvectors and scalar value, Eigen value (eigenvector and eigenvalue) Fig. 4.

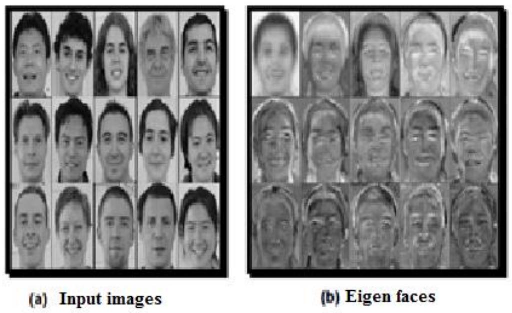


Figure 4. Example of images processed with the method of Eigen faces.

We have a facial image of N pixels. This will be represented by the vector $\Gamma$ of dimension N is calculated by the equation (1).

$$S\left\{\Gamma_i \middle| i=1,\ldots,M\right\} \quad (1)$$

Equation (1) is the set of training images. The average face of these M images is given by equation (2):

$$\psi = \frac{1}{M}\sum_{i=1}^{M}\Gamma_i \quad (2)$$

Then each $\Gamma_i$ different side of the mean $\Psi$ by $\Phi_i$ is calculated by the equation (3).

$$\Phi_i = \Gamma_i - \Psi; i = 1,...,M \tag{3}$$

The covariance matrix for pictures with which you train the system is constructed by the equation (4):

$$C = AA^T \tag{4}$$

where, $A = [\Phi_1,...\Phi_M]$ are vectors based on facial space and the faces are then Eigen orthogonal Eigen vectors of the covariance matrix C.

Find the eigenvectors of the matrix C of N by N is a very difficult task in a typical image, the image should be simplified. Because the number of training images is usually less than the number of pixels in an image, there will be only M-1, rather than N, meaningful eigenvectors. From this account Eigen faces are calculated by first searching the Eigen vectors is calculated by the equation (5).

$$V_l\left(l_i = 1,...,M\right)M(L): L = AA^T \tag{5}$$

The Eigen vectors the matrix C are expressed by a linear combination of the differences between images with faces weight is calculated by the equation (6).

$$U = [u_1,...,u_M] = [\Phi_1,...,\Phi_M][v_1,...,v_M] = A*V \tag{6}$$

In practice, a small set of M' (M' < M) Eigen faces is sufficient to identify the face. Therefore, only M 'significant eigenvectors are in the L matrix, the eigenvalues corresponding (Eigen vector scalar value), longer M' are selected for calculating (7) Eigen faces, this results in greater compression. M 'is determined by a threshold, the radius of the sum of Eigen values: $\theta_\lambda$ :

$$M' = \min\left\{ r \mid \frac{\sum_{l=1}^{M} \lambda_l}{\sum_{l=1}^{M} \lambda_l} \rangle \theta_\lambda \right\} \tag{7}$$

### B. Face Recognition Using Eigen Faces

Face recognition based on Eigen faces is a procedure based on two stages: Step training and Step Recognition.

1) Step training

In the training stage, the face of each known person, $\Gamma_k$, is projected into a facial space and M 'dimensional vector, M', $\Omega_k$ is obtained by equation (8) :

$$\Omega_k = U^T\left(\Gamma_k - \Psi\right); k = 1,..., N_c \tag{8}$$

where $\mathbf{N_c}$ is the number of classes faces.

To describe the kind of face in a facial space there are two methods. The first method relates to an average representation, the class vector averaging each projected image of training vectors is calculated. The second method is the representation of set point, which describes a class of face by a set of vectors designed for a single image, all images.

The threshold value away, $\theta_c$, defining the maximum allowed distance from a class of face to the facial space is defined as the calculation of half the largest distance between any two kinds of faces, as defined by equation (9):

$$\theta_c = \frac{1}{2}\max\left\{\| \Omega_j - \Omega_k \|\right\}; j,k = 1,..., N_c \tag{9}$$

Calculating the facial space and faces all kinds of images that will be on the basis of images (images of train system), concludes the training stage.

The training method explained in this system is for recognition through Eigen faces. In chapter four general techniques are presented for training and learning faces using neural networks and genetic algorithms.

2) Recognition stage

In the recognition stage, a new image is projected on the facial area calculated for equation (10)

$$\Omega = U^T\Gamma - \Psi \tag{10}$$

The distance of $\Omega$ face for each class is given by equation (11)

$$E_k^2 = \| \Omega - \Omega_k \|^2; k = 1,..., N_c \tag{11}$$

In order to discriminate between images and pictures faceless face, the distance E between the original image, $\Gamma$, and the reconstructed image in a space of Eigen face, $\Gamma_f$, is calculated with equation (12):

$$E^2 \| \Gamma - \Gamma_f \|^2 \tag{12}$$

where:

$$\Gamma_f = U * \Omega + \Psi$$

These distances are compared with the threshold calculated in equation (9).

### C. Digital Image Processing

The set of techniques and processes to discover or to highlight information in an image using a computer as the main tool known as digital image processing.

### D. Artificial Neural Networks

This technology can be developed both software and hardware and with it you can build systems that can learn, adapt to varying conditions, or even if it has a large enough collection of data, predicting the future state of some models. [4]

*1) An artificial model neuronal*

Model Rumelhart and McClelland (1986) defines a Processing Element (PE), or artificial neuron as a device from a set of inputs xi (i = 1 ... n) or vector x, generates a single output y.

This artificial neuron consists of the following elements (Fig. 5):

1) Set of inputs or input vector *x, n* components
2) Set of synaptic weights *wij*. Represent the interaction between the presynaptic neuron j and postsynaptic i.

3) Rule propagation *d (wij, xj (t))* provides the postsynaptic potential, hi *(t)*
4) Activation function equation (13) provides state of the neuron activation function of the previous state and postsynaptic value.

$$a_i(t) = F(a_i(t-1)), h_i(t) \tag{13}$$

5) Output function *Fi (t)*: the output *yi (t)*, depending on the activation state

Several ANN based on popular Back propagation whose behavior is comparable with human operators. Another typical application is industrial inspection.

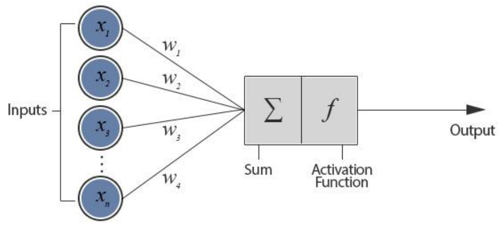


Figure 5. Artificial neuron model.

*2) Backpropagation network architecture*

The basic processing unit of the Back propagation network is shown in Fig. 6. The entries are shown on the left and right are units that receive the output of the processing unit located in the center of the figure [5].

The processing unit is characterized by performing a weighted sum of the inputs *Sj*call, make an ajaj out and have a value associated to be used in the process of adjusting the weights. The weight associated with the connection from unit *i* to unit *j* is represented by *wji*, and is modified during the learning process.

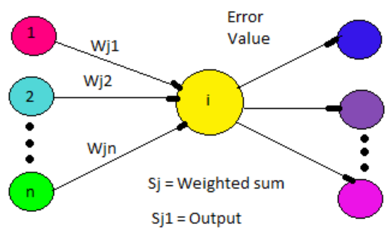


Figure 6. Basic processing unit backpropagation.

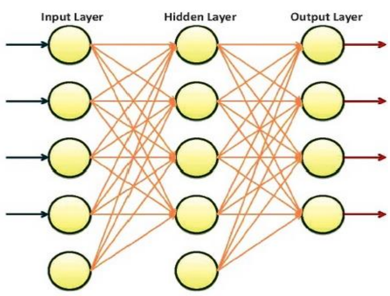


Figure 7. Red Backpropagation completely interconnected.

Normally, Backpropagation uses three or more layers of processing units. Fig. 7 shows a typical three-layer backpropagation topology. The bottom layer is the input layer, and is characterized by the single layer processing units which receive inputs from the outside. They serve as distributors points, do not perform any calculation. The processor units of the other layers process the signals as shown in Fig. 7. The next layer is the hidden layer, and all processing units are interconnected with the bottom layer and the top layer. The top layer is the output layer that presents the network response.

*3) Training algorithm*

The Backpropagation networks have a method of supervised training. A network is presented with pairs of patterns, an input pattern paired with a desired output pattern. For each presentation weights are adjusted so as to reduce the error between the desired output and network response.

The backpropagation learning algorithm involves a propagation phase forward and one step back propagation. Both phases are performed for each pattern presented in the training session.

This algorithm is one of the most popular networks for training multilayer perceptron and consists of the following steps

Consider:

$W_{ji}$ =weight (value) of the connection that goes to the neuron j from the neuron i. Ep, error pattern which is given by equation (14):

$$Ep = \frac{1}{2}\sum_j \left(sd_j - sr_j\right)^2 \tag{14}$$

where $sd_j$ y $sr_j$ are output and the desired output of the network in the neuron j, respectively. ET, the total error in the training set, which is given by equation (15).

$$ET = \sum_p E_p \tag{15}$$

$Op_j$ is the output of the j-esima neuron pattern p is given by equation (16) which in turn is the activation function. In this case is used as the activation function sigmoid function, which is given by (17):

$$Op_j = F(NETp_j) \tag{16}$$

$$F(NETp_j)\frac{1}{1+e^{-NETp_j}} \tag{17}$$

is given by the equation (18):

$$NETp_j = \sum_i W_{ij} Op_i \tag{18}$$

where $Op_j$, is the network entry, if *i* is in the input layer of the network; *Opi* is the output of the i-esima neuron in the previous layer, if is not in the input layer.

The steps followed in the retro propagation algorithm are:

1) Initialize all weights and biases of the network with small random values.
2) Give as input to the network the first p pattern in the training set and initialize the ET to zero.
3) Perform network assessment.
4) Get the error*Ep* network and accumulate this error in ET.

5) Adjust the weights (*Wji*) in the network by applying the following rule (generalized delta rule) equation (19)

$$W_{ji}(t+1) = W_{ji}(t) + \Delta pW_{ji} \tag{19}$$

$\Delta pW_{ji}$ is obtained by the equation (20):

$$\Delta pW_{ji} = n\delta pj * Opi \tag{20}$$

where n is the learning coefficient which must be initialized to any value between 0 and 1.

The vlue of $\delta pj$ is calculated as follows:

If j corresponds to the output layer of the network $\delta pj$ then it *es* given by equation (21):

$$\delta pj = (sd_j - sr_j)\left[F(NETp_j)\right]\left[1 - F(NETp_j)\right] \tag{21}$$

If *jnot* for the output layer, so $\delta pj$ is then calculated as follows equation (22):

$$\delta pj = \left[F(NETp_j)\right]\left[1 - F(NETp_j)\right]\sum_k \delta pk * Wkj \tag{22}$$

6) Feed the network with the following pattern in the training set and return to step 3.
7) Once the network is fed with all the patterns of the training set, return to step 2.
8) Once the network is fed with all the patterns of the training set, return to step 2.Wj

*4) Network structure*

The network consists of the input layer, which for this special case is the data matrix discussed above, has two hidden layers and an output layer, which will be detailed below.

The input layer has 10304 nodes to the database proposal and 8288 nodes for the database created, the first hidden layer is 2 * (10-2) neurons, the second k + m layer neurons and output neurons *k*.

The activation function of hidden layers is hyperbolic tangent consistent with the positive or negative nature of the input signal, the output layer should lead to a set of alternatives yes or no, compactly representable by a sigmoid [0,1].

The output consists of m matrices kxk identity of order, thus ensuring that a value is taken for each of the images and can discriminate between each individual, this is used when a treatment set of images is performed and more than one person.

## III. Results and Discussion

There are two ways to represent images digitally, vector format and raster format latter represents raster image format through a rectangular array (matrix or array) of colored dots called pixels [6].

JPEG, TIFF, GIF, BMP, PNG, PGM, HDF, PCX, XWD, ICO and CUR: In Matlab the following image formats are supported.

Imread function in Matlab Table I, can be used to read images. If the image is grayscaleimread then returns a two-dimensional array. If the image is RGB imread then returns a three-dimensional array.

Preprocessing of the images is the same for the training stage, as for the recognition stage, with the difference that in the first stage the first 5 takes images of an individual, and for the remaining five second. To obtain a new matrix and be normalized data enters the simulation stage for recognition, which is similar to the training simulation. Thus is extracted from each diagonal submatrix and transposes to have final data as a row vector, that the programmer only by convention code 2. Table II.

TABLE I. Code 1 for Training Matlab

| Code 1 For training Matlab commands follows is used: |
|---|
| 1 redne=newff(minmax(Pn),[21k+2),k+m,k],etansigi,lansigi,logsig'ytrainrp'); |
| 2 redne.trainParam.show=10; |
| 3 redne.trainParam.goal=0.001; |
| 4 [redne,tr]=train(redne,Pn,t); |
| 5 Out=eye(k); |
| 5 ; for rr--¨1:m-1; |
| 6 out=[t,eye(k)]; |
| End |
| 7 for i=1 :m*k |
| 8 a(: ,D=sim( redne, Pn(: ,i)); |
| End |
| *End of Code* |

TABLE II. CODE 2 FOR TRAINING MATLAB

| Code 2 For training Matlab commands follows is used: | |
|---|---|
| for n=m+1:m+m; | A2=a(1:3,4:6); A2=(diag(a2))' |
| for i=1:k; | b2=b(1:3,4:6); B2=(diag(b2))' |
| the_file=rC:\rostros\s' int2str(i) int2str(n)'.pgml; | D2=B2-A2 |
| foto=fopen(the_file,'r'); | a3=a(1:3,7:9); A3=(diag(a3))' |
| [w(:,;(*(n-1)+0,pix]=fread(foto,10304,'int8=>doubles); | b3=b(1:3,7:9); B3=(diag(b3))' |
| j=fclose(foto); | D3=B3-A3 |
| end | a4=a(1:3,10:12); A4=(diag(a4))' |
| end | b4=b(1:3,10:12); B4=(diag(b4))' |
| w=w(:,xx:xx); | D4=B4-A4 |
| [wn,meanw,stdp]=prestd(w); | a5=a(1:3,13:15); A5=(diag(a5))' |
| w=w(:,16:30); | b5=b(1:3,13:15); B5=(diag(b5))' |
| for b(: ,D=sim( redne,Wn(:, i)); | D5=B5-A5 |
| end | End of code |
| a1=a(1:3,1 :3); | |
| Al =(diag(a1))'; | |
| b1=b(1:3,1:3); | |
| B1=(criag(b1))' D1=B1-A1 | |

## IV. CONCLUSIONS

We have developed a face recognition system, which uses the methodology of Artificial Neural Networks. By using an artificial neural network, the system is tolerant to variations in facial expressions and facial details such as the use of earrings, sunglasses, among others. The results obtained by the system indicate that combining the artificial neural network, with the proposed method of extracting features, a very acceptable efficiency is obtained.

The feature extraction method of face images is tolerant to variations in facial expressions, and rotations that are not very significant.

The variations in illumination should not be significant, since the feature vectors, with which the neural network is trained, are in terms of the gray levels of the original image. Therefore, if the illumination of the face images varies significantly between training set and the test set, the system will have a percentage of acceptable generalization

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