Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing00 (2015) 000–000

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

6th International Conference on Applied Human Factors and Ergonomics (AHFE 2015) and the Affiliated Conferences, AHFE 2015

New Mobile phone and Webcam Hand Images Databases for Personal Authentication and Identification

Ahmad Hassanat[a*] , Mouhammd Al-Awadi[a] , Eman Btoush[a] , Amani Al- Btoush[a] , Esra'a Alhasanat[a] , Ghada Altarawneh[b]

[a]*IT Department, Mutah University, Mutah – Karak, 61710, Jordan*
[b]***Accounting Department,** Mutah University, Mutah – Karak, 61710, Jordan*

Abstract

In this work we created two hand image databases, using Mobile phone cameras, and webcams. The major goal of those databases is to build upon person's authentication/identification using hand biometrics, decreasing the need for expensive hand scanners. both databases consists of 3000 hand images, 3 sessions x 5 images per person x 200 persons, and are available to freely download. The test protocol is defined for both databases; simple experiments were conducted using the same protocol. The results were encouraging for most of the persons (accuracy were greater than 80%), except for those who rotated their hands extremely.

Peer-review under responsibility of AHFE Conference.

Keywords: Hand biometrics, hand shape biometric, hand image database, hand segmentation, hand geometric features

1. Introduction

A person's authentication/identification using biometrics has attracted a great deal of researchers' interest recently. This is due to the many applications that make use of biometrics, such as remote log-in to secured systems, securing mobile devices, cars, buildings, in addition to surveillance and terrorists monitoring applications.

* Ahmad Hassanat. Tel.: +962-3-237-2380-99; fax: +962-3-237-5540
E-mail address: ahmad.hassanat@gmail.com

Peer-review under responsibility of AHFE Conference.

The Hand Geometry is one of physical characteristics that is proved to be a good biometric to identify/authenticate persons, that because it has several advantages over other biometrics, such as ease of use, being non-intrusive, ease of fusion with other biometrics such as fingerprint and palm, and only a small amount of data being required to uniquely identify a person. Hand Geometry measurements are easily collectible, can be captured by a simple camera or a special scanner. Hand shape biometrics is user-friendly and strong method to both environmental conditions and individual anomalies. This technology was first introduced in 1971, a Patent of Ernst and Miller [1] [2]. a lot of work has been done since then.

Most of hand biometric systems use pegs to determine the location of a user's hand and to separate the fingers [3]. However, using pegs is inconvenient during image acquisition of user's hands. Pegs make the system not user friendly; in addition, we need to train persons of how to use the peg system. To avoid these problems some research use peg-free systems. Obviously a system depending on a camera rather than a scanner is a peg-free system.

There is only a small number of hand images databases available for research; most of them represent only a small number of users, using special and expensive scanners. This work attempts to provide two Hand Images Databases: one is created using a mobile phone camera of modest quality, which we called mobile hand images database (MOHI), and the other is created using a webcam with low quality images, which we called webcam hand images database (WEHI), in addition to setting the test protocols for each database. Both MOHI and WEHI are made freely available through Mutah University website: http://www.mutah.edu.jo/en/colleges/science.html

We opted for low quality images, because they were all we could get with the great availability of low-priced mobile phone's cameras and webcams. Such databases allow us (and other researchers) to find out to what extent low quality hand images could be used for authentication/identification systems, and therefore, if it is enough to use just a webcam or mobile phone camera to identify persons.

Reducing the expensive cost of hardware that comes with most biometric systems is essential for increasing the number of users (popularity). This might come about if the results of the work using the low quality images databases were positive. Because of the low quality images, a researcher may opt for using only hand geometry features for authentication/ identification, excluding minutiae and other fine details. Both of MOHI and WEHI consist of 200 male and female users, with three age groups, old, middle and young, each user's right hand was imaged five times for each three different sessions for each database, this gives us a 6000 hand images. Hands were imaged with random rotation of the hand, and random opening of the fingers.

The rest of this paper is organized as follows: the second section of the paper shows the related work, in addition to a brief description of the current hand databases. In Section (3), we describe MOHI and WEHI databases in details. The test protocol of both databases is described in section (4) followed by the experiments results and discussions.

2. Literature review

There is an increasing demand of using hand-geometry after it has become one of the important approaches of biometric systems. Accordingly, many hand-geometry based biometric systems have been proposed to improve the hand geometry methods or investigate new methods to increase the accuracy and reliability of those techniques.

Anil et al. [4] and Sanchez-Reillo et al. [3] proposed some hand geometric features, such as width and length of fingers, hand size, and height. The problems of these methods, is that the users must place their hands on a specific plate. The user has to put his/her fingers between fixation pegs. using scanners in general brings up some health concerns.

De Santos Sierra et. al. [5] proposed a feature extraction method that provides fixed hand measurements to previous changes. They used a database containing hand images of 120 different individuals, using mobile device. The classifiers used were Support Vector Machines (SVM) and k-Nearest Neighbor. Luque-Baena et. al. [6] used a methodology based on genetic algorithm, mutual information and hand segmentation approach to extract the hand features. They used several database and attained high accuracy results.

Guo et. al. [7] used a hand geometrical features for personal identification, they employed infrared illumination device. The users can put their hand anywhere at the head of the camera, with no need for pegs or templates. Their proposed method achieved False Accept Rate (FAR) of just 1.85%.

Saxena et. al. [8] focused on the lengths and widths of fingers, in addition to the width of the palm. Their study presented an algorithm with a new threshold to separate the hand from the background image. Their algorithm achieved 97.44% accurate, and 98.72% accurate verification.

Mathivanan et. al. [9] proposed a method to combine 2-D and 3-D hand geometry features. Their combination made the results better. Their experiments were conducted using a database of 150 images taken from 50 persons, the acquire hand images in this study was a contact-free.

Kang and Wu [10] proposed a method using Fourier descriptors for hand shape recognition, which focused on both finger contour and finger area, to determine the valley and peak points in accurate way. After that they use score-level fusion based on a weighted sum to get the matching results. Poonam and Sipi [11] proposed a using hand contour matching. They used Euclidian distance to extract hand shape features by calculating the starting reference value and then calculating the finger's peak and valley points. Their experiments conducted on 300 images, six images per person, three for the right hand and the same for the left.

Gupta and Singla [12] developed a verification method using a database imaged by a camera. The database was collected from five subjects, 10 images for each one with different phases and illumination. The authentication accuracy of the system was 99.8%. Dhole and Patil [13] proposed an identification method by extracting 28 features from the hand. The images were taken by a digital camera using black background behind each hand, assuming that the user’s fingers are not to be attached. Each image resolution was is 120 dpi. The error rates were 0.48% FAR, and 1% FRR.

Varchol and Levicky [14] used a database consists of 408 hand images from 24 people (female and male). These images were taken by a scanner with flat surface. The users put their hands on the surface of the scanner and the palms were controlled by pegs. They used different pattern recognition methods such as Euclidian distance, Hamming distance, and Gaussian mixture model for verification. Their experiments error rates were 0.18% FAR, and 14.58% FRR.

Our work is not intended to compete with the previous work on hand biometrics, it is rather oriented to create new hand databases using the available webcams and mobile cameras, to be available for our future work, and freely available for other researchers as well.

2.1. Current hand biometric database

There are many databases for hand biometrics in the literature, however, most of those databases are either not available for research community, contain small number of images, small number of users, or taken by expensive scanners. Table 1 shows some of the hand biometrics databases used in the literature. This list is not meant to be exhaustive, nor to describe the databases in detail, but merely to provide an example of the literature databases.

Table1. summary of some of the hand databases used for biometrics

Database	#Users	#Images/User	Device Used.	Reference
1	642	3	HP Scanjet 5300c scanner at 150 dpi	[15]
2	150 137 100	GPDS : 10 sample public IIT Delhi: 6 sample The CASIA :6 sample	GPDS desk-scanner IITD: circular fluorescent illumination around camera lens CASIA: CCD camera fixed at the bottom of the device.	[6]
3	9	3	Commercial 3-D scanner.	[16]
4	100	10	Commercial thermal camera called testo 882-3.	[17]
5	5	10	Conventional CCD cameras.	[12]

6	50	6	The images are captured using a scanner	[11]
7	50	3	A 3-D digital camera.	[9]
8	86	3	Images are acquired by a commercial scanner.	[18]
9	100	60	One commercial webcam, one Infrared (IR) filter, and four sets of double-row GaAs infrared emitting diode with 12 diodes in each set.	[7]
10	100	6	Digital camera and black flat surface used as a background.	[13]
11		120	Commercial scanner. The images were taken with a resolution of 300 dpi	[19]
12	3 DB used: 120 235 287	10	The first database :so the mobile device (an HTC) Second database :camera resolution of these images is 800x600 pixels Third database : Olympus C-3020 digital camera (1280 x 960 pixels) was used to acquire images	[5]
13	25	10	Color digital camera	[20]
14	50	10	A flatbed scanner as an input device.	[21]
15	24	17	Low cost, high speed processors and solid state Scanner.	[14]
16	2 DB used : 9 20	 8 6	CCD color digital camera, placed a fixed distance above the platform,	[22]
17	70	10	Collected data done using a document scanner.	[23]
18	20	20	platform designed for the proposed (CCD color camera, pleased above a platform)/(images captured is 640*480 pixels color photograph in JPEG format)	[24]
19	50	10	A light source, a camera, a single mirror and a surface (with five pegs on it).	[4]

3. Databases description

To capture hand images we used two cameras:

- Mobile phone cameras to create MOHI.
- Webcams to create WEHI.

Those databases designed to be used for different purposes such as:

- Distinguish between male and female
- Classification of people by age groups
- Identification persons
- Authentication persons.

MOHI and WEHI images were taken to the right hands of 200 persons in four different cities, three different sessions each. Where in each session, five images were captured by a digital cameras (MOHI), and another five by a webcam (WEHI) for the same person. The background was a white paper for all images. We could not do more than 200 persons because people were very reluctant about giving their hand images.

To mimic the real world variations, we allowed variation in rotation, scale and light conditions. The images were taken in 4 different cities, 50 persons from each city. To measure the accuracy of the system in the case of uncooperative users, we allowed extreme variations in rotation (around X, Y, and Z axes), scale and light in the last group of persons from 51 to 200.

Each image in MOHI database was 8 mega pixels (3264 x 2448). Each image in WOHI database was 2 mega pixels (640 x 480). The time between sessions was about 3 days. The total number of images is 6000 hand images, 3000 for MOHI and 3000 for WEHI.

We followed the following rule for naming the image files, the file name starts with the session number (S1, S2 or S3), followed by the person number (P), followed by gender (male: M or female: F), then the age of the person, and finally the image number within each session from 1 to 5. Table (2) explains the naming system of the image files.

Table 2. Examples different image file names from MOHI and WEHI databases

#example	Session	subject	Gender	Age	#Image	Image Filename
1	S1	1	Female	11	1	S1-P1-F-11- 1
2	S1	1	Female	11	2	S1-P1-F-11- 2
3	S2	6	Male	40	3	S2-P6-M-40- 3
4	S2	35	Female	36	5	S2-P35-F-36-5
5	S2	103	Female	24	4	S2-P103-F-24- 4
6	S2	182	Male	27	5	S2-P182-M-27-5
7	S2	161	Male	49	1	S2-P161-M-49-1
8	S3	17	Male	45	2	S3-P17-M-45-2
9	S3	77	Male	15	3	S3-P77-M-15-3
10	S3	152	Male	63	2	S3-P152-M-63-2

4. Testing protocol

Both MOHI and WEHI were recorded in 3 different sessions, and both can be used for authentication and identification problems. S1 can be used for training, S2 might be used for testing, and S3 might be used for verification the test results. Or any other way around, as there is nothing special for any session. To increase training data, researchers can use 2 sessions for training and the remaining session for testing, using 3-fold cross validation.

Researchers can use any hand segmentation method, and any feature extraction method, using any classifier. Figure (1) shows a typical system for identifying or authenticating persons using MOHI or WEHI.

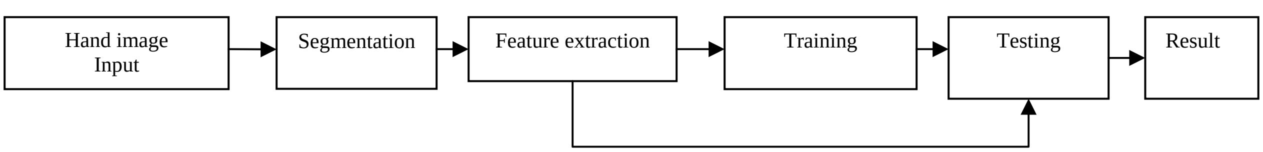

Fig. 1. hand geometry recognition overview diagram.

To implement this protocol, we opt for a simple identification system, using 3-fold cross validation. For segmentation and classification we used artificial neural network (ANN) with back propagation.

Each hand image contains two different areas, the hand area and the back ground, the skin color is different from the background color, so we opt for our algorithm described in [25], which is based on training an ANN on the color of the pixel and its 8 neighbors to segment lips from the face. This algorithm is modified to segment pixels to skin or non-skin color. The algorithm uses fusion of different color model to form the feature vector that represents the 9 pixels, those obtained from a number of images to train the ANN. Feeding the trained ANN with the feature vectors, which are extracted from the pixels of an input image, segmented the hands perfectly. The accurate segmentation result is due to the distinguished color of the hand skin from the background, see figure (2, middle).

We used the well-known Canny edge detection [26] method to detect the edges of the segmented hand. Despite there are more than 90 geometry features to choose from, our hand shape feature extraction method focused on the most important 19 feature points (for simplicity), which are represented using the Chain Code algorithm [27]. The Chain Code Algorithm is employed to represent the shape of the hand, because it is not affected by the rotation of the hand [28], see figure (2, right).

The 19 selected features include Pinkie length, Ring finger length, Middle finger length, Index finger length, Thumb length, Lower palm length, Upper palm length, Thumb width, Index finger width, Middle finger width, Ring finger width, pinkie width, Pinkie lower width, Ring lower width, Middle lower width, Index upper width, Middle upper width, Ring upper width, and Pinkie upper width.

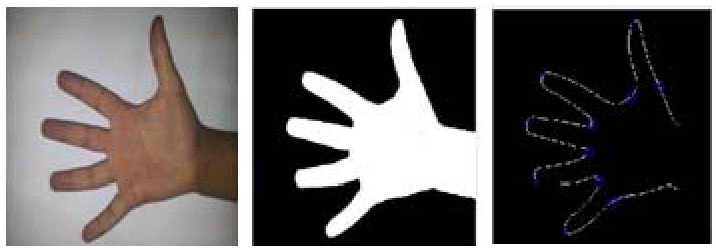

Fig. 2. (left) original image, (middle) segmentation hand, (right) the extracted features.

For training and testing we employed ANN with back propagation, which consists one input layer with 19 nodes represent the 19 features, One hidden layer with 40 nodes, and one output layer of 200 nodes representing all persons in the database. Same network is used for both MOHI and WEHI.

5. Result and discussions

In this paper we are more interested in identifying persons based on their hands, rather than building a secured authentication system, e.g. identifying terrorists from their hand coming into view. The previous test protocol is applied on both MOHI and WEHI.

Because the last 50 persons in both databases were recorded in extreme conditions of light, rotation and scale, we showed their results separately. The results of persons from 1 to 150 are shown jointly. Table (3) shows the results of both MOHI and WEHI.

Table 3. Identification results of MOHI and WEHI databases

Persons	MOHI Accuracy	WEHI Accuracy
(1-150)	0.820	0.813
(151-200)	0.428	0.372

As can be noticed from table (3) the results of identifying persons from MOHI are slightly better than those of WEHI, this is because MOHI is recorded using higher quality cameras (8 MP). However, the results were not significantly higher because we only used geometric features, based on the shape of the hand, which can be well preserved using a webcam (low quality). This experiment proves that a webcam is enough to identify persons using shape features. With some user's cooperation and more features, we might not have the need for expensive hand scanners.

The accuracies of identifying the first 150 persons were encouraging. But the accuracies of identifying the last 50 persons in both databases were significantly low; this is expected because the 19 features used were not enough to recover the real shape of hands from the damaged shapes resulting from the extreme rotation. This situation may happen in the real life when trying to identify a person showing a rotated hand in a digital image.

6. Conclusion

Hand geometry is a promising biometric. Accuracy can be increased by employing new features and techniques. It is important to increase the accuracy of this biometric, so as to relax the dependent on Hand scanners, which have several disadvantages, such as high cost, large size, not available to all users (particularly home and office users), not user-friendly and bring up health issues. Knowing that, mobile cameras or webcams are enough to preserve the shape information of hands. We hope that creating MOHI and WEHI contributes to the perfection of hand geometry biometrics.

The rotation of the hand around the z-axes (the virtual line perpendicular to the palm and the camera's lens) does not make any difference, as it can be solved using available methods that are invariant to rotation. While the rotation of the hand around the x and y axes produces different pose of the hand, and damage some of its geometry features depending on the rotated angle. The higher the angle, the worse the shape.

It is important to find geometric features that are not affected by such rotations, because sometimes a rotated hand image is the only evidence we have got, e.g. a terrorist's hand image. Our future work will focus on finding such invariant features.

References

[1] R. H. Ernst, "Hand ID system," *U. S. Patent*, 1971.

[2] R. P. Miller, "Finger dimension comparison identification system," *U. S. Patent no. 3576538*, Apr. 1971.

[3] C. S.-A. a. A. G.-M. R. Sanchez-Reillo, "Biometric identification through hand geometry measurements," *IEEE Trans. Pattern Anal. Mach. Intel*, no. 22, p. 1168–1171, 2000.

[4] A. Ross and A. K. Jain, "A Prototype Hand Geometry-based Verification System," *2nd International Conference on Audio- an video-based Biometric Person Authentication*, pp. 166-171, 1999.

[5] A. de Santos Sierra, J. Guerra Casanova, C. S. Avila, and G. B. del Pozo, "A comparative study on unconstrained hand biometrics," *International Conference on Hand-Based Biometrics (ICHB)*, pp. 1-6, 2011.

[6] R. M. Luque-Baena, D. Elizondo, E. Lopez-Rubio, E. J. Palomo, and T. Watson, "Assessment of geometric features for individual identification and verification in biometric hand systems," *Expert systems with applications*, vol. 40, no. 9, pp. 3580-3594, 2013.

[7] J. M. Guo, et al., "Contact-free hand geometry-based identification system," *Expert Systems with Applications*, vol. 39, no. 14, pp. 11728-11736, 2012.

[8] N. Saxena, V. Saxena, N. Dubey, and P. Mishra, "Hand geometry: A new method for biometric recognition," *International Journal of Soft Computing and Engineering (IJSCE)*, vol. 2, no. 6, pp. 2231-2307, 2013.

[9] B. Mathivanan, V. Palanisamy, and S. Selvarajan, "Multi-dimensional hand geometry based biometric verification and recognition system," *Int J Emerg Technol Adv Eng*, vol. 2, no. 7, pp. 348-354, 2012.

[10] W. Kang and Q. Wu, "Pose-Invariant Hand Shape Recognition Based on Finger Geometry," *Systems, Man, and Cybernetics: Systems, IEEE Transactions on*, vol. 44, no. 11, pp. 1510-1521, 2014.

[11] R. Poonam and D. Sipi, "Hand Geometry Recognition System Using Feature Extraction," *International Journal of Advanced Research in Computer Engineering and Technology (IJARCET)*, vol. 2, no. 6, pp. 2064-2067, 2013.

[12] A. Gupta and S. K. Singla, "Hand Geometry Based Biometrics Using LabVIEW," *International Journal of Advanced Research in Computer Science and Software Engineering*, vol. 3, no. 7, pp. 395-398, 2013.

[13] S. A. Dhole and V. H. Patil, "Person Identification Using Peg Free Hand Geometry Measurement," *International journal of engineering science and technology*, vol. 4, no. 6, pp. 2943-2949, 2012.

[14] P. Varchol and D. Levicky, "Using of hand geometry in biometric security systems," *RADIOENGINEERING*, vol. 16, no. 4, pp. 82-87,

2007.

[15] W. a. Q. W. Kang, "Pose-Invariant Hand Shape Recognition Based on Finger Geometry," *IEEE*, vol. Volume:44, no. 11, pp. 1510-1521, 2014.

[16] S. M. Basheer and M. J. Robinson, "Reduce Data Utilization Scheme for Biometric Hand Recognition using Six Features," *International Journal of Scientific & Engineering Research*, no. 4, pp. 717-724, 2013.

[17] X. Font Aragonès, "Visible, near infrared and thermal hand-based image biometric recognition," PhD Thesis, Departament d'Arquitectura de Computadors, Universitat Politècnica de Catalunya, 2013.

[18] A. Abdesselam and A. Al-Busaidi, "Person Identification Prototype Using Hand Geometry," in *In The International Conference on Computing, Networking and Digital Technologies*, 2012, pp. 114-122.

[19] O. O. V. Villegas, H. M. Orozco, H. D. Domínguez, L. O. Maynez, and V. G. Sánchez, "Biometric Human Identification of Hand Geometry Features Using Discrete Wavelet Transform," *INTECH Open Access Publisher*, p. , 2011.

[20] V. Yadav, "Design of a Hand Geometry Based Verification System," PhD Thesis, PATIALA, 2010.

[21] H. Yan and D. Long, "A novel bimodal identification approach based on hand-print," *Image and Signal Processing, CISP'08. Congress*, no. 4, pp. 506-510, 2008.

[22] Y. Ma, F. Pollick, and W. T. Hewitt, "Using b-spline curves for hand recognition," in *17th International Conference on Pattern Recognition*, 2004, pp. 274-277.

[23] Y. Bulatov, S. Jambawalikar, P. Kumar, and S. Sethia, "Hand recognition using geometric classifiers," *Biometric Authentication*, pp. 753-759, 2004.

[24] R. Sanchez-Reillo, C. Sanchez-Avila, and A. Gonzalez-Marcos, "Biometric identification through hand geometry measurements," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, no. 22, pp. 1168-1171, 2000.

[25] A. B. A. Hassanat, M. Alkasassbeh, M. Al-Awadi, and E. A. A. Alhasanat, "Color based Lips segmentation method using Artificial Neural Networks," in *The International Conference on Information and Communication Systems (ICICS)*, Amman, 2015.

[26] J. Canny, "A Computational Approach To Edge Detection," *IEEE Trans. Pattern Analysis and Machine Intelligence*, vol. 8, no. 6, p. 679–698, 1986.

[27] H. Freeman, "On the Encoding of Arbitrary Geometric Configurations," *IRE Trans. Electron. Comput*, vol. EC-10, pp. 260-268, 1961.

[28] A. B. Maity, S. Mandal, and R. Podder, "Edge Detection Using Morphological Method and Corner Detection Using Chain Code Algorithm," *International Journal of Computer Science Issues (IJCSI)*, no. 8, pp. 583-588, 2011.