A NOVEL APPROACH FOR PATTERN RECOGNIZATION USING NEURALNETWORK OF HAND BIOMETRICS

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Abstract: *Hand geometry is considered to achieve medium security with lesser cost along with several other advantages as compared to other available techniques. The physical dimensions of a human hand known as hand or palm geometry, contains information that is capable of authenticating the identity of an individual. The hand geometry based identity verification system is being widely used in various applications like access control, time and attendance, point-of-scale, anti-pass back and interactive kiosks etc. The goal of a biometric verification system consists in deciding whether two characteristics belong to the same person or not. The present work presents a biometric user recognition system based on hand geometry. It explores the features of a human hand, extracted from a color photograph which is taken when the user is asked to place his/her hand on a platform especially designed for this task.*

Different pattern reorganization techniques have been used for classification and verification. It consists of a database where all the information about the authenticated users is stored. The system extracts the features from a test image

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and compares it with the stored information on the database. The experimental results show that the proposed system has an encouraging performance. The false acceptance rate are reduced down to 0.02, respectively. Experimental result, up to 95 percent rate of success in classification, will show the possibility of using the system in medium/high security environment with less cost.

Keywords*: Biometric verification, hand geometry, hand contour, landmarks, Palmprint recognition, neural networks, support vector machine*

Introduction

Biometrics is the tool which measure individual's unique physical or behavioral characteristics to recognize or authenticate their identity and it is most secure and convenient authentication tool. Biometric measures cannot be borrowed, stolen, or forgotten and forging one is practically impossible. Common physical biometrics includes fingerprints, hand or palm geometry, retina, iris, and facial characteristics. Behavioral characteristics include signature, voice, keystroke pattern, and gait. Biometrics is the science of using human measurements to identify people.

Biometric is automated methods of identifying a person or verifying the identity of a person based on a physiological or behavioral characteristic. Examples of physiological characteristics include hand or finger images, facial characteristics. Behavioral characteristics are traits that are learned or acquired. Dynamic signature verification, speaker verification and keystroke dynamics are examples of behavioral characteristics.

Working Principle of Biometric Technologies

Biometric technologies capitalize upon unique, permanent, and scannable human characteristics. A unique characteristic is one that no other person shares. This characteristic should also remain the same over times.

All biometric devices take a number of measurements from an individual then digitally process the result of these measurements and save this representation of the individual's traits into a template. Templates are then stored in a database associated with the device or in a smartcard given to the individual. This is called enrollment.

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At their most basic level, biometric technologies are pattern recognition systems that use either image acquisition devices, such as scanners or cameras in the case of fingerprint or iris recognition technologies, or sound or movement acquisition devices, such as microphones or platens in the case of voice recognition or signature recognition technologies, to collect the biometric patterns or characteristics.[5]

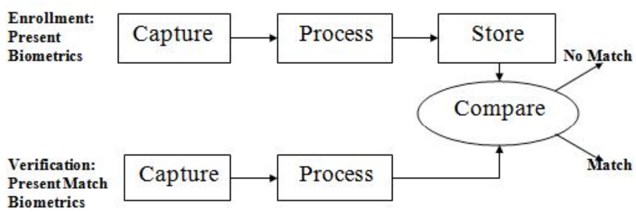

***Fig:** Generic biometric processes*

Performance Measures

The performance of a biometric system is measured in certain standard terms.

These are main three types of standard terms given below-

(i) False Acceptance Rate:

FAR is the ratio of the number of unauthorized users accepted by the biometric system to the total of identification attempts to be made. This is also known as type 2 error, False Acceptance Rate is when an imposter is accepted as a legitimate user, This happens when the system find that the biometric data is similar to the template of a legitimate user. FAR is calculated by

FAR (λ) = Number of False Attempts / Total Number of Attempts

Where (λ) = Security Level

(ii) False Rejection Rate:

FRR is the ratio of the number of number of authorized users rejected by the biometric system to the total number of attempts made. False Rejection Rate known as type 1 error, when a legitimate user is rejected because the system is not found that the current biometric data of the user similar to the biometric data in the templates that are stored in the database.

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Now since there is no zero error in a system that is in the real world, we calculate the FRR using a simple math equation:

FAR (λ) = Number of False Rejections / Total Number of Attempts

(iii) Equal Error Rate:

Equal error rate is a point where FRR and FAR are same. The ERR is an indicator on how accurate the device is, the lower the ERR is the better the system.

Now if we have a score of the FAR & FRR we can create a graph that indicates the depends of the FAR & FRR on the threshold value. The following is graph is an example:

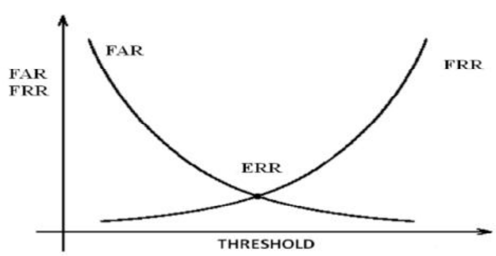

Fig: *Equal Error Rate*

Hand Geometry

Hand geometry recognition systems are based on a number of measurements taken from the human hand, including its shape, size of palm, and lengths and widths of the fingers. Commercial hand geometry-based verification systems have been installed in various places around the world. The technique is very simple relatively easy to use, and inexpensive. Environmental factors such as dry weather or individual anomalies such as dry skin do not appear to have any negative effects on the verification accuracy of hand geometry-based systems. [13]

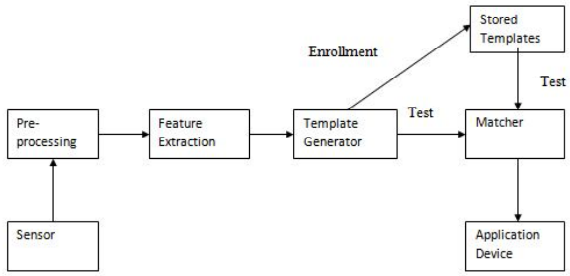

Fig : *Biometric Technique*

A. Hand Geometry Biometric System Module

A biometric system consisting of five important modules, first module is image acquisition which reads image, second module is image preprocessing which include Conversion to Gray scale, Applying Thresholding, De-Noise, Edge Detection, Morphology Optimal dilation and erosion Third module is feature extraction, Fourth is matching, and Fifth is decision. Firstly image of hand is captured through a digital camera/scanner then it is fed to the next module i.e. image preprocessing module. The role of the preprocessing module is to clean up the noise because the input image having some noise due to dust on the palm, atmospheric conditions.

1. *Image Acquisition*

The first stage of any vision system is the image acquisition stage. The image acquisition involves capturing and storing digital images from vision sensors like color digital cameras, monochrome and color CCD cameras, video cameras, scanners etc. The image acquisition system comprises of a light source, a digital camera/scanner. The input image is a color/grayscale image of the hand palm. It is necessary that the fingers are separated from each other. The hand should be placed in a relaxed state with fingers separated from each other. There are various format stored for the images such as .jpeg, .tiff, .png, .gif and bmp. The captured images are stored in one of the following formats on the computer for possible image processing. After the image has been obtained, various methods of processing can be

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applied to the image to perform the many different vision tasks required today.

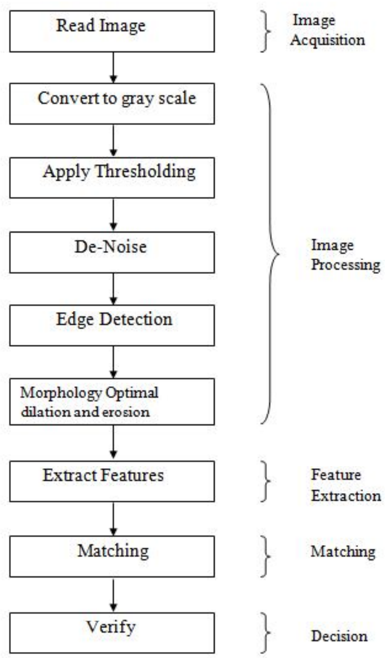

Fig: *Hand Geometry Biometric System Module*

2. *Image Processing*

The next stage is image preprocessing module. Image preprocessing relates to the preparation of an image which includes Conversion to Gray scale, Applying Thresholding, De-Noise, Edge Detection, Morphology Optimal Erosion, Dilation for later analysis and use. The role of the preprocessing module is to prepare the image for feature extraction. The first step in the preprocessing block is to transform the color image into a gray scale image and this result to noisy gray scale image. In the next step, filtering is used in order to reduce the presented noise. Then, edge detection algorithm is applied for obtaining edge of the noiseless gray scale image. Image preprocessing module is consists of following operations. [12]

3. *Feature Extraction*

The next module of hand geometry biometrics is feature extraction. In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction..

The hand geometry-based authentication system relies on geometric invariants of a human hand. The first feature that can be extracting is the tips of the finger. The second major feature is the distances between the tips of the finger.. One or more measurements can be taken for the tip and distance at varying points along the finger. The length of the lines on the finger can also be used as the measure of finger width.

Fig: *Image acquisition*

4. *Matching*

The last module of the biometric system is matching. The feature matching determines the degree of similarity between stored feature vector and claimed feature vector. Here the features extracted in the previous section are matched up with the features of that individual previously stored in the database.

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5. ***Decision***

After calculating the distance, the system compares the result with a predefined threshold and classifies the claimer. The system accepts the claimer if and only if the calculated distance is lower than the threshold, and it rejects the claimer if and only if the calculated distance is higher than the threshold.

Problem Formulation & Proposed Solution

A. *Problem Formulation*

Biometrics technology allows determination and verification of one's identity through physical characteristics. Biometrics is a more foolproof form of authentication than typing passwords or even using smart cards, which can be stolen. Biometric systems replace conventional identification techniques since these are more convenient and reliable. Hand geometry biometric systems can be used in low to medium security applications. If this system combined with fingerprints and palmprint in a multi modal system it can prove very useful in high security applications. The advantage of combining these features lies in the fact that while taking the data for hand geometry, the data for fingerprints and palmprint can be collected simultaneously. Most of the present available hand geometry system always uses pegs to fix the placement of the hand. The main weaknesses of using pegs are that pegs deform the shape of the hand and users might place their hands incorrectly. These problems can certainly reduce the performance of the biometric system. Another problem with these pegs is that it is not possible collect the data for hand geometry, fingerprints and palmprint, simultaneously in a multimode biometric system. The purpose of this research is to design a biometric system based on hand geometry without pegs. Therefore, users can place their hands freely on the system platform. These types of biometric systems are not complex and yields good performance.[10]

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B. *Proposed Solution*

The proposed hand geometry biometric system provides a new approach to extract the hand geometry features. Data is read and processed independently of the position of the user hand. In this system, the selected features are not varying with variation of hand position. The main goal of this project work is to implement a system which can be able to acquire the images freely without any restriction by allowing the user to put his/her hand virtually in any position.

The proposed system extracts the left and right tip of each finger and also takes left and right tip point of thumb. Also the palm width and two other distances between left tip point of little finger and bottom left point of palm and between right tip point of thumb and bottom right point of palm are measured. The most important geometric part of the palm for feature extraction is the fingers. For each finger and thumb two points, one is left top tip and second is right top tip are taken which makes it a total of 10 features for the four fingers and thumb. Including palm width and two other distances and two ratios brings the number of total features to 17. All the landmark points on the right hand palm are defined below and shown in fig 4

WD- Distance between two bottom points of palm

LD- Distance between left tip point of little figure and bottom left point of palm

TD- Distance between right tip point of thumb and bottom right point of palm

R_1- Ratio R_1

R_2- Ratio R_2

In this proposed system 21special features extracted from the palm. The definition of these features are given below

(i) The “WD” is obtained by measuring the distances from the bottom left point of palm to the Bottom right point of palm as shown in fig.5.1. .

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(ii) The "LD" is obtained by measuring distances from left tip point of little finger to bottom left point of palm as shown in fig 5.1.

(iii) The "TD" is obtained by measuring distances from right tip point of thumb to bottom right point of palm as shown in fig. 5.1

(iv) Ratio R_1 is calculated by dividing LD / TD.

(v) Ratio R_2 is calculated by dividing TD / WD

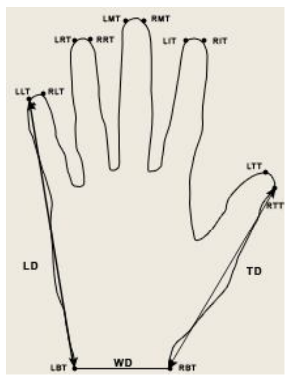

Fig : *Define all landmark point and all features*

Results and Discussion

The following parameters which defines our mathematical model for doing discriminant analysis from authorized and unauthorized person.

X_1 = TopFigTipX

X_2 = TopFigTipY

X_3 = ThumTipX

X4 = ThumTipY

X5 = LittleFigTipX

X6 = LittleFigTipY

X7 = RingLeftFigTipX

X8 = RingLeftFigTipY

X9 = RingRightFigTipX

X10 = RingRightFigTipY

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X11 = IndexRightFigTipX

X12 = IndexRightFigTipY

X13 = Ratio R_1

X14 = Ratio R_2

A. *Mean Squared Error*: It can also be further independent from above graphs that the **mean squared error** is also reducing in each stage, especially after the back propagation algorithm training. It must be noted that if the standard error of estimate is closed to zero that means that the regression model have been comfortably been able to identify true nature of fitting of the pattern parameters(dependent or independent variables).

B. *Confusion Matrix*: A research basically is about continuous valued function for example a classification model build to identify safe or risky and at the same time to predict the potential of customize expenses. Similarly in our case we have done data classification in two steps:

First step includes the training data sets or training samples

Second step includes the machine learning using back propagation learning.

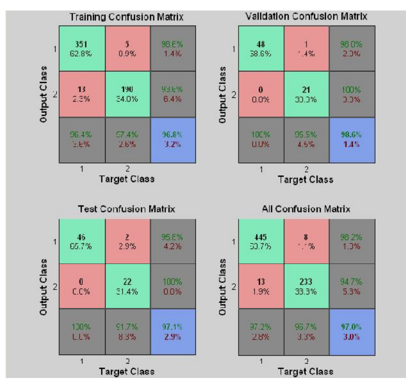

***Fig:** Confusion Matrix*

In our case we have taken 5 images per subject and observed 30 subjects. The model we have build is highly scalable and interpretability can be understood in terms of its confusion matrix graph as shown above. Our system is highly tolerant to the noisy data and has ability to classify data that is not trained, during the learning process the network learns by adjusting the various weights so that it is able to predict correct class labels of input sample, here it is how it is learning using back propagation algorithm.

D. *All ROC*: Fig(b) is the ROC curve showing the All performance of Hand Bio metric system operated as unimodal. On the ROC curve, the higher the line is drawn, the grater the GAR is .97 and therefore the more the accurate is the system. There are different FAR intervals, each of them have a corresponding GAR value. has the highest value of 82% GAR at 18% FAR. The receiver operating characteristics (ROC) curve are used extensively used for performance evaluation in biometrics systems therefore, this analysis is conducted at each stage.

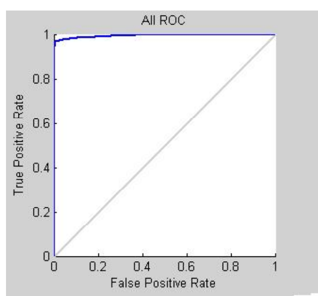

Fig: *All ROC*

D. *Performance:* As it can be seen from above graph the intersection point shown in the graph signifies point where the data set passes through each phase is optimally performing with respect to MSE. The optimal performance point is (8, 10^{-2}).Fig 5(c)

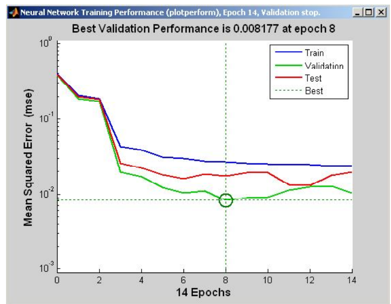

Fig: *Neural network training performance*

Conclusion

A peg-free hand-geometry verification system has been developed in this thesis work which is independent of orientation and placement of the hand. The system is experimented with a database consisting of 150 images collected over time from 30 users. 5 sample images from each user were used for verification purpose. The verification system extracts the feature vector from the image and stores the template for later verification. FRR is obtained by comparing the two feature vectors of the same hand and FAR is obtained by comparing the feature vectors of two different hands.

The system shows effectiveness of results using neural network with accuracy around 95%.

This special project would detect whether a user is a member of a system or not. If he/she is a valid user of the system, then he/she is identified and the output is 'Yes'. If the user could not be identified by the system, its output is 'No'. Implementation of the program results in a much secure and accurate system.

Scope of Further Work

These days support vector machines have gaining lot of importance for doing classification and prediction in the field of machine learning, although Back Propagation Algorithm is highly successful algorithm till date for machine learning and having very wide application in bioinformatics. The Back Propagation Algorithm has been also be used by physiologist and neuro-biologist, but in recent development support vector machine has been found place in bio informatics fertinity. For future scope with some more bio-metric matrices can build multi-model support vector machines for more accuracy.

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