Retina and Fingerprint based Biometric Identification System

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ABSTRACT
Artificial Neural Network(ANN)s are efficient means of prediction, optimization and recognition. Retina is an unique biometric pattern that can be used as part of a verification system. An ANN can be configured and trained to handle such variations observed in the texture of the fingerprint and retina. Fingerprint recognition is one such area that can be used as a means of biometric verification where the ANN can play a critical rule. 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 and fingerprint images and that way provides the insights for developing a system which require these samples for verification and authorization. A system designed to provide authentication decision using these two inputs can be a reliable means of verification. Such a system designed using ANN and using retina and fingerprint inputs 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; fingerprint; minutiae; retina; blood vessel.

1. INTRODUCTION
Biometrics is an emerging field of technology using unique and measurable 'physical and behavioural' characteristics that can be processed electronically to established identification, perform v erification and automated recognition of a person. These physical attributes include facial appearance, fingerprint and geometry, handwriting, iris, retina, veins and voice. Retina identification is an automatic 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. Similarly, fingerprints also have been used for biometric identification. The fingerprint of an individual is unique and remains unchanged over a lifetime. No two persons have the same set of fingerprints. A fingerprint is formed from an impression of the pattern of ridges on a finger. A ridge is defined as a single curved segment and a valley is the region between two adjacent ridges. The minutiae which are the local discontinuities in the ridge flow pattern provide the features that are used for identification. Details such as the type, orientation and location of minutiae are taken into account when performing minutiae extraction [2]. Artificial Neural Network (ANN)s are efficient means of prediction and recognition [3]. Retina is another unique biometric pattern that can be used as part of a verification system. Fingerprint recognition is one such area that can be used as a means of biometric verification where ANN can play a critical role. An ANN can be configured and trained to handle such variations observed in the texture of the fingerprint and 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 and fingerprint 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 these two inputs can be a reliable means of verification. Such a system based on ANN and designed using retina and fingerprint inputs 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 and fingerprint 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].

2. BASIC THEORITICAL ASPECTS RELATED TO THE PROPOSED SYSTEM
Here we briefly cover the basic theoretical aspects related to the work.

2.1 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 [2].

2.2 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].

2.3 Fingerprint: These are graphical flow-like ridges and valleys present on the surface of human fingers [4]. Typically, there are two prominent types of minutiae (ridge endings and ridge bifurcations) that constitute a fingerprint pattern. A ridge ending is defined as the ridge point where it ends abruptly. A ridge bifurcation is defined as the ridge point where a ridge diverges into branch ridges. A fingerprint can be represented by the minutiae locations, types and attributes like orientation. A good quality fingerprint image typically has about 40 to 100 minutiae, but a dozen of minutiae are considered sufficient to identify a fingerprint pattern [5].

2.4 Fingerprint Recognition: It is one of the popular biometric techniques. It refers to the automated method of verifying a match between two fingerprint images. It is formed by the ridge pattern of the finger [5].

3. SYSTEM MODEL

A generic fingerprint and retina based biometric identification system in block diagram form is shown in Figure 1.

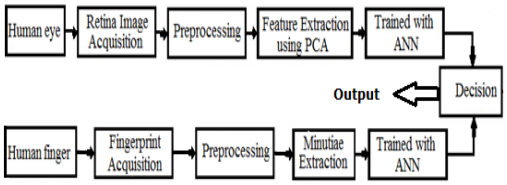

Figure 1: Process logic of the complete system

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.

4. DESIGN AND IMPLEMENTATION OF THE PROPOSED SYSTEM

In this work the focus is to study the comparison of the performance of these two identification systems that provides reliability, accuracy and reduced overall match speed.

The proposed system consists of two parts based on retina and fingerprint images.
The steps of the algorithms of the composite system model is shown in Figure 2.

TABLE I: Properties of CN

CN	Properties
0	Isolated point
1	Ending point
2	Connective point
3	Bifurcation point
4	Crossing point

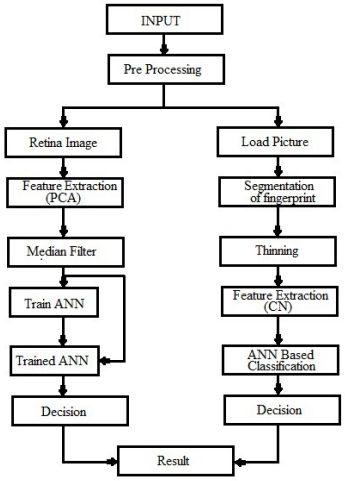

Figure 2: Composite system model

Figure 2 shows a composite system model of retina based verification system and a fingerprint based verification method which includes the relevant blocks in the process logic shown in Figure 1. In this proposed model, a multi stage approach is used. The decision obtained from the composite system is used to generate the response. 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 and resizing the original images to required size. In case of fingerprint image preprocessing, it includes image segmentation, ridge orientation estimation, ridge frequency estimation, thinning etc. 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. In case of the fingerprints, first an image thinning is done. The thinned images are next

considered for the minutiae feature extraction. The minutiae feature extraction algorithm extracts the main minutiae features required for matching two fingerprints. Here, Crossing Number (CN) method is used for minutiae extraction of fingerprints [8]. The ridge pixel can be divided into bifurcation, ridge ending and non- minutiae point based on it. The CN algorithm is working on pixel representation '1' or '0', but the decision of minutiae point can be selected for each pixel value. This method extracts the ridge endings and bifurcations from the skeletonized image by examining the local neighborhood of each ridge pixel using a 3x3window.

The CN for a ridge pixel P is given by:

$$CN=0.5\sum_{i=1}^{8}|P_i - P_{i+1}|, \quad P_9 = P_1 \text{.....(1)}$$

Where P_i is the pixel value in the neighborhood of P. For a pixel P, its eight neighboring pixels are scanned in an anticlockwise direction as follows:

P4	P3	P2
P5	P	P1
P6	P7	P8

After the CN for a ridge pixel has been computed, the pixel can then be classified according to the property of its CN value. With this formula, if CN=1 it corresponds to the end point and if CN=3, it corresponds to Bifurcation point of minutiae. Other properties of CN are described in Table I. In applying this algorithm, border area may be ignored, since there is no need to extract minutiae point on border area of the image that will gives more false minutiae points.

After a successful extraction of minutiae, they are stored in a template, which contain the position, direction, type and quality of the minutiae. 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 and fingerprints.

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 II. We have considered an SNR variation of 0 to 3 dB. For the fingerprint approach, the ANN input layer has 160 neurons and is trained for 200 to 5000 epochs. The results obtained are average values of at least fifteen trials for the epochs considered.

5. EXPERIMENTAL DETAILS AND RESULTS

The performance of Retina Recognition System (RRS) and the Fingerprint Recognition Systems (FRS) are 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 and 60 identical retina images and fingerprint 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 II.

Table II: ANN specifications

Input Data Size	For retina- PCA features of length 300. For fingerprint case- CN features of length 160
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 0.75 times of the feature vector.
ANN training method	Back propagation with Levenberg-Marquardt optimization
Average training epochs	MLP- 200 to 5000
Mean square error (MSE) goal	10^{-4}

Original, gray scaled and resized retina images are shown in Figure 3.The average MSE convergence plot shown by the ANN during training while configuring the RRS and FRS is shown in Figure 4.

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

Epochs	% Success rate of RRS	% Success rate of FRS
300	86	85
500	91	92
1000	92	93
2000	92.5	93.5
3000	93.2	93.8
4000	94.5	95.2

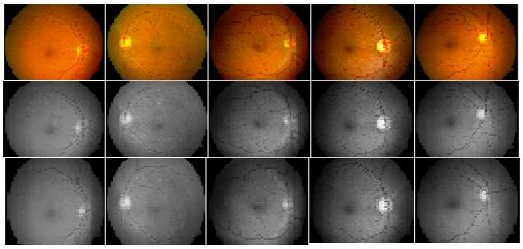

Figure 3: Original retina Images (1st row), gray scale retina images (2nd row), resized retina images (3rd row).

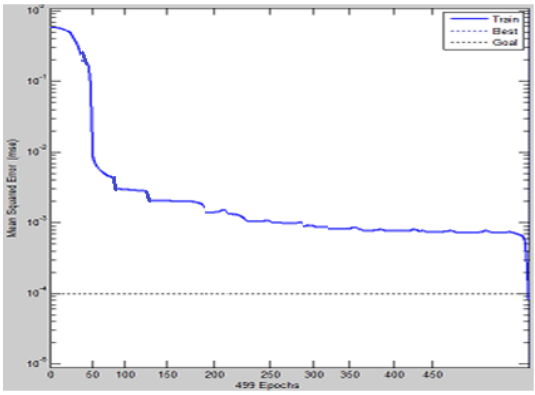

Figure 4: Average MSE convergence of the ANN

Figure 5: Original Fingerprint image

Figure 6: Thinned Fingerprint image

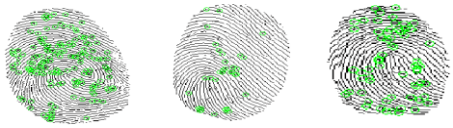

Figure 7: Minutiae Extracted Fingerprint

Original, thinned and minutiae extracted fingerprints are shown in Figures 5 to 7. For retina images features are extracted using principal component analysis (PCA). For fingerprints CN features are used for training the ANN. The average test results of recognition for various training epochs for both the RRS and FRS are shown in Table III. 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 each of 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.

6. CONCLUSION

Here we described a retina and fingerprint 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 and fingerprint images and that way provides the insights for developing a system which require these samples for verification and authorization. A system designed to provide authentication decision using these two inputs 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.

7. REFERENCES

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