

Iris Recognition Using Wavelet Transform and Artificial Neural Networks

Dr. Hadeel N. Abdullah 

Electrical Engineering Department, University of Technology/Baghdad.

Ahmed A. Abdullah

Electrical Engineering Department, University of Technology/Baghdad.

Email: handsome.eng82@yahoo.com

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Abstract

In this approach to get more accuracy of the iris recognition, is composed of many steps: capturing the iris image, determining the location of the iris boundaries, normalization, preprocessed using median filter to remove noise, using wavelet transform for two types of filter, Haar and Daubechies (db4), in order to extract the features and finally using the matching by artificial feed forward neural network with back propagation algorithm (FFBNN) for training and testing iris image. In this proposed system, two database systems are used. The first is CASIA database system (version 1.0) (Chinese Academy of Sciences Institute of Automation). And, the second is REAL database system by using real persons and each person takes many images for recognition through camera Mobile Type of Galaxy Note3. In CASIA System, the iris recognition rate for Haar filter was 84.2% and for Daubechies filter was 92.8%, while in Real system, the iris recognition rate for Haar filter was 90% and for Daubechies filter was 98.7%, this means the Daubechies filter was the best in time and error from the Haar filter. Finally, this system is efficient, because the performance measurement of FAR was 0%. The results and the experiments were implemented by P4 computer and the software package MATLAB (R2011a).

Keywords: Iris recognition, Wavelet transforms, Feed Forward Back propagation Neural Network (FFBNN)

تمييز قزحية العين باستخدام التحويل الموجي والشبكات العصبية الاصطناعية

الخلاصة

في هذا البحث تم اقتراح طريقة للحصول على تمييز لقزحية العين بدقة كبيرة وهذه الطريقة تتضمن عدة خطوات. النقاط صورة قزحية العين، وتحديد مكان وجود حدود القزحية، التطبيع، المعالجة باستخدام فلتر متوسط لإزالة الضوضاء، استخدام التحويل الموجي لنوعين من المرشحات (هار و دوبيشيز) من أجل استخلاص الميزات واخيرا مرحلة المطابقة باستخدام الشبكات العصبية الاصطناعية ذات التعويض الامامي مع الانتشار الخلفي من أجل تدريب واختبار صور القزحية. في هذا النظام المقترح، تم استخدام اثنين من نظم قواعد البيانات، الأول نظام قاعدة بيانات CASIA (الإصدار 1.0) والثاني نظام قاعدة البيانات الحقيقية عن طريق النقاط العديد

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

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من الصور لكل شخص باستخدام كاميرا الجوال من نوع غالاكسي NOTE3. في نظام كاسيا معدل تميز القرحة للفلتر هار كان 84.2% وللفلتر دويشيز كان 92.8%. اما في النظام الحقيقي فان معدل التميز للفلتر هار كان 90% وللفلتر دويشيز كان 98.7%, هذا يعني ان الفلتر دويشيز كان الافضل في النتائج من الفلتر هار. اخيرا هذا النظام كفء لان قياس الاداء عن طريق نسبة القبول الخاطئة كانت 0%. النتائج و التجارب نفذت باستخدام حاسبة نوع بانتيوم 4 ، و البرامج كتبت باستخدام الماتلاب (R2011a).

INTRODUCTION

Iris Recognition is a Biometric Technology which deals with identification based on the human iris. It is considered to be the most accurate biometric technology available today compared with many kinds of biometric technologies used, like Fingerprint scanning, Face recognition, Voice recognition and Hand geometry scanning because it has some advantages, such as uniqueness, stability and high recognition rate etc., makes iris recognition so accurate.

The iris is a thin circular diaphragm, which lies between the cornea and the lens of the human eye. The iris is perforated close to its center by a circular opening known as the pupil. The function of the iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of the pupil. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter. Figure (1) shows a front-on view of the iris [1].

The iris is an externally visible and it is a protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals. Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye and encode it into a biometric template, which can be stored in a database [2].

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be extracted, so that comparisons between the templates can be made [3]. The wavelet transform is used to extract features from the enhanced iris images.

Different approaches advised by researchers to extract iris features. Daugman developed first iris recognition system and used two dimensional Gabor filter for feature extraction. Alternative approach based on wavelet transform to extract iris features is suggested by various researchers. L. F. Araghi et al. [4] proposed Iris Recognition based on covariance of discrete wavelet using Competitive Neural Network (LVQ) Learning Vector Quantization. A set of Edge of Iris profiles are used to build a covariance matrix by discrete wavelet transform using neural network. B. Logannathan and A. Marimuthu [5] propose a wavelet probabilistic neural network (WPNN) for iris biometric classifier. The WPNN combines wavelet neural network and probabilistic neural network for a new classifier model which will be able to improve the biometrics recognition accuracy as well as the global system performance. G. kaur et al. [6] they proposed two different methods of iris recognition mechanism are analyzed, first is support vector machine and second is the Phase based method.

Block diagram of the proposed Algorithms

Generally, the iris recognition system is composed of many stages, as shown in figure (2).

Iris Image acquisition

Capturing images of iris is the first stage of an iris-based recognition system. The success of the other recognition stages depends on the quality of the images taken from iris during the image acquisition stage. There are two types of the database that were used in the present work are:

(1) CASIA iris image database (version 1.0) (CASIA-Chinese Academy of Sciences Institute of Automation): (CASIA) is the Chinese Academy of Sciences - Institute of Automation eye image database containing 756 grayscale eye images with 108 person eyes and 7 different images of each person eye. The iris images in CASIA database have iris radius from 80 to 150 pixels and pupil radius from 30 to 75 pixels. The camera is situated normally between half a meter to one meter (3 to 10 inches) from the subject. Iris images from each class are taken from two sessions with one month interval between sessions. The images were captured, especially for iris recognition research using specialized digital optics developed by the National Laboratory of Pattern Recognition China.

Some details about the image used in this work include:

Type of camera: CCD (Charge Coupled Device)

Dimensions: 320 x 280

Width: 320 pixels & Height: 280 pixels

Horizontal resolution of camera: 96 dbi & Vertical resolution of camera: 96 dbi

Bit depth: 8 & Item type: bitmap image

(2) Real database: This kind of database concerns with the process of taking pictures of several people by Mobile Camera (SAMSUNG Galaxy Note3), and every person took many images for training and testing to distinct the iris. This type of camera was used with normal light, flash mode and under the influence of light rays of the sun.

The dimensions of the images in this system are not equal, each eye image is different from the other eye images dimensions because of the difference in the sizes of the eyes, and this is one of the characteristics of real database. The process of taking the picture for people has to be in constant conditions for all, for example, the same time and place and under the same weather conditions so as not to affect the process that characterizes the iris.

The estimated distance between the camera and the person is from (7 to 9 cm). Normal light will cause reflections within the iris and will affect the distinction of the iris with eyelashes and rotation of the head, as shown in figure (3). Some details about the real image include:

Type of camera: Mobile Galaxy Note3

Camera maker: SAMSUNG & Camera model: SM-N900

Dimensions: 640 X random

Width: 640 pixels & Height: random pixels

Horizontal resolution of camera: 72dbi & Vertical resolution of camera: 72 dbi

Bit depth: 24

Color representation: sRGB

Flash mode: flash

Interface: USB

Item type: JPEG image

Iris Segmentation by Hough Transform

After capturing the images of iris, the second stage of iris recognition is to detect the actual iris region from a digital eye image. Canny Edge Detection scheme and a Circular Hough Transform, are applied to detect the iris boundaries in the eye's digital image to overcome the eyelids and eyelashes which normally occlude the upper and lower parts of the iris region.

The Hough transform is a standard computer vision algorithm that can be used to determine the parameters of simple geometric objects, such as lines and circles, present in an image. The circular Hough transform can be employed to deduce the radius and centre coordinates of the pupil and iris regions. Canny edge detection is used to create an edge map, the boundary of the iris is located and the parabolic Hough transform is used to detect the eyelids, as shown in figure (4).

In this work, figures (5) show the templates generated after segmentation for CASIA and REAL database, respectively.

Iris Normalization by Daugman's rubber sheet model

Once the segmentation module has estimated the iris's boundary, the normalization module uses Daugman's rubber sheet model to transform the iris template from Cartesian to polar coordinates. Figure (6) shows the block diagram of iris normalization stage, and figures (8) and (9) reveal the templates generated after normalization for CASIA and REAL database, respectively.

After that, the normalized iris image contains eyelashes as a part of original eye image and it acts as a noise data, so it causes difficulty in iris recognition stage. In order to remove this noise (eyelash), an algorithm was proposed to crop the iris template to one fourth of its size. In the CASIA database system, after finding a region where there are eyelashes, which is limited to a value between (50-110) pixels, (30) P threshold was added in order to overcome the area of eyelashes and moving into adjacent areas, as explained in figure (8a). In the Real database system values, the eyelashes are limited to be between (8-75) pixels, and the threshold value added is equal to (40) P to overcome the eyelashes, as shown in figure (8b).

Then, a 2-D median filtering was added to enhance the template more and in order to eliminate the remnants of the existing noise to configure good template before entering into the next stage for the feature extraction, as shown in figures (9).

Feature Extraction

The Wavelet transforms are used to extract the feature of normalized iris image, wavelet coefficients vectors are used as a feature for iris recognition. There are four types of wavelet coefficients e.g. approximate, horizontal, vertical and diagonal detail can be used, here simple Harr wavelet and Daubechies are used.

The wavelet energy in horizontal, vertical and diagonal directions at the i -level can be respectively defined as [7]:

$$E_i^h = \sum_{x=1}^M \sum_{y=1}^N (H_i(x,y))^2 \quad \dots (1)$$

$$E_i^v = \sum_{x=1}^M \sum_{y=1}^N (V_i(x,y))^2 \quad \dots (2)$$

$$E_i^d = \sum_{x=1}^M \sum_{y=1}^N (D_i(x,y))^2 \quad \dots (3)$$

These energies reflect the strength of the images' details in different directions at the i -level decomposition. Hence, the feature vector is $(E_i^h, E_i^v, E_i^d)_{i=1,2,3,\dots,k}$

Where,

K is the total number of wavelet decomposition level.

Training and Testing Datasets

In this work, there are two types of systems, CASIA Database and Real Database, and both of them will be training and testing through the program MATLAB R2011a. Basically, the iris image patterns must be divided into two sets which are the training set and the testing set in order to train the neural network model and test its performance. In this Paper, the CASIA Database System used 10 persons and each person 7 images (5 for training and 2 for test), while in Real Database system used 8 person and each person 10 images (7 for training and 3 for test).

Training ANN with BP algorithms

The Back Propagation learning process works in small iterative steps: one of the example cases is applied to the network, and the network produces some output based on the current state of its synaptic weights (initially, the output will be random). This output is compared to the known-good output, and a mean-squared error signal is calculated. The error value is then propagated backwards through the network, and small changes are made to the weights in each layer. The weight changes are calculated to reduce the error signal for the case in question. The whole process is repeated for each of the example cases, then back to the first case again, and so on. The cycle is repeated until the overall error value drops below some pre-determined threshold. Here are some situations where a BP ANN might be a good idea:

- A large amount of input/output data is available, but you're not sure how to relate it to the output.
- The problem appears to have overwhelming complexity, but there is clearly a solution.
- It is easy to create a number of examples of the correct behavior.
- The solution to the problem may change over time, within the bounds of the given input and output parameters (i.e., today $2+2=4$, but in the future we may find that $2+2=3.8$).
- Outputs can be "fuzzy", or non-numeric.

The structure of the neural network can be modified by modifying the number of neurons in each of the layers (input, hidden and output). In this work for both CASIA Database System and Real Database System, Levenberg-Marquardt algorithm (TRAINLM) was used to learn BPNN, and the type of activation function is tansig. In CASIA Database System, the Artificial Neural Network (ANN) was trained with input layer consisting of 25 neurons, 2 hidden layers each layer consists of 10 neurons, and output layer consisting of 10 neurons, as shown in figure (10). In Real Database System the Artificial Neural Network (ANN) was trained with input layer consisting of 25 neurons, 2 hidden layers each layer consists of 10 neurons and output layer consisting of 8 neurons, as shown in figure (11).

Results of Training ANN with BP Algorithm

The performance was measured by the means of squared error. In CASIA Database System, figures (12) show the performance plots of the training error for both filters (Haar & Daubechies4(db4)), respectively.

Figure (13) manifest the regression plots for each filter, the regression plots are used to validate the network performance. These plots display the network outputs with respect to targets for training set. For a perfect fit, the data should fall along a 45 degree line, where the network outputs are equal to the targets. For both filters, the fit is reasonably good, with R values in each case equal 1 and this means that the training accuracy percentage is %100.

As in Real Database System for both filters, figures (14) show the performance plot of the training error, figure (15) show the regression plots.

Results of Testing ANN

The testing process was done using a testing dataset that was fed to the neural network to observe whether the iris system recognized or not .

One of the most important criteria that must be checked to evaluate the performance of the neural network operation is the accuracy. The accuracy of the testing process for iris recognition is defined as “the percent of the number of the correct iris samples to the total number of the irises” and can be calculated by equation (4):

$$\text{Accuracy (100\%)} = \frac{N_c}{N_t} \times (100\%) \quad \dots (4)$$

Where,

N_c denotes to the number of correct iris samples.

N_t is the total number of iris samples.

The accuracy of testing result for both Database Systems and each system with two filters was calculated and illustrated in Table (1).

Table (1): The performance results of testing ANN for the both database.

Database system	Algorithm	Type of filter	Testing Accuracy (100%)
CASIA(version 1.0)	Back-Propagation	Haar	84.2
CASIA(version 1.0)	Back-Propagation	db4	92.8
REAL	Back-Propagation	haar	90
REAL	Back-Propagation	db4	98.7

Performance measurement

This system, in general, makes two possible decisions; the authorized person is rejected, and the unauthorized person (impostor) is accepted.

The accuracy of the proposed system is then specified based on the rate in which the system makes the decision to reject the authorized person and to accept the unauthorized person.

False Rejection Rates (FRR) is used to measure the rate of the system to reject the authorized person, and False Acceptance Rates (FAR) is used to measure the rates of the system to accept the unauthorized person. Both performances can be expressed as:

$$\text{FRR} = \frac{\text{NFR}}{\text{NAA}} \times 100\% \quad \dots (5)$$

$$\text{FAR} = \frac{\text{NFA}}{\text{NIA}} \times 100\% \quad \dots (6)$$

Where,

NFR is referred to the number of false rejections.

NFA is referred to the number of false acceptances.

While,

NAA and NIA are the numbers of the authorized person attempts and the numbers of impostor person attempts, respectively.

Thus, low FRR and low FAR are the main objective in order to achieve both high usability and high security of the system.

Datasets and Experimental Results

The Chinese Academy of Sciences–Institute of Automation (CASIA) eye image database and Real eye image database were used in the experiment. CASIA database system for both filters (Haar & db4) used 10 persons authorized, 5 persons unauthorized and each person has 3 images. Also, the Real database system for both filters used 8 persons authorized, 5 persons unauthorized and each person has 3 images.

Table (2) shows the testing performances of FRR and FAR for both database systems, thus it can be concluded the use of gives filter Daubechies gave better results than the filter Harr for both CASIA and Real systems, and this system seems in a good level of security by the value of FAR (False Acceptance Rates).

Table (2): Testing performance of iris.

Database system	Type of filter	FRR(100%)	FAR(100%)
CASIA(version 1.0)	Haar	55	0
CASIA(version 1.0)	db4	25	0
REAL	haar	33.3	0
REAL	db4	4.1	0

Conclusions

The analysis was carried out to compare the results of FFBNN between two types of wavelet transform (Haar and Daubechies) for both database systems (CASIA & REAL).

In CASIA Database System, the Artificial Neural Network (ANN) for both filters was trained with input layer consisting of 25 neurons, two hidden layers each layer consists of 10 neurons and output layer consisting of 10 neurons, and the proportion of the training was 100%. For Haar filter, the performance of training was measured by the means of squared error which was $9.92e-11$ and time equal to 38 second with 1000 iterations, while for Daubechies filter the MSE was $9.64e-11$ and time equal to 15 second with 1000 iterations. Finally, the accuracy of testing result for Haar filter was 84.2%, while for Daubechies filter was 92.8%. In this system, according to the results gained by the above experiences, the Daubechies filter was the best in time and error compared with the Haar filter.

Also, in the Real Database System, the Artificial Neural Network (ANN) for both filters was trained with input layer consisting of 25 neuron, two hidden layers each layer consists of 10 neurons and output layer consisting of 8 neurons, and the proportion of the training was 100%. For Haar filter the performance of training was measured by the means of squared error which was $9.86e-11$ and time equal to 89 second with 2000 iterations, while for Daubechies filter, the MSE was $9.76e-11$ and

time equal to 17 second with 2000 iterations. Finally, The accuracy of testing result for Haar filter was 90%, while for Daubechies filter was 98.7%. In this system, according the results obtained by the above experiences, the Daubechies filter was the best in time and error compared with the Haar filter. Through the table (2), the performance is equal zero of FAR for both database systems which have two types of filter.

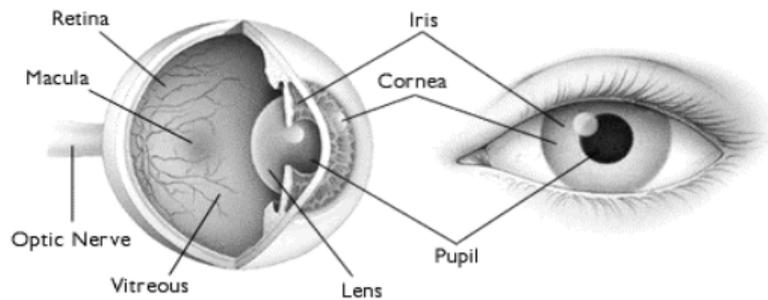


Figure (1): A front-on view of the human eye [1].

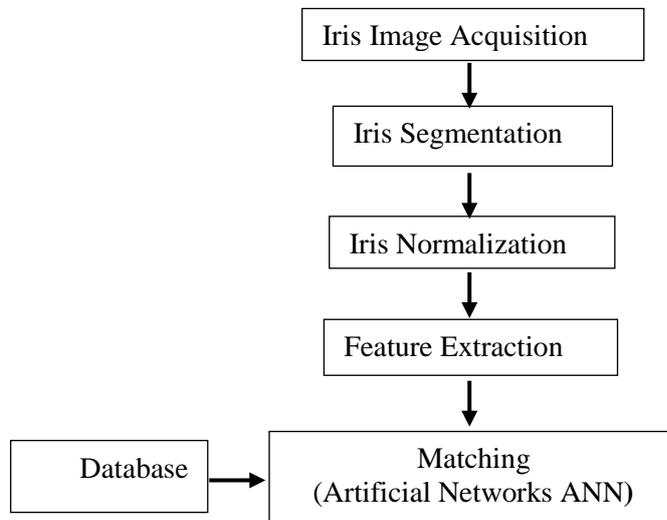


Figure (2): Block diagram of the proposed Algorithms.

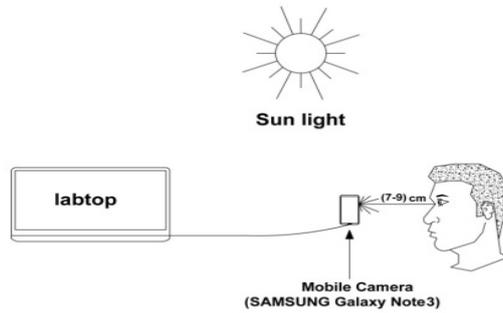
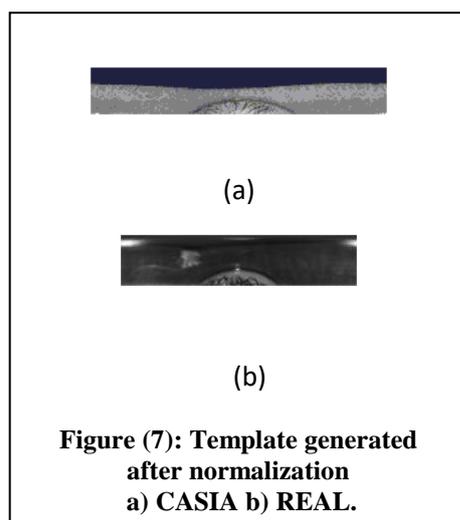
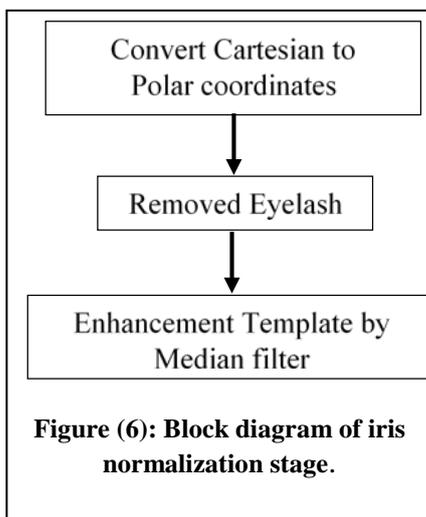
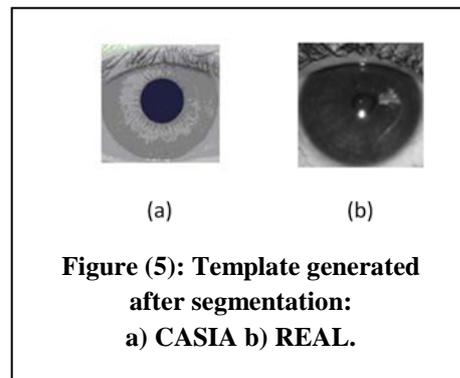
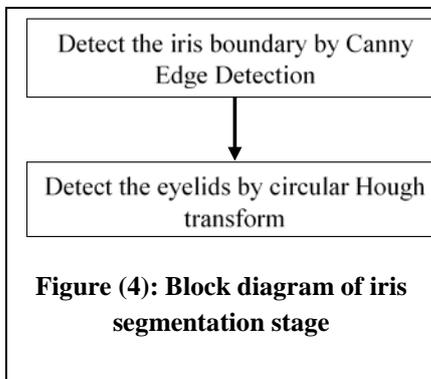


Figure (3): Proposed iris image acquisition device for real database.



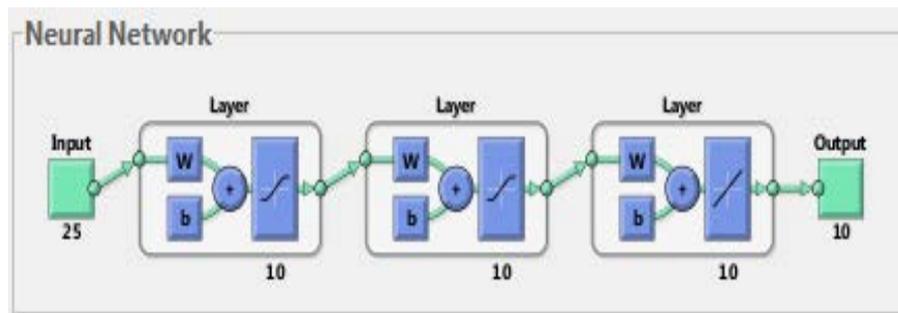
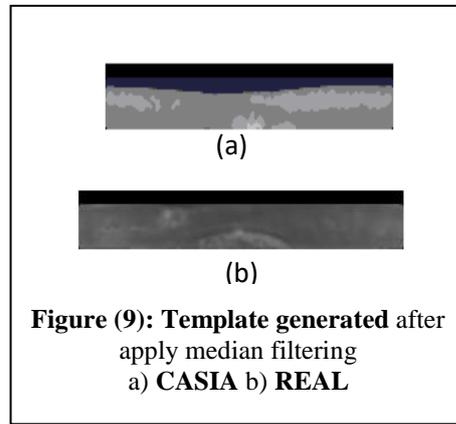
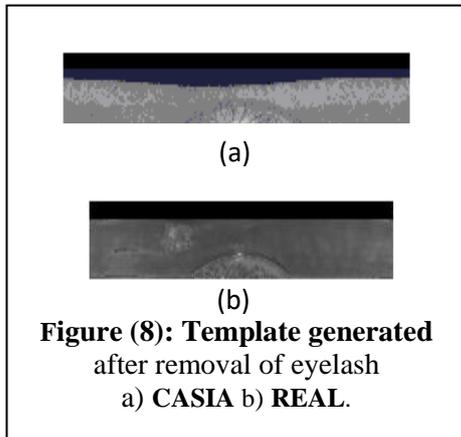


Figure (10): Training ANN Using BP for CASIA system.

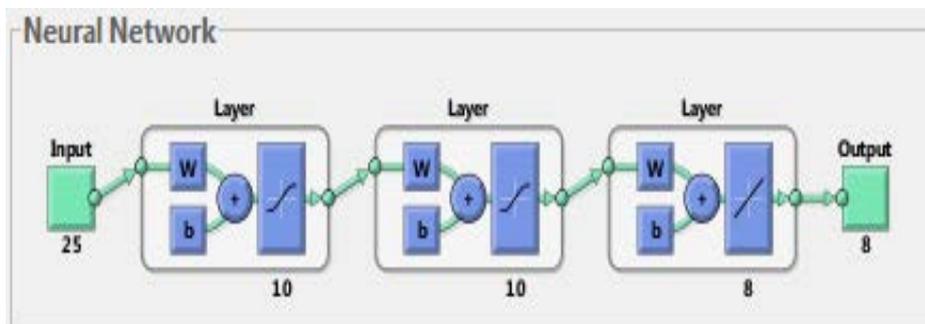


Figure (11): Training ANN Using BP for Real system.

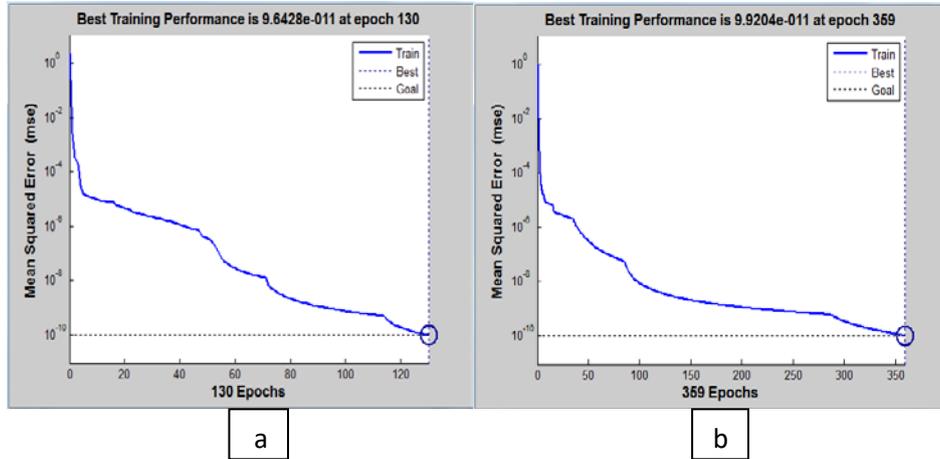


Figure (12): Performance plot for ANN training with BP algorithm for (a) filter Haar (b) filter db4.

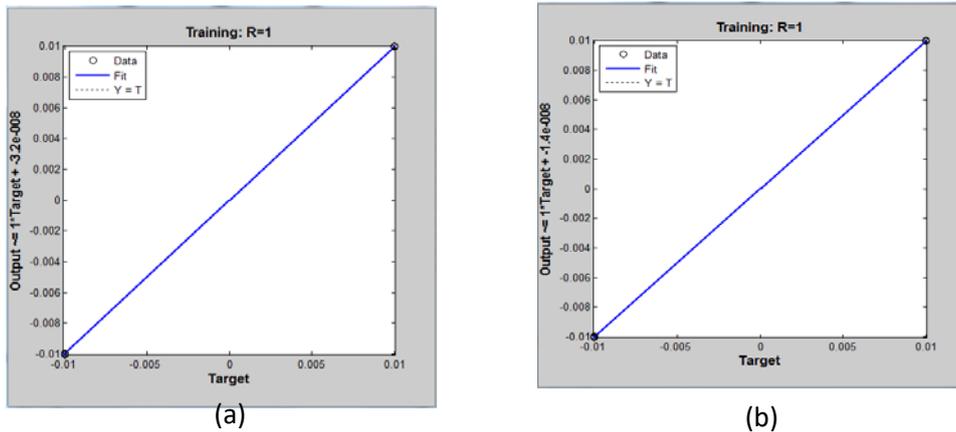


Figure (13): Regression plot for ANN training with BP algorithm for (a) filter Haar (b) filter db4.

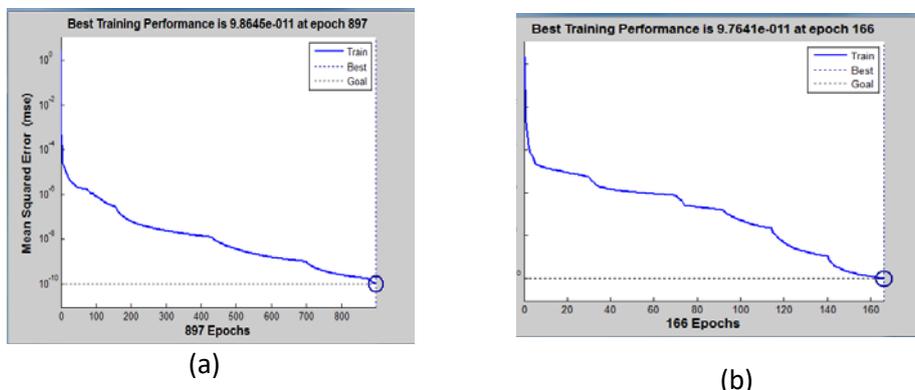


Figure (14): Performance plot for ANN training with BP algorithm for (a) filter Haar (b) filter db4.

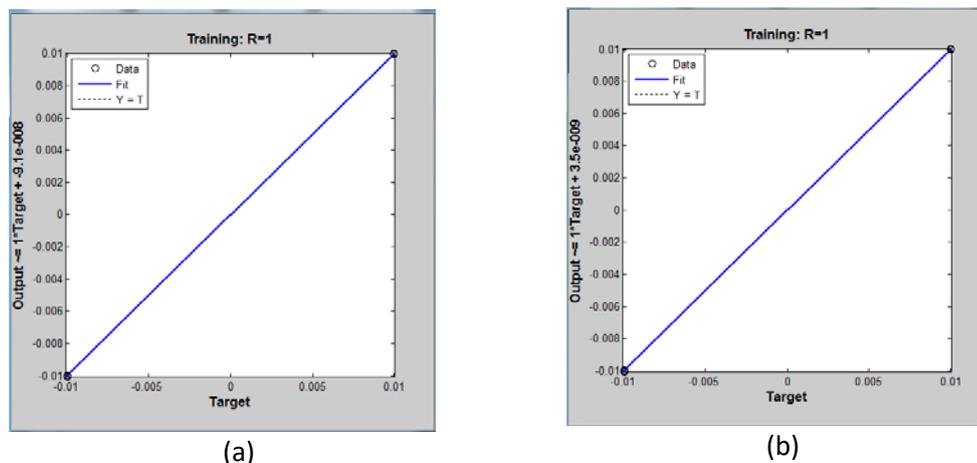


Figure (15): Regression plot for ANN training with BP algorithm for (a) filter Haar (b) filter db4.

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