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# ARTIFICIAL NEURAL NETWORK AIDED RETINA BASED BIOMETRIC IDENTIFICATION SYSTEM

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**Abstract-** Artificial Neural Network (ANN)s are efficient means of prediction, optimization and recognition. Retina is a unique biometric pattern that can be used as a part of a verification system. An ANN can be configured and trained to handle such variations observed in the texture of the retina. The specialty of the work is associated with the fact that if the ANN is configured properly it can tackle the variations in the retinal images and that way provides the insights for developing a system which requires the samples for verification and authorization. A system designed to provide authentication decision using the input can be a reliable means of verification. Such a system designed using ANN and using retina input is described here. Experimental results show that the system is reliable enough for considering it as a part of a verification mechanism.

***Keywords-*** artificial neural network*; retina; blood vessel*

## I. INTRODUCTION

“Biometrics” the term is usually associated with the use of unique physiological characteristics to identify an individual. The application which most people associate with biometrics is security. However, biometric identification has eventually a much broader relevance as computer interface becomes more natural. Knowing the person with whom you are conversing is an important part of human interaction and one expects computers of the future to have the same capabilities.

A number of biometric traits have been developed and are used to authenticate the person's identity. The idea is to use the special characteristics of a person to identify him. By using special characteristics we mean the using the features such as face, retina, handwriting, veins, voice, iris, fingerprint and signature etc. The method of identification based on biometric characteristics is preferred over traditional passwords and PIN based methods for various reasons such as: The person to be identified is required to be physically present at the time-of-identification. Identification based on biometric techniques obviates the need to remember a password or carry a token. A biometric system is essentially a pattern recognition system which makes a personal identification by determining the authenticity of a specific physiological or behavioral characteristic possessed by the user. Biometric technologies are thus defined as the "automated methods of identifying or authenticating the identity of a living person based on a physiological or behavioral characteristic". Retina identification is an automated method that provides true identification of the person by acquiring an internal body image which is difficult to counterfeit [1]. Retina identification has found application in high security environments. Retina is a unique biometric pattern that can be used as a part of a verification system. Artificial Neural Network (ANN)s are efficient means of prediction and recognition [2]. An ANN can be configured and trained to handle such variations observed in the texture of the retina. The specialty of the work is associated with the fact that if the ANN is configured properly it can tackle the variations in the retinal images. This way the approach provides the insights for developing a system which requires these samples for verification and authorization. A system designed to provide authentication decision using this input can be a reliable means of verification. Such a system based on ANN and designed using retina input is described here. Experimental results show that the system is reliable enough for considering it as a part of a verification mechanism.

The rest of the paper is organized as follows: Section II provides the brief description of a generic retina recognition system. Section III provides the background principles related to the working of the proposed model. All experimental results and related discussion is provided in Section IV -V. This paper is concluded by summing up the work in Section VI. Some of the relevant literatures are cited between [1]-[2] and [4]-[8].

## II. BASIC THEORITICAL ASPECTS RELATED TO THE PROPOSED SYSTEM

Here we briefly cover the basic theoretical aspects related to the work.

*A. Retina:* Retina is the vascular pattern of the eye which is not easy to change and replicate. The patterns are different for right and left eye. The retina of an individual is unique and remains unchanged over a lifetime [3].

*B. Retina Recognition:* Such a system captures and analyzes the patterns of blood vessels on the thin nerve on the back of the eyeball that processes light entering through the pupil. Retinal patterns are highly distinctive traits. Every eye has its own totally unique pattern of blood vessels. Even the eyes of identical twins are distinct [1].

*C. Artificial Neural network:* An artificial neural network is a system based on the operation of biological neural networks or it is an emulation of biological neural system. The ANN can be defined to be parallel, distributed processor that has a natural capacity for retaining experimental knowledge and extending it for use in subsequent stages. ANNs have seen an explosion of interest over the last few decades and are being successfully applied across an extraordinary range of problem domains. The basic idea behind the use of ANN in Retina Recognition System are :

- A neural network can perform tasks that a linear program cannot.
- When an element of the neural network fails, it can continue without any problem by their parallel nature.
- A neural network learns and does not need to be reprogrammed.
- It can be implemented in any application.
- It can be implemented without any problem.

Figure1. shows an image of the retina structure.

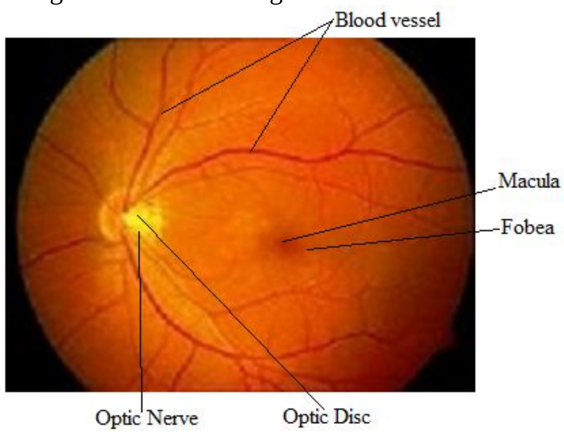


**Figure 1: Structure of a retina**

## III. SYSTEM MODEL

A generic retina based biometric identification system in block diagram form is shown in Figure 2.

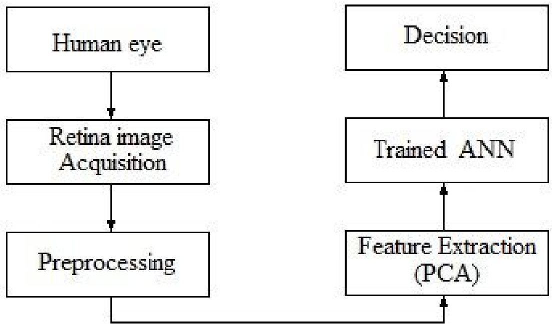


**Figure 2: Process logic of the complete system**

It involves the following modules:

- Image acquisition: It is required to capture a sequence of input images.
- Image preprocessing: It includes various stages which should be taken for making an image suitable for manipulation and interpretation by subsequent stages. The steps include removal of noise and variation of intensity recorded, sharpening, improving the contrast and strengthening the texture of the image. Another important aspect is image restoration which extracts image information from a degraded form to make it suitable for subsequent processing and interpretation [5].
- Feature extraction: It is a process through which certain vital information and details of an image section is captured for subsequent interpretation.
- Classification: This is the key component of the system and determines the system's performance to a large extent. An ANN is used as classifier and it produces the correct result by classifying the feature extracted templates and matching these features with known patterns in the feature database.

## IV. DESIGN AND IMPLEMENTATION OF THE PROPOSED SYSTEM

In this work the focus is to study the system performance of the identification system that provides reliability, accuracy and reduced overall match speed. The steps of the algorithms of the system model are shown in Figure 3.

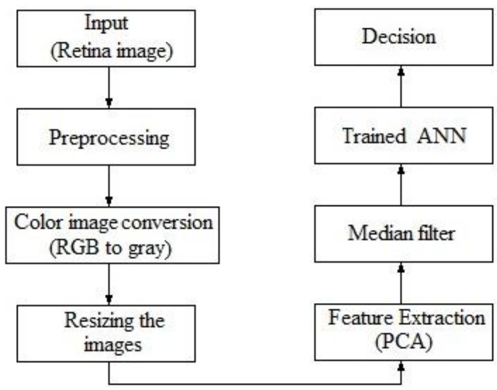


**Figure 3: System model**

Figure 3 shows a system model of retina based verification system which includes the relevant blocks in the process logic shown in Figure 2. In this proposed model, a multi stage approach is used. The decision obtained from the system is used to generate the response. These stages are retina image acquisition, image preprocessing, feature extraction using Principal Component Analysis (PCA), use of Median filter to remove noise of the input images, trained with artificial neural network and decision. During image acquisition the operations are performed separately. Retina images captured by the Fundus camera are pre-processed for subsequent manipulation.

Retina image preprocessing includes gray image conversion, resizing the original images into required size. Original retina images, gray scale retina images, resized retina images are shown in figures 4 to 6 respectively. The next stage is feature extraction. Retina features include patterns of blood vessels [2]. In this proposed model, we are using Principal Component Analysis (PCA) to extract the retina features.

PCA is a way of identifying patterns in data, and expressing the data in such a way as to highlight their similarities and differences. Since patterns in data can be hard to find in data of high dimension, where the luxury of graphical representation is not available, PCA is a powerful tool for analyzing data. The other main advantage of PCA is that once you have found these patterns in the data, and you compress the data, i.e. by reducing the number of dimensions, without much loss of information. Principal Components Analysis (PCA) reduces the data into two dimensions.

The median filter is a nonlinear digital filtering technique used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. Median filtering is very widely used in digital image processing because under certain conditions, it preserves edges while removing noise. The function medfilt2 ( ) performs 2-D median filtering. The syntax b=medfilt2 (A, [m n]) performs median filtering of the matrix A in two dimensions.

In this proposed model, ANN is used as classifier for recognition. Here, a feed forward back propagation ANN is configured for the classification of the retina. For this retina based system, the feature length is 300 which determine the size of the input layer of the ANN. The ANN considered have two hidden layers and its key specifications are provided in Table I.

We have considered an SNR variation of 0 to 3 dB. The ANN is trained for 200 to 4000 epochs.

The results obtained are average values of at least fifteen trials for the epochs considered.

**Table I: ANN specifications**

| | |
|---|---|
| Input Data Size | For retina- PCA features of length 300. |
| SNR | 0 to 3db |
| ANN type | MLP with two hidden layers. First hidden layer- 1.5 times the length of feature vector and second hidden layer 0.5 times of the feature vector. |
| ANN training method | Back propagation with Levenberg-Marquardt optimization |
| Average training epochs | MLP- 200 to 4000 |
| Mean square error (MSE) goal | $10^{-4}$ |

## V. EXPERIMENTAL DETAILS AND RESULTS

The performance of Retina Recognition System (RRS) is analyzed in terms of computational speed and reliability. The overall computational time taken by the system is reduced to a greater level. A total of 40 identical retina images have been provided to the system for training, validation and testing of the system. After extensive training, the system is subjected to certain variations with signal to noise ratio (SNR) range between 0 to 3 dB to achieve robustness and proper recognition. The ANN considered is configured using the specifications shown in Table I.

**Table II: Average success rates achieved between a few numbers of training epochs.**

| Epochs | % Success rate of RRS |
|---|---|
| 300 | 86 |
| 500 | 91 |
| 1000 | 92 |
| 2000 | 92.5 |
| 3000 | 93.2 |
| 4000 | 94.5 |

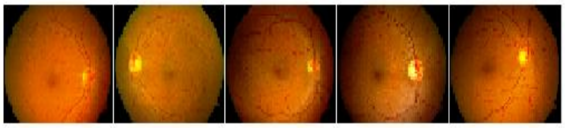

**Figure 4: Original retina images**

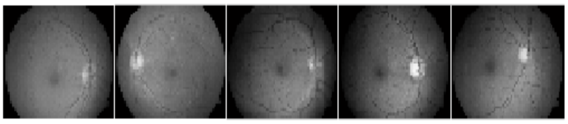

**Figure 5: Gray scale retina images**

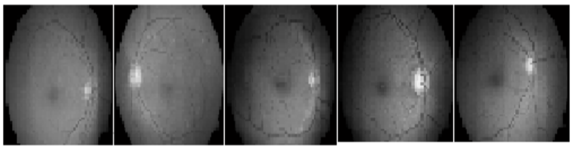

**Figure 6: Resized retina images**

The MSE convergence plot shown by the ANN during training while configuring the RRS is shown in Figure 7.

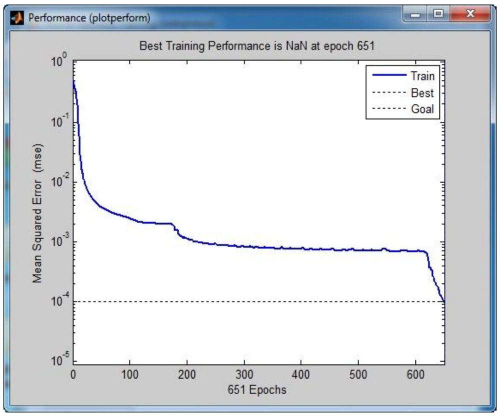


**Figure 7: MSE convergence plot of the ANN**

For retina images, features are extracted using principal component analysis (PCA). The average test results of recognition for various training epochs for the RRS is shown in Table II.

The epochs are between a few hundreds to a few thousands and the success rate is around 85 to 95%. The training time required is between 35 to 55 seconds for a set of ten samples each. The results are derived by performing fifteen trials for the sample sets and the average results are quoted. The strength of the proposed system is its speed, computational efficiency, robustness, dual track decision and high precision which shall make it suitable for certain application.

## VI. CONCLUSION

Here we described a retina based system where the ANN forms a critical decision support system. The specialty of the work is associated with the fact that if the ANN is configured properly it can tackle the variations in the retinal images and that way provides the insights for developing a system which requires the samples for verification and authorization. A system designed to provide authentication decision using the input can be a reliable means of verification as has been observed from experimental results. The system proposed here is reliable and efficient enough to be a part of a biometric verification system. The overall performance of the system can be enhanced further by considering more number of samples and variations and by using of statistical and hybrid systems together with ANN based blocks.

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