Personal Identification with Iris Patterns

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الملخص

تم في هذا البحث تصميم نظام للتعرف على الأشخاص اعتمادا على بصمة القزحية. حيث تم اعتماد اتجاهين رئيسين للوصول إلى الغاية المنشودة: الأول يتكون من عمليات تحليل الصورة للتوصل إلى قاعدة بيانات كل قزحية، والثاني هو استخدام الشبكات العصبية لغرض التمييز.

تتضمن عمليات تحليل الصورة كل العمليات على صورة العين التي تم التقاطها ولغاية الوصول إلى أوضح صورة للقزحية واستخراج البيانات من هذه الصورة. تبدأ العملية بالتقاط صورة تحوي كل العين الخارجية: القزحية، البؤبؤ والرموش. لذا فصورة القزحية تحتاج إلى استخراج ومن ثم تحسين نقشتها الخاصة. إن هذه الصورة المحسنة سيتم تقسيمها إلى 100 جزء، ويمكن بسهولة استخراج الانحراف المعياري لكل جزء من هذه الأجزاء. و سيتم استخدام هذه القيم كإدخالات لشبكة عصبية من أجل التمييز.

تم استخدام إحدى طرق الشبكات العصبية للمقارنة وهي الشبكة العصبية ذات الانتشار العكسي. إن قيم الأوزان والإخراج في الشبكة العصبية المستخدمة سيتم خزنها داخل ملف نصي ليتم استعمالها في عملية التمييز. وقد نجحت الشبكة وحققت (نسبة خطأ القبول = 10% - نسبة خطأ الرفض = 10%).

ABSTRACT

This research is aimed to design an iris recognition system. There are two main steps to verify the goal. First: applying image processing techniques on the picture of an eye for data acquisition. Second: applying neural networks techniques for identification.

The image processing techniques display the steps for getting a very clear iris image necessary for extracting data from the acquisition of eye image. This picture contains all the eye (iris, pupil and lashes). So, the localization of the iris is very important. The new picture should be enhanced to bring out the pattern. The enhanced picture is segmented into 100 parts, then a standard Deviation (STD) can easily be computed for every part. These values will be used in the neural network for the identification.

For neural network techniques, Backprobagation neural network was used for comparisons. The weights and output values will be stored in a text file to be used later in identification. The Backprobagation network succeeded in identification and attained to (False Acceptance Rate = 10% - False Rejection Rate = 10%).

Keywords: Backpropagation, Image, Iris, Recognition.

1. Introduction

1.1 Biometric authentication systems

Biometrics is a methodology for recognizing and identifying people based on individual and distinct physiological or behavioral characteristics [1].

A good biometric has two basic characteristics: Stability and Distinctiveness. A stable biometric doesn't change over time. "Clearly, hair length would not be a good biometric identifier". A distinctive biometric is unique to an individual [1].

Traditional methods for personal identification are based on what a person possesses (a physical key, ID card, etc.) or what a person knows (a secret password, etc.). These methods have some problems. Keys may be lost, ID cards may be forged, and passwords may be forgotten. In recent years, biometric personal identification grows as an interesting field from industrial and academic point of view[2].

1.2 Types of biometric systems

Biometric technologies can be divided into two major categories according to what they measure:

- Systems based on physiological characteristics of a person (such as the fingerprint or hand geometry).
- Systems based on behavioral characteristics of a person (such as signature dynamics).

Biometric systems from the first category are usually more reliable and accurate as the physiological characteristics are easier to repeat and often are not affected by current (mental) conditions such as stress or illness [3].

In general physiological biometrics systems are more accurate and have higher cost than behavioral biometrics systems, see Fig. (1): [1].

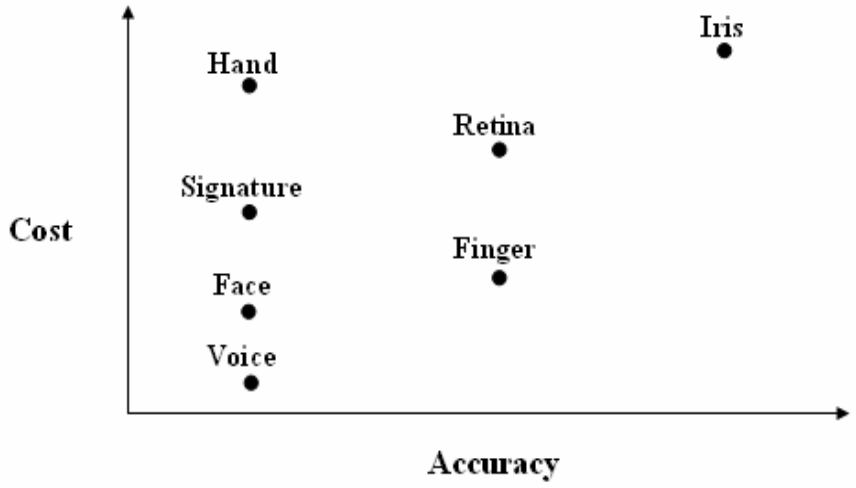

Figure (1): Comparison between cost and accuracy for different biometric systems

1.3 Features of iris recognition

Iris is a colored circular muscle, which is beautifully pigmented giving us our eye's color (the central aperture of the iris is the pupil). This circular muscle controls the size of the pupil so that more or less light, depending on conditions is allowed to enter the eye [1].

Iris consists of lines, dots, rings, pits, crypts, freckles, stromal fibers, contraction furrows, collagenous filaments, and serpentine vasculature. Scientists have identified 250 features unique to each person's iris – compared with about 40 for fingerprints – and it remains constant through a person's life, unlike a voice or a face, fingerprint and hand patterns can be changed through alteration or injury. Even identical twins do not have identical irises. Iris identification is more accurate than other high-tech. ID Systems available that scans voices, faces, and fingerprints [1]. See Fig. (2).

The iris begins to form in the third month of gestation and the structures creating its pattern are largely complete by the eighth month, although pigment accertion can continue into the first postnatal years [4].

In addition, as an internal (yet externally visible) organ of the eye, the iris is well protected from the environment and stable over time [4].

The pattern of the human iris differs from person to person, even between monocular twins. Because irises react with such sensitivity to light, causing the size and shape to change continuously, counterfeiting based on iris patterns is extremely difficult. However, the iris pattern is so highly detailed that it is also difficult to identify [5].

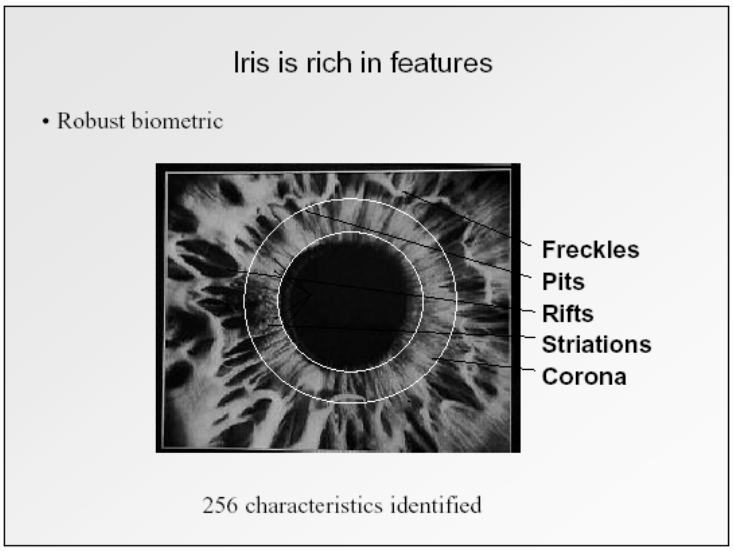

Figure (2): Iris features

1.4 Aim and structure of the project

The general purpose is a high confidence and real time recognition of an individual's identity by mathematical analysis of the random patterns that are scanned from the iris of an eye [6].

On this study, there is two main schemes to reach the target. First: The whole image processing on the picture of an eye. Second: The neural networks which used for identification.

2. Image Processing

2.1 Image acquisition

An important and difficult step of an iris recognition system is image acquisition. Since iris is small in size and dark in color (especially for Asian people), it is difficult to acquire good images for analysis using the standard Charged Coupled Device (CCD) camera and ordinary lighting[2]. We have designed our own device for iris image acquisition, which can deliver iris image of sufficiently high quality. In which the process of measurement is being fast, comfortable as well as robust against natural modifications of the eyes. It employs a digital video camera (Sony DCR-TRV265E) with the box of alumina which have a hole to put the eye on it, can be a good way to capture the image. With Near-Infrared (NIR) wavelengths, even darkly pigmented irises reveal rich and complex features [7]. See Fig. (3):

Figure (3): picture of eye taken by video camera connecting to computer using windows movie maker program

To capture the rich details of iris patterns, an imaging system should resolve a minimum of 50 pixels in iris radius [7].

2.2 Image standardization

The acquired image always contains not only the 'useful' parts (iris) but also some 'irrelevant' parts (e.g. eyelid, pupil etc.). under some conditions, the brightness is not uniformly distributed. In addition, different eye-to-camera distance may result in different image sizes of the same eye. For the purpose of analysis, the original image needs to be preprocessed [2].

Both the inner boundary and the outer boundary of a typical iris can be taken as circles. But the two circles are usually not co-centric. Compared with the other part of the eye, the pupil is much darker. We detect the inner boundary between the pupil and the iris by means of thresholding. The outer boundary of the iris is more difficult to detect because of the low contrast between the two sides of the boundaries [2].

The size of the pupil may change due to the variation of the illumination and the hippus, and the associated elastic deformations in the iris texture may interfere with the results of pattern matching. For the purpose of accurate texture analysis, it is necessary to compensate this deformation [2]. By white light flash from the video camera we can get a fixed narrow pupil size, it is easy to map the iris to a square block of texture of a fixed size 100×100 pixels. See Fig. (4.a) and Fig. (4.b).

(a) **(b)**

Figure (4): Standardization for:

a) Picture acquisition

b) Picture after preprocessing

2.3 Image enhancement

The original iris image has low contrast and may have non-uniform illumination caused by the position of the light source. These may impair the result of the texture analysis. Therefore it is necessary enhancing the image to reduce the effect of non-uniform illumination [2].

2.4 Steps of image analysis:

Fig. (5) shows the block diagram of the steps adopted in processing the eye image.

1- Normal eye picture: Captured picture is on type JPG with size 240×320×3 pixels scanning the whole eye area.

2- Unsharp filter: A 3-by-3 unsharp masking filter which creates from the negative of the Laplacian filter with parameter alpha.

$$\frac{1}{(a+1)}\begin{bmatrix} -a & a-1 & -a \\ a-1 & a+5 & a-1 \\ -a & a-1 & -a \end{bmatrix} \quad \dots (1)$$

Alpha must be in the range 0.0 to 1.0 [8]. So, it is taken equal to 0.2.

3- Dividing picture matrix: Three colors can be separated from the original image to have two dimensional image matrix for every color (Red, Green and Blue), the green part will be taken for analysis as the value of its wavelength range is located in the middle of the other two ranges.

4- Histogram equalization: For equalizing image data, it implies the finding of the transform function T() which produce a value s for every pixel value r in the original image:

$$s = T(r)$$

By choosing the transformation function [9]:

$$s = T(r) = \int_0^r P_r(w)dw \quad \dots (2)$$

5- Low pass filter: To extract the pupil and any darkness part of the picture. The used mask is:

```
h = [ 1   1   1;
      1   8   1;
      1   1   1 ];
```

6- Translate to Binary picture: An image containing only black and white pixels, it is represented as a logical array of 0's and 1's.

7- Density darkness of pupil: Morphological dilation operations performed on the binary picture to expand all sides of the foreground component by ones.

8- Reference point for iris location: This is performed by repeating the dilation process until reaching last black point.

9- The boundary of pupil: It is the boundary making edge between pupil and iris, it can easily be found by using Sobel filter, The coefficients of Sobel filter are:

BV_0	BV_1	BV_2
BV_7	F(i,j)	BV_3
BV_6	BV_5	BV_4

The mid coefficient is calculated in Sobel by this equation:

$$F(i,j) = (x^2+y^2)^{1/2} \quad \dots(3)$$

10- The Iris picture: The iris picture can be extracted at this stage in a square box (100 × 100). If the reference point has the coordinate (x_0, y_0) then the texture box for iris with the pupil in natural narrow size can be extracted by this statement:

BW=BW0([x0-49:x0+50],[y0-49:y0+50]);

11- Average filter: Each output pixel value is set to an "average" of the pixel values in the neighborhood of the corresponding input pixel.

12- Enhancement contrast filter: Morphological Top-hat and bottom-hat filtering can be used together to enhance contrast in an image.

13- Histogram equalization: it is important to equalize the values of the previous texture image such that the output image will contain a uniform distribution of intensities.

Fig. (6) and Fig. (7) shows the image analysis picture for each step:

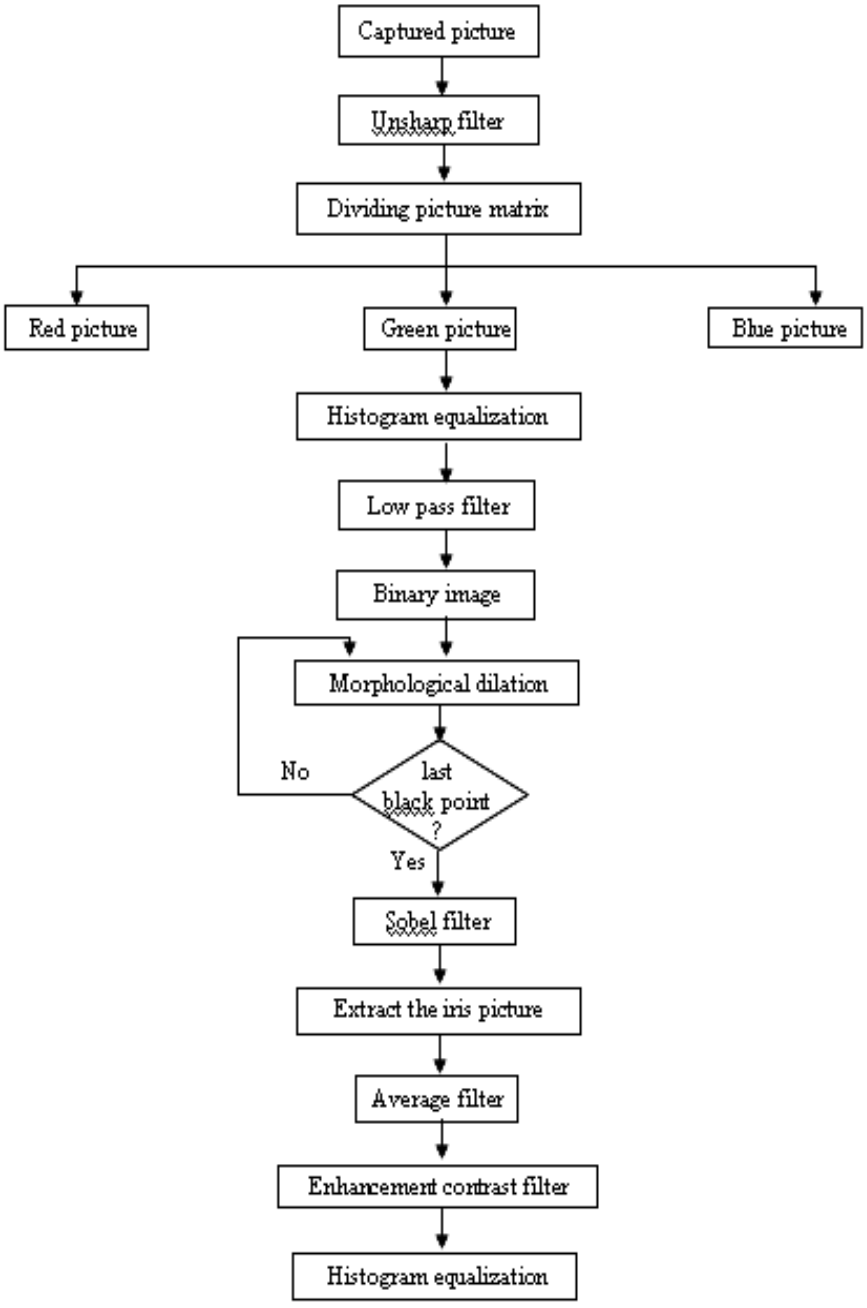

Figure (5): The block diagram of the steps adopted in the analysis of the eye image

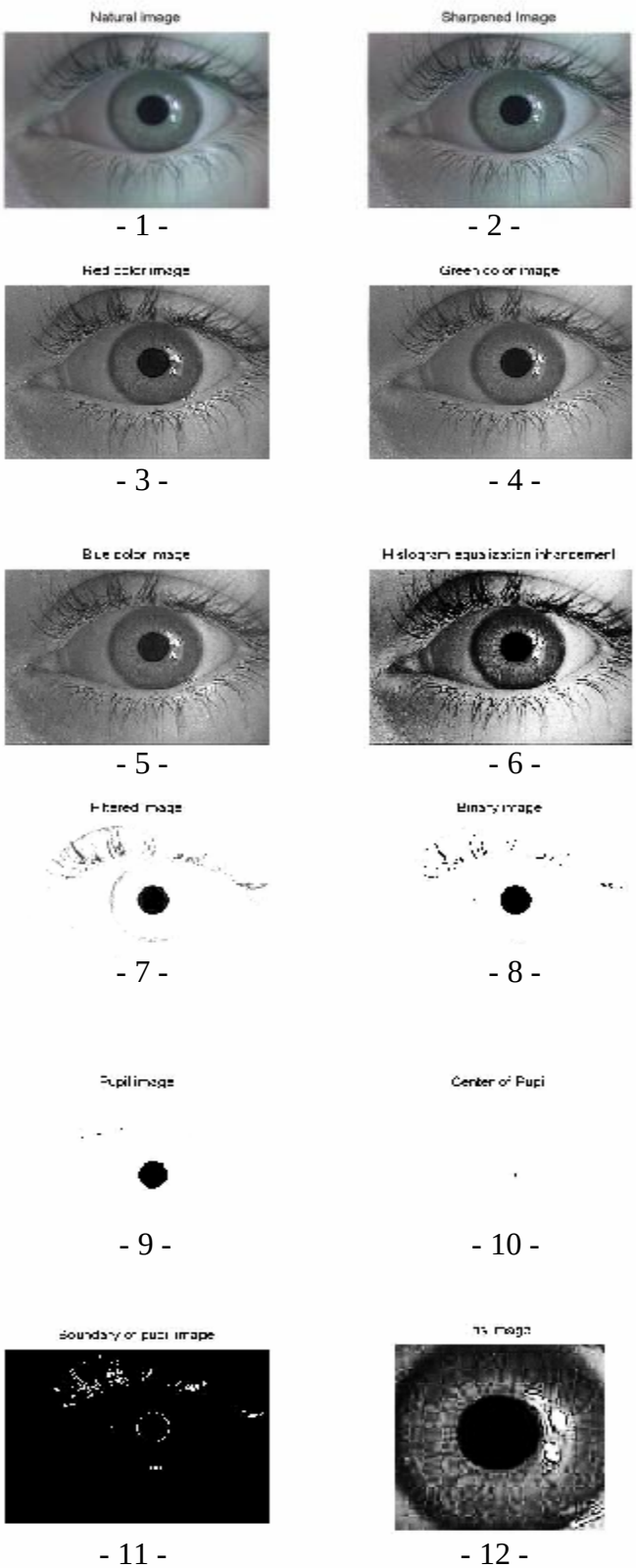

Figure (6): Steps of analysis from picture acquisition of eye until iris localization and extraction

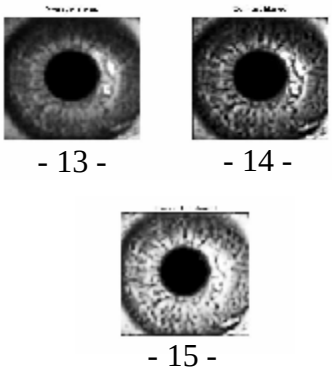

Figure (7): Steps of analysis for iris enhancements

3. Neural Networks

3.1 Facility of neural networks

The neural network techniques could be adopted for the purpose of comparison and identification.

Applications using such nets can be found virtually in every field that uses neural nets for problems that involve mapping a given set of inputs to a specified set of target outputs. As is the case with most neural networks, the aim is to train the net to achieve a balance between the ability to respond correctly to the input patterns that are used for training (memorization) and the ability to give reasonable (good) responses to input that is similar, but not identical, to that used in training (generalization).

3.2 Backpropagation neural network

Properly trained backpropagation networks tend to give reasonable answers when presented with inputs that they have never seen. Typically, a new input leads to an output similar to the correct output for input vectors used in training that are similar to the new input being presented. This generalization property makes it possible to train a network on a representative set of input/target pairs and get good results without training the network on all possible input/output pairs[8].

The training of a network by backpropagation involves three stages: the feedforward of the input training pattern, the calculation and backpropagation of the associated error, and the adjust of the feedforward phase. Even if training is slow, a trained net can produce its output very rapidly. Numerous variations of backpropagation have been developed to improve the speed of the training process.

Although a single-layer net is severely limited in the mappings it can learn, a multilayer net (with one or more hidden layers) can learn many continuous mapping to an arbitrary accuracy. More than one hidden layer may be beneficial for some applications, but one hidden layer is sufficient[10].

3.3 Architecture of standard backpropagation

A multilayer neural network with one layer of hidden units (the Z units) is shown in Fig. (8). The output units (the Y units) and the hidden units also may have biases (as shown). The bias on a typical output unit Y_k is denoted by w_{0k}; the bias on a typical hidden unit Z_j is denoted v_{0j}. these bias terms act like weights on connections from units whose output is always 1. Only the direction of information flow for the feedforward phase of operation is shown. During the backpropagation phase of learning, signals are sent in the reverse direction[10].

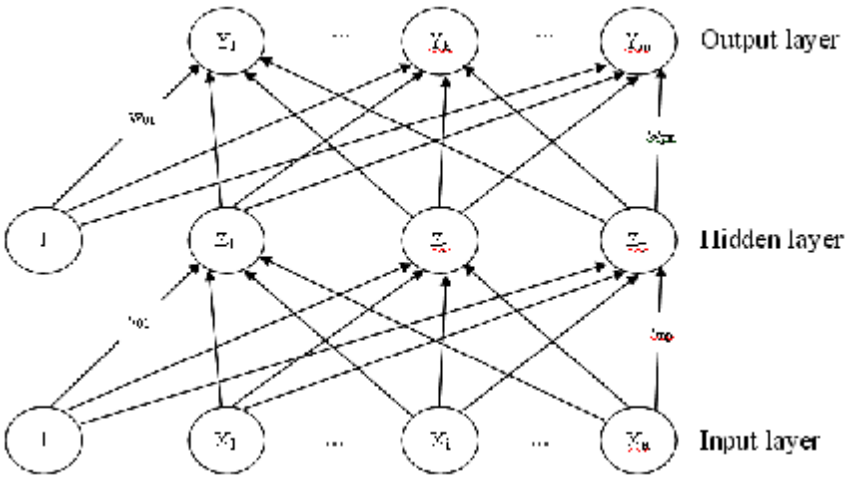

Figure (8): Backpropagation neural network with one hidden layer.

3.4 Training algorithm for backpropagation neural network

The general training algorithm for one hidden layer backpropagation neural network, which is adequate for a large number of applications, is as follows:

Step 0. Initialize weights.

(Set to small random values).

Step 1. While stopping condition is false. do Steps 2-9.

Step 2. For each training pair. do Steps 3-8.

Feedforward:

Step 3. Each input unit (x_i, i = 1……n) receives input signal x_i and transports this signal to all units in the layer above (the hidden units).

Step 4. Each hidden unit (z_j, j = 1……p) sums its weighted input signals.

$$z_in_j = v_{0j} + \sum_{i+1}^{n} x_i v_{ij} \qquad ...(4)$$

Where v_{0j},v_{ij} is the bias and weights on a typical hidden units, x_i is the input signal and z_in_j is the input net of hidden layer.

Then applies its activation function to compute its output signal.

$z_j = f(z_in_j)$.

and sends this signal to all units in the layer above (output units).

Step 5. Each output unit (y_k, k = 1 …… m) sums its weighted input signals.

$$y_in_k = w_{0k} + \sum_{j=1}^{p} z_j w_{jk} \qquad ... (5)$$

Where w_{0j},w_{ij} is the bias and weights on a typical output units, z_i is the hidden signal and y_in_j is the input nets of output layer.

Then applies its activation function to compute its output signal.

$y_k = f(y_in_k)$.

Backpropagation of error:

Step 6. Each output unit (Y_k, k = 1……..m): receives a target pattern corresponding to the input training pattern, computer its error information term.

$$d_k = (t_k - y_k)\, f'(y_in_k) \qquad ... (6)$$

Where t_k is the desigred target and d_k is the error on output layer.

So, to alculate its weight correction term (used to update w_{jk} later).

$$Dw_{jk} = ad_kz_j \quad ...(7)$$

Where a is the learning rate.

So, to calculates its bias correction term (used to update w_{0k} later).

$$Dw_{0k} = ad_k \quad ...(8)$$

And sends d_k to units in the layer below.

Step 7. Each hidden unit (Z_j, j = 1……p) sums its delta inputs (from units in the layer above).

$$d_in_j = w_{0k} + \sum_{k+1}^{m} d_k w_{jk} \quad ...(9)$$

Where d_in_j is the errer inputs on hidden layer.

This error inputs multiplies by the derivative of its activation function to calculate its error information term.

$$d_j = d_in_j f'(z_in_j) \quad ...(10)$$

Where d_j is the errer on hidden layer.

Calculates its weight correction term (used to update v_{ij} later)..

$$Dv_{ij} = ad_jx_i \quad ...(11)$$

And calculates its bias correction term (used to update v_{0j} later).

$$Dv_{0j} = ad_j \quad ...(12)$$

Update weights and biases:

Step 8. Each output unit (Y_k, k = 1…….m) updates its bias and weights (j = 0……..p):

$$w_{jk}(new) = w_{jk}(old) + D\,w_{jk} \quad ...(13)$$

Each hidden unit (Z_j, j = 1……..p) updates its bias and weights (i = 0……n):

$$v_{ij}(new) = v_{ij}(old) + D\,v_{ij} \quad ...(14)$$

Step 9. Test stopping condition. [10].

3.5 Momentum technique

In backpropagation with momentum. The weight change is in a direction that is combination of the current gradient and the previous gradient: This is a modification of gradient descent whose advantages arise chiefly when some training data are very different from the majority of the data (and possibly even incorrect), is desirable to use a small learning rate to avoid a major disruption of the direction of learning when a very unusual pair of training patterns is presented. However it is also preferable to maintain training at a fairly rapid pace as long as the training data are relative similar.

Convergence is sometimes faster if a momentum term is added to the weight update formulas. In order to use momentum, weights (or weight updates) from one or more previous training patterns must be saved. For example, in the simples form of backpropagation with momentum, the new weights for training step t+1 are based on the weights at training steps t and t-1. the weight update formulas for backpropagation with momentum are

$$w_{jk}(t+1) = w_{jk}(t) + ad_kz_j + m[w_{jk}(t)-w_{jk}(t-1)] \quad \ldots(15)$$

or

$$Dw_{jk}(t+1) = ad_k z_j + mDw_{jk}(t) \quad ...(16)$$

and

$$v_{ij}(t-1) = v_{ij}(t) + ad_j x_i + m[v_{ij}(t)-v_{ij}(t-1)] \quad ...(17)$$

or

$$Dv_{ij}(t+1) = ad_j x_i + mDv_{ij}(t) \quad ...(18)$$

Where t is the step training time, a is the learning rate, d_j and d_k is the error on the hidden and output layer respectively and μ is the momentum parameter which constrained to be in the range from 0 to 1, exclusive of the end points [10].

3.6 Suggested topology

The Backpropagation network which is suggested has one node in the input layer, three nodes in the hidden layer and one node in the output layer. The activation functions used are tan-sigmoid activation functions in the hidden layer and pure-linear activation function in the output layer. And momentum technology is used to speed up convergence. By this topology the Backpropagation network is able to recognize a sample among different irises.

As mentioned previously, image segmented into 100 square matrixes and the standard deviation (STD) calculated for each segment as (STD1, STD2, ……, STD100). These values flow serial to the input layer for training.

4. Results

It is important to see differences between the iris images for different persons and a convergence between the iris images for the same person in data values. After image segmentation, taking STD values for each image segment may give suitable results because of its features, where it reduces the huge numbers of iris image data and exhibits the variations between image segments. This step prepares the iris pattern data to be used in the next stage neural network. Fig. 9 shows that the STD values for two images had the same iris pattern. It proves that image data is nearly for the same iris person pattern.

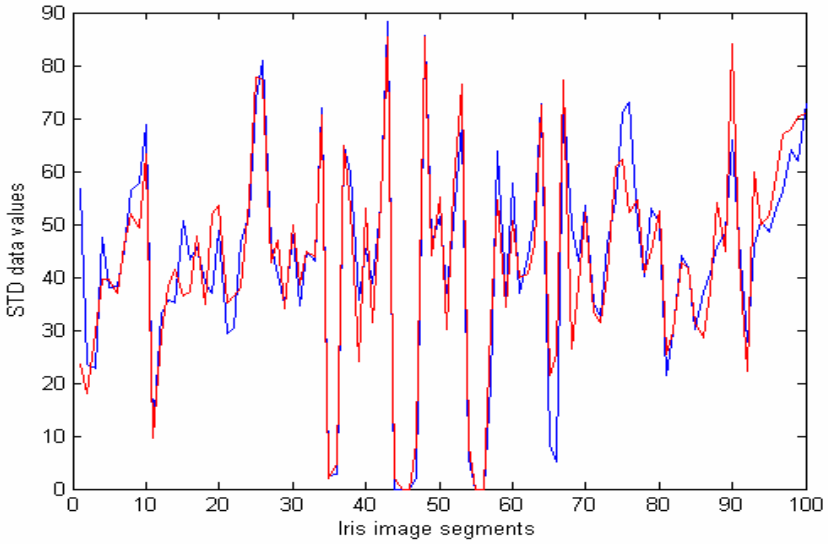

Fig. 9: STD curves of two iris segmentation images for the same eye

In the previous figure, the little differences for the values between the two images are due to the random noise from camera and the small change in illumination. This equilization for the same iris images STD values will lead to give different STD curves between different iris images. Fig. 10 below shows the differences between the right iris and the left iris for the same person:

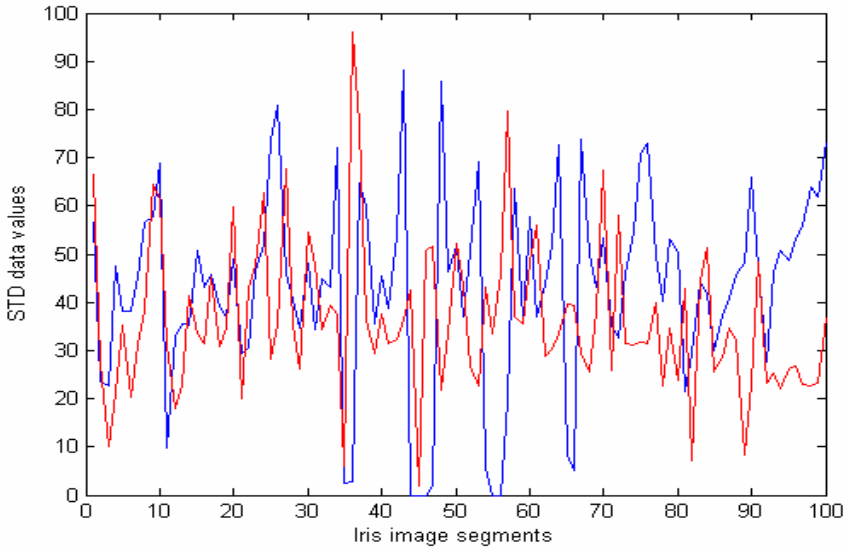

Fig. 10: STD curves of the right iris and the left iris for the same person

The backpropagation network topology, as shown in Fig. 11, is a multiple-layer consisting of 1 node for input, 3 nodes for hidden and 1 node for output. It has 10 weights and biases to be stored in the database file. The data input stream is serial for each iris image. By using this network in the system, an execution time is about 7 seconds or less for iris image training due to the feedbackword in BPN learning algorithm.

Backpropagation network topology attained FAR 10% and FRR 10%.

The network can train for 100 samples. Such that any iris introduced to the system could identified if it is on these trained sample and rejected if it is out the trained samples. The calculated weights (including biases) are stored in the database file and become the comparison base to detect any other iris image. Every iris image to be tested enters the network in the same way, the output values will be compared with the outputs of the original image. Then the error will be compared with 0.00001 tolerance value.

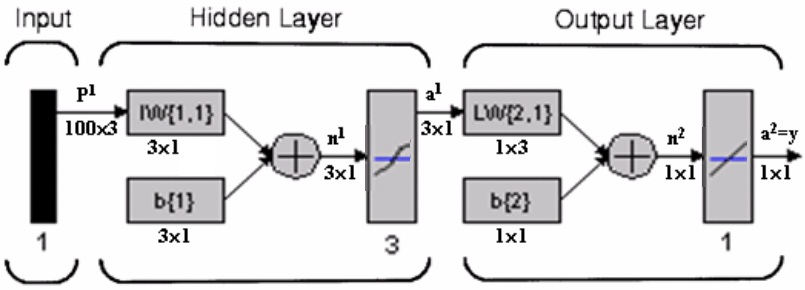

Fig. 11: Backpropagation network architecture

5. Conclusion

A powerful practical identification system is designed, this system has the ability to discriminate 100 samples with capability to extend this discriminations power to any required number according to the application.

Image processing techniques were a dopted to acquire all the data necessary for the target. STD statistical analysis was employed to accommodate the acquired image data with the input target of the neural network.

Backpropagation trained neural network was used to compare the sample under test with the training samples, with the following topology:

1- The network contain one node on input layer, three nodes on hidden layer and one node on output layer.
2- The activation functions used are: sigmoid activation function for the hidden layer and linear activation function for the output layer.
3- Momentum technology is adopted.

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