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A Survey of Hand Geometry Recognition

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Abstract: ***In modern security systems, to recognize a person earlier recognition techniques such as ATM cards, pin code have been replaced with person's biological characteristics as fingerprint, eye, hand, etc. This technology is referred to as biometrics. In this paper, a biometric technique based on human hand's shape and features that are hand geometry will be discussed. It has gained popularity in low to medium security system because of its ease of collectability, public acceptance and low template size. This paper present survey of the hand geometry biometric technology and basic steps of hand geometry recognition. To determine performance of hand geometry system various parameters like FAR, EER, FFR, ROC curve will be discussed This paper will compare the work done by various researchers on hand biometrics based on image acquisition technique, population size, features extracted, performance, etc. At last, few limitations of the system will be provided and future work will be discussed that may further improve biometrics.***

Keywords: biometrics, hand geometry, recognition

I. INTRODUCTION

With the increasing frauds in today's world security is a big issue. So to increase the security we need to automate various identification systems. For that biometrics emerged as a new technology. Biometrics emerged as an automated identification system based on person's biological traits. Two types of traits are used- physiological and behavioral [1]. Physiological characteristics relate to the shape of the body and includes- fingerprint, face recognition, hand geometry, iris recognition, palm recognition, etc. Behavioral characteristics relate to the behavior of the person and it includes - signature recognition, keystroke dynamics and voice recognition. Biometrics has replaced traditional identification system in many applications like immigration and border security, ATMs, government IDs, etc. A good biometric system must following qualities- universality, permanence, uniqueness, collectability, circumvention, performance.

Biometrics resolves the identity of individual in two ways:

» Identification: to identify the individual's identity.

» Verification: to verify the person's identity.

In this paper, we will discuss about one of the biometric techniques- Hand Geometry. Hand geometry recognition system resolves the identity of an individual by extracting various hands' geometric features (finger lengths, width, ratios, area, etc.).Basically, hand geometry resolves the identity of the individual by extracting following features: fingers lengths, fingers width, palm length, area of palm, etc. shown in fig. 1

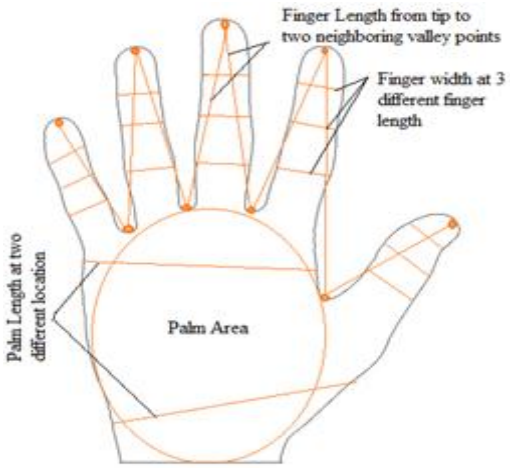

Fig 1: Various hand features that are extracted during hand geometry recognition.

Although hand geometry recognition systems are not much popular for identification as fingerprint, but they are used for verification in low to medium security applications like cash vault systems, time and attendance related applications, dual custody applications, etc. they have become popular for following reasons:

1. Hand images can easily be captured by using conventional CCD cameras.
2. It is mostly acceptable by the public because it is not related to any criminal records.
3. It has low template size (9 bytes) so it can be stored easily.

So, because of the above reasons hand geometry biometrics is mostly acceptable by public [2].

The rest of the paper is organized into following ways. Section 2 will present a literature survey of hand geometry. Section 3 will present basic steps of hand geometry recognition. Section 4 will present performance parameters. Section 5 will present work done by various researchers in tabular form and finally in section 6 conclusion and future scope will be discussed.

II. Literature Review

The use of hand images for the biometric verification has been gaining popularity. Various works have been done by different researchers. In this section we will review the work done by various researchers on hand geometry recognition.

Peter Varcholet.al. [1] have proposed biometric security system using hand geometry. By performing experiments they are able to how show that human hand geometry dimensions are capable of verifying an individual. For capturing the hand images they have used the simple setup of a scanner and a flat surface. To control the movement of hand pegs are used. From all 408 hand images of 24 people they extract 21 elements from a hand like finger length, heights, area, etc. Since recognition three experiments are performed with Euclidean distance, Gaussian mixture model(GMM) and Hamming distance and best results are obtained with GMM with EER=4.62% and FAR=0.1812%.

With the use of pegs in the above proposed system users are not able to place the hand freely and shape of the hand is also deformed. So some researchers try to capture images without using pegs. Miguel Adan et.al. [3] proposed biometric for verification/identification purposes based on natural hand layout. Pictures of left and right hands have been used in the experiment. For capturing the images mobile experimental prototype with 2 CCD cameras have been built where pegs are not required to assist the placement of the hand. In this system polar representation of contour of the hand is used to extract features and finally normalized similarity measure is used for verification. This system is tested on 5640 pictures of 470 users and shows 97.6% accuracy in identification and EER is 1.3%.

Joan Fabregas et.al.[11] have investigated how the biometric system based on hand geometry is affected by image resolution. Researchers have reduced resolution from initial 120dpi up to 24dpi. The experiments are performed by using two

databases, one underhand database and other is overhand database and capture 10 different images of 85 people and 15 features have been extracted which define hand geometry. For identification two classifiers are used- SVM and Neural networks. At the end they conclude that without any loss of recognition rate, resolution can be reduced to 72dpi.

Bahareh. Agile, et.al., [4] has used only four finger geometry for personal identification/verification. They proposed the method which is insensitive to rotation of the hand so that images can be captured by desk scanner where users can freely place his hand and pegs are not required. They extract 24 features from 4 fingers and have used Euclidean and absolute distance as a classifier. The proposed method has been applied on 500 pictures of 50 users and shows 99.81% accuracy in identification and EER is 0.1743% using the absolute distance classifier.

Keeping in view the hygiene of individuals some researchers proposed contactless hand geometry system in which a person is not expected to touch any surface which is good for individual hygiene. Jing-Ming Guo et.al. [6] have designed contact free system of hand geometry using a commercial webcam and infrared devices for illumination. Using infrared devices, it is possible to employ the system in dark and real environment. After capturing the image and preprocessing the image 34 hand's features have been extracted using 13 important points of hand for further recognition. For recognition libSVM framework is employed and obtained the result of false accept ratio (FAR) 1.85%, which is acceptable to uniquely identify the individual.

Another method of using hand geometry features for human identification and verification is proposed by Rafael M. Luque-Baena et.al.[7] using genetic algorithm and mutual information. Rather than classification they designed the system for identification. As the images are captured by without any contact with the surface so the orientation of hand is necessary. For feature extraction a strong hand segmentation is employed and a genetic algorithm is used to select the best suited features. Experiments are performed on three public databases- GPDS, CASIA and IITD databases and 100% results have been shown with GPDS and 9% with others.

Marcia V.P. Do Nascimento et.al. [9] studies the comparison of various learning algorithms used for hand geometry recognition. For this they capture 678 images from 97 persons keeping in view the user comfort. In their study,they also use cross validation and random subsampling techniques. For comparison support vector machine was applied in 2 implementations- SMO and libSVM and algorithm for Bayesian network was BayesNet.and results have shown the same accuracy with BayesNet and SMO.

For better results some researchers have combined hand geometry with other hand techniques like palm print, hand shapes, fingerprint texture, etc. and develop multimodal biometric system.

Miguel A. Ferrer et.al. [2] proposed a biometric identification system by combining hand geometry with fingerprint and palm print texture and develop a cheap multimodal biometric system. For performing the experiments 10 images of right hand of 109 people have been captured by using a scanner. For hand geometry 15 hand geometry features have extracted and SVM is used as a verifier. For palm print and fingerprint 2D Gabor phase encoding techniques have been employed and hamming distance is used as a verifier. Results have been shown by fussing at three different levels.

Wei-Chang Wang et.al. [12] proposed another method of biometrics by combining hang geometry with palm print. For feature extraction they utilize the concept of morphology and Voronoi diagrams. Recognition is done in two stages- Coarse recognition and Fine recognition and achieve better result compare to eigenpalm method with FAR 0.0035 and FRR % 5.7692%.

III. Basic Steps Of Hand Geometry Recognition

Hand geometry recognition system generally has two phases:

» Enrollment phase: In this phase template of an individual's identity is stored in the system database. It consists of three steps: image acquisition, preprocessing and feature extraction. Them the template is stored in the database.

» Recognition Phase: In this phase individual's identity was verified by comparing the features extracted with the template already stored in the database. It consists of five steps: Image acquisition, preprocessing, feature extraction, matching module and decision module.

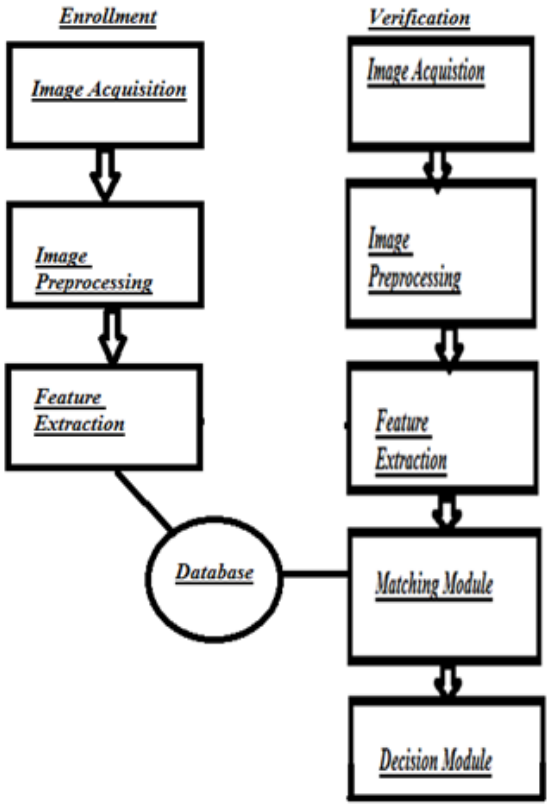

Fig. 2. Basic hand geometry module

A. Image Acquisition

Image acquisition is the first step of geometry recognition. It includes capturing the image of the hand. Image acquisition has three kinds of scenarios:

» Constrained and contact based image acquisition: These systems require a flat platform and pins so that individual place hand in a particular position.

» Unconstrained and contact based systems: These systems do not require pegs but require a platform to place the hand

» Unconstrained and contact-free image acquisition: These systems, neither requires pegs nor the platform to place the hand [3].

B. Image Preprocessing

The next step is image preprocessing. The image acquired in the first step may not be in the form that it can be used for further processing. So it is required to convert the image so that features can be easily extracted from it. For that, first of all an image is transferred into a grayscale image using various MATLAB functions like rgb2gray or im2bw. Then various noise

removal algorithms, edge detection algorithms or morphological operators can be applied to smoothen the image so that it can be effectively used for further analysis.

C. Feature Extraction

In this module various hand geometric features are extracted like finger length, finger width, Palm length, Palm width and Hand length. For finding these features we have to first find out fingertips, valley points and landmark points and then extract those features. For this morphological operators, an algorithm based on counting pixels or Competitive Hand Valley Detection Algorithm [4] can be used in MATLAB.

D. Matching Module

After extracting features there is a matching module. In this module features extracted in the previous module are compared with the template of an individual earlier stored in the database during the enrollment phase. For that various classifiers are available. These classifiers used are SVM, Neural network approach, k-NN, genetic algorithm, fuzzy logic, HMM, Euclidean distance, Absolute distance, etc. and a matching score is calculated which is a number which shows the relationship between extracted features and those already stored in the template.

E. Decision Module

The last step is the decision module. The matching score calculated in the previous module is used in this module. The matching score calculated is compared with the threshold. For accepting the identity of the user the matching score should be less than the threshold otherwise the user is rejected.

IV. Performance Parameters

In order to check the accuracy of the system following performance parameters [5] are available.

A. FAR (False Acceptance ratio)

It is the ratio of the number of times the system accepts the unauthorized users to total number of attempts.

$$\text{FAR} = \frac{\text{NUMBER OF FALSE ACCEPTANCE}}{\text{TOTAL NUMBER OF ATTEMPTS}}$$

For accurate system FAR should be as less as possible.

B. FRR (False Rejection Ratio)

It is the ratio of the number of times the system rejects the authorized users to total number of attempts.

$$\text{FAR} = \frac{\text{NUMBER OF FALSE REJECTION}}{\text{TOTAL NUMBER OF ATTEMPTS}}$$

Less the value of FRR more the accuracy of the system.

C. EER(Equal Error Rate)

EER is the point where FAR and FRR equals each other. It is the measure of accuracy of the system. Accuracy of the system increases with a decrease in the value of EER. EER is obtained in the ROC (Receiver Operating Characteristics) which is a plot of FAR and FRR.

V. Comparison Of Work Done By Various Researchers

In this section work done by various researchers on hand geometry based on various factors that are pegs used, population size, no. of samples/ person, features extracted, recognition method, identification rates will be discussed in tabular form in Table 1.

Table 1: Comparison of various techniques

Year	Pegs	Image acquisition Method	Population Size	No. of samples/ person	Verification/ identification	Features Extracted	Recognition Method	FAR/FRR	Identification Rate
2007 [1]	Yes	Scanner	26	20	V	Finger Width at 3 different heights, Finger height, Palm size(21)	Euclidean distance, Hamming Distance, Gaussian Mixture Model	Best result with GMM with FAR=0. 1812% FRR=14.583%	_
2007 [2]	No	Desktop Scanner with resolution of 150dpi	109	10	V	Geometric features(15),palm print and fingerprint texture	SVM for geometric features and Hamming distance for others.	FAR= 0% FRR= 0.15%	_
2008 [3]	No	CCD cameras	470	6-8	V/I	L/R Hand's contour	Normalized Similarity Measure	FAR= 1.304% FRR= 1.2766%	97.6%
2009 [4]	No	Desktop Scanner (GPDS database)	50	10	V/I	Geometric measurements(Length and width) of four fingers(24)	Euclidean distance and absolute distance.	EER= 0.1743% with absolute distance classifier	99.811%
2012 [5]	No	CCD camera	200	20	V/I	Hand contour	Coherent Distance Shape Contexts (CDSC)	EER= 0.9%	99.60%
2012 [6]	No	Webcam	50	60	V/I	Finger lengths (Distance of fingertip from neighboring valleys and center of palm), Finger widths (at 4 diff. Heights) (34)	SVM	FAR= 1.85%	96.23%
2013 [7]	-	GDPS database,	144	10	V/I	Geometric features of hand like area, perimeter, length, width, aspect proportion, hu moments, etc.	GA- kNN ,GA – SVM ,GA- LDA	EER= 4-5%	100%
		CASIA database	100	6					97%
		IITD database	137	10					100%
2014 [8]	-	JUET database	50	10	V	Hand shape (2) and geometrical features (7).	Distance classifier	EER=0.31%	-
		IITD database	240	6					
2014 [9]	No	DSLR camera	97	7	V	8 measurements from each finger, 2 angle measurement from each finger except thumb and 6 descriptors from hand (54)	Bayesian network and SVM	Accuracy =99.85%	-

2014 [10]	-	GPDS database	144	10 (Right hand)	V/I	Hand contour and Hand shape	DHMMK + SVM	EER=0.31	99.87%
		UST database	287	10 (Left) & 10 (Right)				EER=0.017	99.92%
		Mid infrared GPDS database	100	10 (Right)				EER=0	100%

VI. Conclusion

Biometrics can be used as an automated method for identifying and verifying the identity of an individual. After doing review of hand geometry recognition system we have concluded that hand geometry can be used as a good technique for verification but not for identification. We have also concluded that peg free acquisition devices are mostly acceptable by users and give better results. For making this system more reliable and to allow it to be used for verification purposes, it can be fused with other biometric techniques like palm print, fingerprint, palm vein, etc. and we can use more reliable classifiers like Neuro fuzzy classifier, etc.

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