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An Efficient Technique for Human Verification Using Finger Stripes Geometry

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Abstract: This study attempts to improve the performance of person verification by finger stripes geometry, which is an efficient, simple, fast, easy to handle and cost effective compared with other biometric human verification technique. Finger stripe geometry is a new biometric type in verification process. This finger stripe based verification consists of two main attributes, feature extraction by image processing and feature learning by ANN (Artificial Neural Network). The Distance Based Nearest Neighbor Algorithm, which shows greater accuracy than NN is also applied here. Using this approach, experimental result provides, Total Success Rate (TSR) is 98.79%, False Acceptance Rate (FAR) is 3.21% and False Rejection Rate (FRR) is 0%. Since the proposed method requires very small computational time, the practical implementation requirement for a large number of person verification is possible.

Key words: Biometrics, feature extraction, back propagation algorithm, distance based nearest neighbors algorithms, human verification, artificial neural network

INTRODUCTION

Biometrics technology deals with physical or biological measurement on characteristics of an individual person (Weicheng and Tieniu, 1999). Due to increase in concern over terrorism, biometric identification is gaining more importance (Raul *et al*., 2000). Automated biometrics-based personal identification system can be classified into two main categories: identification (1 to many comparisons) and verification (1 to 1 comparison) (Weicheng and Tieniu, 1999; Raul *et al*., 2000; Anil *et al*., 1999). Most of the current researchers in biometrics have been focused on fingerprint and face. The reliability of personal identification using face is currently low as the researchers today continue to grapple with the problems of pose, lighting, orientation and gesture (Ajoy *et al*., 2003). Good frictional skin is required by fingerprint imaging system. Among other identification techniques, a special illumination setup is needed for iris or retina based identification system (Anil *et al*., 1999). To uniquely identify an individual based on biometrics data, some characteristics of biometrics data are desirable. They are highly unique to each individual, easily obtainable, time invariant, able to be acquired as non-intrusively as possible training (Weicheng and Tieniu, 1999). It appears that one of the biometrics mentioned has all of the desirable characteristics.

Suitability of a particular biometric to a specific application depends upon several factors: Comfort, accuracy, acceptability and cost. Among these factors, the user acceptability seems to be the most significant (Anil *et al*., 1999; Kumar and Shen, 2002). For many access control applications, like immigration, border control and dormitory meal plan access, may not be acceptable for the shake of protecting an individual's privacy. In such situations, it is desirable that the given biometric indicator be only distinctive enough for verification but not for identification. As hand geometry information is not very distinctive, it is one of the biometrics of choice in applications like those mentioned above.

Finger stripes geometry is considered to achieve medium security, but it has the following advantages compared to the other techniques (Raul *et al*., 2000; Anil *et al*., 1999). Medium cost or inexpensive acquisition procedure as it only needs a platform and a low / medium resolution CCD camera or scanner, it uses low computational cost algorithms, which lead to fast results, very easy and attractive to users, lack of relation to police, justice, and criminal records, it will be acquirable non-intrusively, only simple shape/geometric features are used, robust to environmental changes and has demonstrated excellent performance in verification tasks. The existing hand geometry based personal verification systems (Raul *et al*., 2000; Anil *et al*., 1999; Ajoy *et al*., 2003) need a lot of features such as lengths, height, widths of different fingers, so a little bit of displacement of hand makes it difficult to acquire data non-intrusively.

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The existing systems use pegs on their platform. If users give pressure then it is hard to collect acquire data. All the methods need complex image acquisition systems. This paper reviews the presently used techniques. It describes a better technique in terms of image acquisition and computational cost. The result of the proposed system also presented and compared with the existing methods.

DESIGN OF THE PROPOSED SYSTEM

The whole process of the research is divided into two steps:

- Feature extraction through image processing.
- Verification process using ANN or Distance Based Nearest Neighbor Algorithm.

Feature extraction: Two different types of distances are used to constitute the feature vectors. These features are extracted from a raw hand image of user. In this system all distances are measured in the unit of pixels.

- Midpoint distance between a pair of stripes (Total 12 distances).
- Width of each stripe (Total 12 widths).

Steps of feature extraction:

Step 1: Color image acquiesced by scanner as Fig. 1. Mode: 300 Dot/Inch. Stretch the image both horizontally and vertically 25%. Three D scanner is preferable. The fingers should lie adjacent to each other but cannot be overlapped.

Step 2: Image dimension may vary due to the irregularities in the image scanning and capturing process. We used a normalized size of 360×270 pixels for all images. During the normalization process, the aspect ratio between width and height of a image is not the same. Following equations are used for the normalization process:

$$X_i = \frac{X_i'}{X_{max}} * Mx \qquad Y_i = \frac{Y_i'}{Y_{max}} * My$$

Where X_i, Y_i are pixel coordinates for the normalized image and, X_i, Y_i are pixel coordinates for the original image, M is the dimensions (width or height) for the normalized image. Applied in Fig. 1a and result in Fig. 1b.

Step 3: A color image consists of a coordinate matrix and three color channels. Coordinate matrix contains, x, y coordinate values of the image. The color channels are labeled as Red, Green and Blue. Since our approach demands finger s tripe images in gray scale, we have to

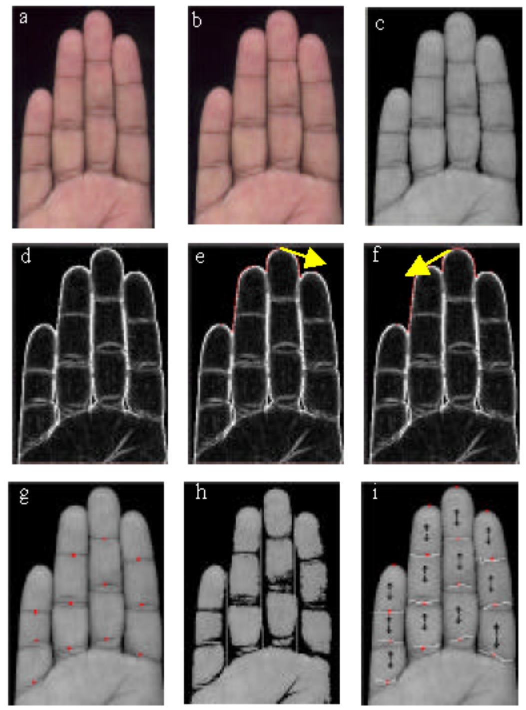

Fig. 1: Steps of feature extraction

X_1	X_2	X_3
X_4	X_5	X_6
X_7	X_8	X_9

Fig. 2: A 3×3 matrix for the pixels of the image(X is the gray-level values). Algorithm: $X_5 = (X_7+2X_8+X_9)-(X_1+2X_2+X_3)$. This is the technique, considered for edge-detection

convert the color image into gray scale. The color image is converted to gray scale using the following equation as in Fig. 1c: Gray Color = (Red+Green+Blue) /3.

Step 4: This step generates thick boundary (edge) outside the fingers as in Fig. 1d. For edge-detection, the pixels of the image are considered as the following matrix (Fig. 2).

Step 5: To detect the top points of the fingers searching starts from the top-left pixel to the right-bottom pixel according to the pixel value. At first the top-point pixel of the middle finger is detected. This searching stop at this moment and a new searching is used towards the right side from the top-point pixel of the middle finger to detect the top-point pixel of the index finger as in Fig. 1e. Then another searching starts towards left again from the top-point pixel of the middle finger to detect the top-point pixel of the ring and little fingers as in Fig. 1f.

Step 6: Construction of trees to detect different regions as in Fig. 1g. Find the meeting pixels of different fingers. Then a line is drawn from that point according to the range of pixel color values to detect different regions.

Step 7: To detect the mid-points first vertical distance between top-point of each finger and the tree is calculated. Horizontally every tree is divided into 3 equidistance regions. Searching from the top-point of a finger, parallel to the tree, a little bit more pixels from a regional boundary, we may get the midpoint of a vertical stripe of the finger. Otherwise the boundary midpoint will be calculated as the finger stripe midpoint as Fig 1h.

Step 8: Finally calculate the midpoint-distance between each stripe and width of each stripe. By searching both sides from the mid-point according to the range of pixel color value Fig. 1i, the total width of a stripe is calculated.

VERIFICATION PROCESS USING ANN

Three different images of same person are collected for NN training purpose. Feature values are extracted and stored in a database after assigning a unique integer ID.

Network architecture:

- Multilayer fully connected feed forward
- 24 input nodes and 1 output node
- 4 hidden nodes
- Slope parameter, á = 4
- Learning Rate, ç=0.01

Procedure of using ANN: Two phases are considered in this study for ANN, such as: Training Phase and verification phase.

Training phase:

- Training phase runs only when the user doesn't provide any ID. The system treats him as a newcomer
- Three hand images are collected from the newcomer user
- Feature values, consisting of 24 distances, are extracted from the hand image.
- Extracted feature values are used to train a Neural Network until error falls below the threshold. Using back-propagation algorithm in such a way that, if these feature values are presented to the input nodes, output from the single output node will be 1. But with other feature values, output will be divided from 1.
- After the training is over, error and weight vectors of the NN will be stored with a to newly assigned unique person ID. The person is informed about this ID which may be used later by him for his verification (Fig. 3).

Verification phase:

- Verification phase runs when the user present his ID provides his hand image.
- Feature values are extracted from his hand image.
- These extracted feature values of newly collected hand's image will be used for the forward propagation of a Neural Network. This network is retrieved from the database using the ID provided by the user as the key to retrieve the NN from the database. If the Error after forward propagation is within the range then it will generate Yes otherwise it will generate No. Error is calculated as:

Error = Ideal output-Actual output = 1-Actual output

Ideal output is during training phase, we trained the network with desired output = 1 with the extracted features values

- If the error is within the range then it will generate Yes otherwise it will generate No.

Procedure of using 3-nearest neighboralgorithm: The feature values in the test pattern will be compared with all stored in the database patterns. According to the distance from the test pattern the whole database is sorted in ascending order of distance. First three ID are selected as the nearest neighbors of the test ID. If any of them matches with the test ID then the person is verified to be accepted otherwise he is rejected.

EXPERIMENTAL SETUP

Databases and enrollment: Since no databank was available for hand geometry based identification system following our method of image extraction, we had to create a database of hand geometry. One of the tasks to be studied for the enrollment process is the number of feature vectors that from the user's

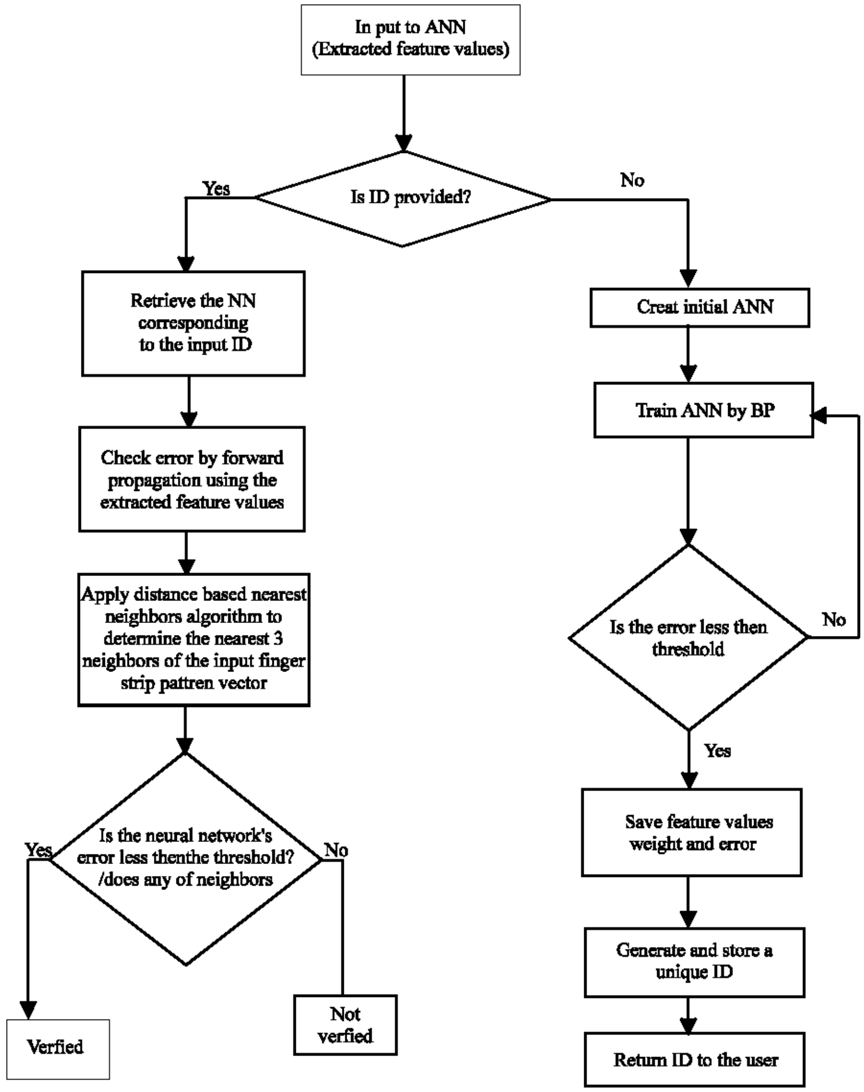

Fig. 3: Flowchart of the proposed system

template. It is obvious that the bigger, the number of samples used, the better template calculated will be created. Three samples for the enrolment set are considered sufficient. We have collected 3 photographs for each of 500 people.

RESULTS

In this study we propose two methods for verification phase. By using ANN our Total Success Rate (TSR) is 95.07% where threshold value is 0.5. When we use Distance Based Nearest Neighbor method then our TSR is 98.79% where threshold value is 6.5. In the both system the number of feature vectors are 24. The best result is 98.79% TSR obtained from Distance Based Nearest Neighbor method. The result for FAR and FRR is given in Table 1. Finally, the results of the proposed methods are compared with the result published in literature where hand geometry based biometric verification system are developed using other methods shown in Table 2. It is observed that the performance of the proposed system is satisfactory among all existing systems.

Table 1: The result for False Acceptance Rate (FAR) and False Rejection Rate (FRR) for the proposed system

	FAR (%)	FRR (%)
Proposed System	3.21	0

Table 2: The results of the proposed method are compared with results published in literature where biometric verification is developed using other methods

Name of the paper	Techniques applications for verification	Feature vector dimension	Decision threshold	Classification success rate (%)
Biometric identification through hand geometry measurement (Raul *et al*., 2000).	Euclidian distance metric	15	200	86
	Gaussain Mixture Models (GMMs)	21	83	97
A prototype hand geometry based verification system (Anil *et al*., 1999).	Absolute distance metric	14	55	94.99
Personal verification using palmprint and hand geometry biometric (Ajoy *et al*., 2003.)	Normalized correlation	16	0.9314	91.66
Hand reorganization using implicit polynomial and geometric features	Geometry	16	Not mentioned	89
	ANNs	24	0.5	95.07
Proposed system	Distance based nearest neighbor	24	6.5	98.79

CONCLUSION

In this study we have introduced a new biometric type, which is finger strips. We have successfully proved that this biometric type works quite well for human verification. Unlike other biometric approaches to attain a high security, this one is not so complicated or awesome to the user. It is important to mention that at first we applied only Back Propagation algorithm with ANN for verification and found accuracy rate 95.07% (out of 500 examples). To increase accuracy rate, we applied Distance Based Nearest Neighbor algorithm later. And that time accuracy rate 98.79% (out of 500 examples). The result depends on how accurately the feature values are extracted. So, in our future work, we will try to develop more efficient feature extraction algorithms and an automated feature extraction device for high accuracy. In addition, we will try to develop a Multi-Biometrics technique (finger strip's geometry with hand geometry) to acquire higher security.

REFERENCES

Anil, K., Jain, Arun Ross and Sharath Pankanti, 1999. A Prototype hand geometry based verification system. 2nd International Conference on Audio and Video based Biometric Person Authentication (AVBPA), Washington DC., pp: 166-171.

Ajoy Kumar, D.C.M., Wang, C. Helen, Shen and Anil K. Jain, 2003. Person Verification Engine palm print and hand geometry biometric. proc. of 4th International Conference on Audio and Video based Biometric Person Authentication (AVBPA), Guiltford, U.K., pp: 668-678.

Kumar, A. and H.C. Shen, 2002. Recognition of palmprints using wavelet-based features. Proc. Intl. Conference System, Cybern., SCI, Orlando, Florida.

Raul Sanchez-Reillo, Carmen Sanchez-Avila, and Gonzalaz-Marcos, 2000. Biometrics Identification through hand geometry measurements. IEEE. Transitions on Pattern Anal. Mach. Intelligence, 22: 1168-1170.

Weicheng, Shen and Tieniu Tan, 1999. Automated Biometrics based person idenification. Proc. Natl. Acad. Sci. USA., 96: 11065-11066.