Biometric identity Authentication System Using Hand Geometry Measurements

Hesham Hashim Mohammed *, Shatha A. Baker*, Dr. Ahmed S. Nori**

*Department of Electrical and Computer Engineering Northern Technical University, Iraq
**Computer Science Dept., Mosul University, Iraq

hesham@ntu.edu.iq

Abstract. In recent years hand geometric dependent biometric system has shown to be the quite acceptable biometric trait and suitable for security applications. It has been recognized as an effective means of authenticating identity in a variety of commercial applications as a result of better hardware and improved algorithms. This paper purpose a hand recognition system that extract 21 features for the right hand to identify and authorize persons. The system has two main parts, the first contain the data collection, explains the basic pre-processing required and how hand geometry characteristics like fingers length, width, coordinates of the base of the fingers, and palm width are extracted to derive the features used for discrimination, While the second part include the training and testing of three artificial neural networks to perform the recognition. After features extraction, the system uses three kinds of artificial neural networks in performing the recognition process, which are feed forward back propagation NN, Elman NN, and the cascade forward neural network NN. The proposed system shows that the Recognition Rate RR for the neural networks after testing were 95%, 92%, 88% respectively.

1. Introduction

Biometric based personal identification can be defined as the effective authentication process which is too difficult to forge. Hand geometry is a technique that relates to the hand geometric structure, which involves finger lengths, finger widths at different locations, palm thickness, palm diameter, etc.[1]. The role of a typical hand geometric system makes use of a camera or scanner-based device to capture the hand images of a person. The images named templates are prepossessed to obtain features, in which a series of measurements is implemented, models are then placed in the database to each of the users. Authentication process is used where the input template is matched only with all the database entries to verify a person's identity. The result is the individual may or may not be authorized [2, 5]

Hand geometry has many advantages compared to other techniques [3] such that:
1. It needs a camera or moderate resolution reader, which means a medium expense.
2. The fast results produced due to Low computational algorithm.
3. Small template size, which reduces the storage needs.
4. Quite user friendly and appealing resulting in a good acceptance by users.

Neural networks are commonly used for pattern recognition in computational techniques because it has provided high precision in this field. Three types of neural networks were used which are feed forward back propagation, Elman, and the cascade forward neural network.
2. Related Works

Hand Geometry has gained tremendous popularity as a biometric identification technique over the last decade. Various researchers have published a great deal of work in the field. Here we highlight some of the successful research performed in the area.

Authors [15] proposed method that calculates 66 features for authorizing and identifying an individual by deriving relationships from attributes such as finger length, finger base coordinates and palm width. The system is then tested on the BPNN and has a 93% recognition rate. The paper [20] suggested approach dependent on the palm print to supply a solution for individual user verification. The both image texture and color details are the main features focused on. This strategy can be utilized in hand held devices since that approach is feasible for devices that have restricted computing resources, the accuracy of the approach reached 91%.

In 2017 Song, et. al proposed a reliable and simple approach that can be applied on multi touch screen devices. The proposed system overcome the problem of behavioral variability by perform authentication through recording hand geometry and behavioral characteristics for the persons, this approach reaches EER of 5.84% with only 5 training samples, then they improve performance to EER of 1.88% with more training samples [13].

The proposed work in [18] present a hand geometry system with reduced set of features, the system proposes extracting features by selecting important points on the palm, two corner valley points with top four fingertip points, and then use these point to form three triangles, the area of these triangles are used as features of the persons and these features are stored in the database. The system used Euclidian distance to perform authentication.

The approach [24] achieves 1.78% EER through the use of a single complicated imaging system to image the geometry of the finger and vein. This approach has two drawbacks; the one is the lower elasticity for users and the other is to employ fingers that cannot be more discriminatory relative to the person's whole hand. A better detection accuracy of the paper [8] is detected from a palm image at 13 important points and 34 features measured from those points are used for further recognition. Experimental findings show a 96.23% overall Correct Identification Rate.

3. Common Human Biometric Characteristics

A biometric technology is characterized as mean of verification, recognition, and their utilize in various spheres of life. Behavioral and Physiological are two divisions of biometric characteristics, as characterized in figure1 [14].

1. Behavioral- characteristics includes the human attitudes such as hand writing, signature, voice print, keyboard typing. The high variations are main problem with behavioral methods which are difficult to cope with. On the other hand, while behavioral characteristics can be difficult to measure because of influences such as illness, fatigue, or, stress they are generally cost less to implement and usually more acceptable to users [4, 11].

2. Physiological characteristics includes the traits like hand geometry, iris pattern, finger vein, fingerprint etc.; The attributes used in the physiological classification are more steady than methods in the behavioral classification as since many physiological features are nearly no alterable without serious harm to the person [9,17].

Biometric has its advantages and disadvantages and therefore biometric is used for a particular application of authentication. The suitability of a given biometric to a specific application depends on different requirements. To be realistic and accurate, biometric systems must satisfy specified requirements. Table 1 demonstrates how these requirements are available in several forms of biometrics [6, 7].
Figure 1. Classification of Biometrics.

![Classification of Biometrics](image)

4. RESEARCH METHOD

The hand geometry biometry system gives sufficiently high accuracy to reliably authenticate individuals, the architecture of proposed systems divided into two parts: enrollment and recognition as shown in figure 2[3, 12].

4.1. Enrollment

A. Image Acquisition

The Image acquisition is the essential and initial step in biometric identity Authentication which is obtained from normal flat bed scanner. The user is asked to put his right hand on the device board. The
palm faces down and the pegs are being used as control points for setting the hand's proper position [23].

B. Pre-processing

Pre-processing is done after the image is taken so that only the hand region information is obtained. A first step is to transform the colored hand image into a gray image where the background is eliminated [1, 15].

The gray image has noise due to the presence of some noise in the captured colored image caused by the dust and surroundings conditions. This lead to the variation in data base feature and measured feature and as a result affect the accuracy of the system. Therefore it's important to eliminate the noise from the image because it could decrease the difference between the real hand and the taken image [16, 19].

In the gray scale image, every pixel's value involves information intensity. It's called black and white. White has the highest intensity while Black is the weakest. Using a Threshold, this process called Binarization is transformed to Binary Image after converting the color image to gray scale. The image thresholding procedure is applying as follows:

\[
\begin{align*}
\text{Input image } (i,j) > \text{Threshold} & , \text{ Output Image } (i,j) = 1 & \ldots (1) \\
\text{Input image } (i,j) \leq \text{Threshold} & , \text{ Output Image } (i,j) = 0 & \ldots (2)
\end{align*}
\]

The resulted image contains only edges to extract geometric features of the hand. The edge is a set of linked high-frequency points in the image. Optically, the edge of the image is a region where there is a severe change in the intensity of the image. In order to detect the edges of the fingers, a canny filter is used for the resulting image since the edge has an effect on the image while the features are extracted [10, 21].

![Figure 3: Converting colored, gray scale and binary image](image)

C. Features Extraction

The human hand’s geometric invariants as keys to hand authentication system. The various features extracted from hand image are exploited by hand geometry based biometric systems to perform personal authentication.

Usual characteristics consist length of the fingers, width of the fingers, width palm or finger aspect ratio etc [22]. The first features that can be extracted is the length of fingers while the second can be dug out the width of fingers. Finally, the width of palm can also be used. 21 features are extracted of the hand image as shown in figure 4 [4-15].

Figure 5 displays the distances between two points, consisting of 21 simple distances. From the lengths of the fingers D1 to D5, the widths of the fingers D6 to D10, and the width of the palm D11, the length from left down corner to each fingertip D12 to D16, and the length from right down corner to each fingertip D17 to D21.
4.2. Recognition

The feature vector obtained through the authentication will enter a process of recognition using artificial neural network to decide whether the individual who claims to be is the person whose hand image was taken. In this paper, the dataset consists of ten persons for each one 10 different right-hand images. The artificial neural network has two phases training and testing phase.

A. Training Phase

In this phase, we selected 7 out of 10 images from each person, this mean that the training images are 70. Each set of features that correspond to the same person are given the same target. The training phase information for each one of the networks is summarized in the following table.

| NN model | Epoch | Time (Min: Sec) | Performance |
|----------|-------|----------------|-------------|
| FFBB     | 803   | 7:41           | 9.98 E-12   |
| Elman    | 861   | 16:15          | 9.97 E-12   |
| CF       | 2747  | 53:30          | 9.99 E-12   |

Figure 4: the properties of hand geometry

Figure 5: Features extracted from the input image
The resulted networks are stored after the training completion to be used in the testing phase; the curves of performance for each neural network are illustrated in the figure 6.

![Performance Curves for the three networks.](image)

**B. Testing Phase**

Each one of the networks that trained on 70 images are now used to test the entire dataset, (i.e. all the 100 images). The results of each network will be discussed in the following Table. Figure 7, shows the architectures of the three networks.
5. RESULTS AND ANALYSIS

The proposed system was trained and tested using 100 images (10 persons, 10 images of each person's right hand were captured). The accurate recognition rate for the matching of artificial neural network shown in Table 4.

Table 4 Artificial neural networks topologies with internal details.

| Architecture       | Feed Forward back-propagation | Elman                  | Cascade Forward                |
|--------------------|-------------------------------|------------------------|--------------------------------|
| Number of input neurons | 21                            | 21                     | 21                            |
| Number of hidden neurons in hidden layer | 14                            | 14                     | 14                            |
| Number of outputs neurons | 10                            | 10                     | 10                            |
| Training method    | evenberg-Marquardt backpropagation | evenberg-Marquardt backpropagation | evenberg-Marquardt backpropagation |
| Transfer function  | Symmetric sigmoid transfer function | Symmetric sigmoid transfer function | Symmetric sigmoid transfer function |
| Error rate measure | Mean squared error             | Mean squared error      | Mean squared error             |
| Stopping criteria  | Either error reaches 10E-12 or training epochs reaches 100000 | Either error reaches 10E-12 or training epochs reaches 100000 | Either error reaches 10E-12 or training epochs reaches 100000 |

All networks stabilized on the first criteria.

Figure 7: Performance Curves for the three networks.

A) FFBBL

B) Elman

C) Cascade Forward
6. CONCLUSION

All biometric techniques differ by level of protection, cost, performance, user acceptance etc. Hand geometry is one of the physiological features for authentication which is based on the assumption, that each person hand is unique. We are trying to enhance the efficiency of the hand geometry based authentication system by reducing the amount of features length of the finger, the finger width, and palm width. These features differentiate each human being from each other. Further we can use a multi-model of NN for improving the efficiency of the system.

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**BIOGRAPHIES OF AUTHORS**

Mr. Hesham Hashim, received his BSc and MSc degree from University of Mosul-Iraq, College of computer science and mathematics, Computer Science department, at 2010, 2013 respectively. He worked as assistant lecturer in computer science department, college of computer science and mathematics, Mosul, Iraq for the period 2013 to the end of 2016. Since 2017 he worked as assistant lecturer in Northern Technical University (NTU), Mosul, Iraq. Now he is a Ph. D student in college of computer science and mathematics. His interested research area includes AI applications, digital image processing and bioinformatics.

Mrs. Shatha obtained a BSc in Computer Science from the University of Mosul in 1997, and in 2013, she earned an MSc in Computer Science from the University of Mosul. She worked as a lecturer in Northern Technical University (NTU), Mosul, Iraq. Her interested research area includes Mobile programming, Information Security and Multimedia communications and Artificial intelligence. Now she is a Ph. D student in college of computer science and mathematics.

Dr. Ahmed S. Nori is currently an Assistant Professor in the Department of Computer Science, College of Computer Science and Mathematics, University of Mosul / IRAQ. He supervised more than 18 M.Sc. Thesis. He received his bachelor, master and doctorate in computer science from the University of Mosul and the University of Baghdad in 1992, 1995 and 2006 respectively. Job with University of Mosul / IRAQ from 1996 until now. His area of study covers information security, image processing, multimedia, computer science, image processing, and Mobile programming.