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Subject Review: Hand Geometry Recognition System

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Abstract
Identity represents the people's assets and the identical verification (ID) is a process that is used to prove the matching between person's identity and what's already claimed. The ID process has many methods and the biometric method is the most important one, because it offers consistent result in the identity verification field. There are many techniques in the biometric verification such as; voice, iris, retina scanning and commonly used the fingerprints. Basically, the human hand contains information aiding the authentication of the of individual identity. The term Hands Geometry, refers to the hands geometric structure. This structure involves hand's shape, fingers length and their width at various locations and palm's width and thickness, etc. However, despite of all the anatomical features the hand has, they are still not enough to be depend on. Since those features are time sensitive, as the hands are always subjected to changes due to illness, aging and weight gain/loss. In fact, it depends on individuals with extremely different hands that will not drastically change with time. The purpose of this article is to survey several articles found in literature about Hand Geometry recognition System, and to compare among different methods used in these articles.

Keywords: Hand geometry, Identical verification process, Biometric verification.

1. Introduction
Nowadays, the field of information technology and digital devices have been invaded all parts of our lives. Such devices need a user's recognition to protect physical, logical resources as well as automating things. There are different systems used to identify an individual. The well-known ID systems are mainly depended on knowledge, as the user needs to remember some passwords as well as owning coded card or Image ID. These systems can recognize things and not human, so they may fail most times because of some shortcomings, like card duplication, forgotten passwords and loses identity card. Therefore, biometrics depended protection systems have become widespread, since they characterized by high accuracy and their ability to distinguish between the real user and the imitators. Another reason is that they depend on the personal physiological characteristics which we are born with, such as: face and ear shape, iris, retina, fingers and hand geometry. This unique characteristic called the physiological-behavioral characteristic [1]. Recently, the most popular control access biometrics is the hand geometry system, and it is noteworthy to mention that the markets of the physical control access were flourished by the presence of such a system [2]. This system works depending on the recognition of the hands of human being and focuses on some details such as their shapes, lengths and sizes [3]. There are three kinds of services provided by hand geometry recognition system which are verification, organization as well as identification. In the verification, providing identity is important as well as the geometry

of the hand and the identity verification will be performed by the system. For the organization service, providing information is not a must, but it can be considered as a legitimate service somehow. While, in the identification service only a geometrical hand data is required, sometimes it can be considered as an intrusion. If the system identified the user the access will be accepted, otherwise the process will be rejected [4]. There are several different types of applications that use the hand geometry recognition system, including time and attendance tracking and access control; it is noteworthy that the time and attendance tracking are mainly used for security [5].

The study parts are organized as followed: The second part is about a literature review of some of the schemes proposed in the last decade about hand geometry recognition system. Third part, the comparative analysis of the methods discussed in the previous part. Finally, conclusions are presented in the fourth part.

2. Literature Review

The study of Faundez-Zanuy, M., M. A. Ferrer-Ballester, C. M. Travieso-González, and V. Espinosa-Duro, [6] presented a geometrical hand based biometric ID system. The recorded data was consisted from (50) individuals and (10) right-hands. Furthermore, they were also described the process of features extraction and the study's results were obtained using multiple organization plans depending on the Multi-Layer Perceptron (MLP). The ID rates were evaluated as well as the values of the Detection Cost Function (DCF) for the confirmation applications. The results revealed an ID up to (100%) and a DCF of nearly (0%).

Kumar, A., and D. Zhang, [7] were presented a study that proposes the by the use of entropy heuristics in order to attain process enhancements. A comparison of assumed enhancement was accomplished based on some classifiers such as: the FFN, the SVM, the k-NN and a naïve Bayes because of the controlled and uncontrolled discretization systems. The study concluded that database results which was consisting of (100 individuals) had achieved an accurate recognition and the practicality of the hand geometrical features discrimination systems was confirmed.

Guo, J.-M., C.-H. Hsia, Y.-F. Liu, J.-C. Yu, M.-H. Chu, and T.-N. Le, [3] presented the study of how to practically use the shape of the hand's palm for extracting the features with simplified algorithms. The study data was including the collection of palm prints of (100) hands, some prints were belonging to the same individuals but with scanning the palm at different positions each time.

A study of Faundez-Zanuy, M., and G. M. N. Mérida, [2] was about describing the hand geometry biometric ID system. They obtained the database from (22) individuals with a traditional documents and papers electronic scanner. The study experiment included the ability to discriminate dissimilar extracted hand's features along with a rate of ID by the use of different classification of a neural network.

The research of Covavisaruch, N., P. Prateepamornkul, P. Ruchikachorn, and P. Taksaphan [8] suggests a study of individual ID and authentication using the geometry of the human hands. The hand's geometrical features that had been depended on in this study includes the palm, fingers widths along with the lengths of the fingers. The individuals' hands were placed freely without any hand fixations. Systems used in this study have (6) dissimilar functional distances on which comparison and test was performed. The tested database consists of (96) individuals. Among the (6) functional distances, only one which was the S1 gave the highest results in the identifications and authentications.

Park, G., and S. Kim, [5] study presented a biometric system with multi-modal property that used a single image copy for features points extraction. Such a system is useful to be constructed for devices with a low-price. The multi-modal hand approached biometric geometry with views of the hand's sides and back and a recognition of the outlined pattern of the vessel's method was accomplished at the score's level. The study recorded that the rate of the equal error was about (0.06%).

The research of Angadi, S. A., and S. M. Hatture [9] suggests an advanced hand geometry-based ID system with a peg-free property that uses a graph representation provided by wavelets. The individual's hands were characterized as weighted and totally completed connected graph with one direction. The graph act as vector for the extracted features. It's also containing an advanced zone-wise wavelet energy. Individual's ID was achieved

by via multi-class Support Vector Machine (SVM). The database consists of (144) individuals with (10) right hands pictures of every involved person were taken from GPDS 150 hands records.

Pititeeraphab, Y., and C. Pintavirooj [10] study concerned about the development of hand ID and geometrical features involving lengths of both hands' length, fingers width and length as well as size of palm. The study used a method characterized by a radius distance to figure out the sites of the fingertips along with fingers concavity from hand contour; because this method is highly flexible and can detect such features accurately. The reference points have been used to identify the hands characteristics. The images collected for the study sample were attained from a simplified inexpensive system. The recorded results proved the method's proficiency.

Shawkat, S. A., K. S. L. Al-badri, and A. I. Turki, [11] studied an automatic recognition system without using a specific hardware. The system affirms on features execution, such features were extracted from a distinctive data and then evolving a classifier with a neural network, which is based on a back-propagation architecture with multi-exercise methods. The morphological (segmentation) operation is used for digging out features. Depending on (500) images the experiments were performed, there was (50 individuals with 10 taken images for each one). This was under typical situations with a possibility of debating on scaling, translation, and rotation with hue and brightness adjustment.

Oldal, L. G., and A. Kovács [12] studied a method that offers a simple solution for a affordable, contact-free authentication system based on palmprint and hands geometry features, by producing a promising outcome of an improvement in the palm feature that matching algorithm. The method will use a distance transform for similarity determination of the palm features following palm images transformation. This can be useful, when the varying intensities of palm lines would reduce the effectiveness of the method.

A study purpose of Mohammed, H. H., S. A. Baker, and A. S. Nori [13], suggests a system for hands recognizing which can evolve (21) features of the right human's hand for individual ID. The system process consists mainly of (2) parts: part one contains the data assembly which describes required pre-processing step, in addition to the process of extraction of the characteristics of hand geometry to obtain the essential features ready for discrimination. This is followed by the second part which includes training along with testing steps of the 3 synthetic neural networks for discrimination performance which are responsible of forward feeding of the back-propagation (NN), Elman (NN), and the cascade neural network (NN).

Research of Al-Fiky, F. M., and Z. S. Ageed, [14] showed that the biometry plays a vital and essential role in individual's discrimination. The study methodology calculated and determined (66) right-hand features. This was accomplished by mainly 2 stages; usually the first stage is about assembling the data and pre-processing technique. Whereas, the second stage involves a synthetic neural system training and testing. The assumed procedure recommended the (BPNN) for the purpose of training with a single inputting layer, a concealed layer and a layer for outputting. The Recognition Rate (RR) of the artificial neural system after test performance and using the recommended features, showed a higher result compared to the preceding work.

In the paper of Iula, A., and M. Micucci [15], they proposed and evaluated a multi-modal ultrasound discrimination scheme which is based on Three-Dimensional (3D) palmprint features and 3D hand geometry combination. This system acquires a whole hand volumetric image for each one of them. Some images with Two-Dimensions (2D) were taken at a depth of different levels. The extraction of 2D topographies and combining them should be done appropriately to accomplish a 3D model for each image. The performed recognition was assessed out of the tests of (verification) and (identification) with a homemade data record. Experimentation was accomplished for the 2 uni-modal biometry followed by 2 modalities fusion at the score level.

Wang, W.-C., W.-S. Chen, and S.-W. Shih, [16] were presented in their study a novel biometric discrimination scheme combining the human geometrical features of the hand and palmprint in the light of morphology. They utilized Voronoi diagram to split the images of the frontal view of the palm into many unequal blocks according to the geometrical features of the hand. Besides, the statistical characteristics of the blocks gray level were served as characteristical values. Study results showed an inspiring performance.

Khaliluzzaman, M., M. Mahiuddin, and M. M. Islam, [17] this study represented a person authentication biometric system on the basis of geometrical features of the hand. The main superior geometrical features of the

right-hand with four fingers were extracted. The purpose of this system was to improve the scheme accomplishments and minimize the features and database size. Thus, four fingers and their tips points along with two corner valley points were estimated. This was followed by computing the edges with 8 distances of the same fingertips with the corner points of the valley. From those edges with 8 distances, only 3 triangles were assessed to be used as three features and stored as the feature vector in the database. After that, comparison was accomplished through the Euclidian distance measurement system between the test candidate hand features and the predefine database feature vector.

The research of Haitham Salman Chyad, Raniah Ali Mustafa, Kawther Thabt Saleh [18], presented a handprint recognition system based on FP-growth algorithm. The system was consisting of three stages. The first stage includes the detection algorithm using HSV color space, a canny algorithm and a grayscale contrast enhancement. This stage separates the skin area in handprint image through first HSV color space and converting RGB to HSV color space associated with specific rules for skin area determination. The skin hand segmentation applied for the split of non-skin and skin areas were detected by hand skin color detection. Then, the image smoothing was performed by using a Gaussian filter followed by converting to a grayscale image, enhancing the contrast and applying canny edge detection. The second stage is about extracting features applying seven moment invariants. The third stage involves handprint image recognition by applying FP-growth algorithm.

3. Analysis of the Compared Schemes

In the followed table (1) a comparative explanation between previously mentioned systems.

Table 1: Comparative explanation of different cancer disease schemes

Ref.	preprocessing	Extraction of the Features	Classification Methods	Accurateness and efficiency	Year
[2]	Low-pass filtering, binarization, contour detection, coding.	This paper proposes lengths and widths measurements of all fingers except the thumb in addition to the hand borders.	- Nearest neighbor classification - MLP classification trained in a discriminatory mode. - Function of the radial basis classification trained in a discriminatory mode.	ID rates in (%) were: 64.55% for the nearest neighbor, 73.64% (MSE) nearest neighbor, 91.82% MLP (MSE, 10 epoch), 92.73% MLP (MSEREG, 50 epoch), 93.64% MLP committee 3 nets (MSE, 10 epoch), 93.64%MLP committee 3 nets (MSE-REG, 50 epoch), 90% function of the radial basis.	2005
[8]	Grayscale image conversion, Median filter and morphological opening and closing.	Widths and lengths of all fingers at three locations and width of the hand's palm.	Functions of 6 distances were investigated as followed: 1. Total distance. 2. Weighted absolute distance. 3. Euclidean distance 4. Weighted Euclidean distance. 5. D1 distance. 6. S1 distance.	Presented a highest accuracy system with 94% and error about 6%.	Jan. 2005

[6]	Binarization and contour Detection.	working out of the geometric measurements.	MLP.	Revealing up to 100% ID and 0% DCF.	2006
[7]	----------	Entropy-based heuristics.	k-NN, SVM and FFN.	The study concluded that data of 100 individuals was achieved a considerable enhancement and usefulness in the discrimination accuracy in the schemes based on hand geometry was confirmed.	June 2007
[16]	The images with colors are turned to gray images, with binarization, morphology (opening) and Sobel filters.	Stripe and block dissection with an extraction of the palm's features.	The procedure of two-stage recognition: -Coarse recognition. -Fine recognition (linear support vector Machine).	The False Acceptance Rate (FAR) was minimized to 0.0035%. while, the False Rejection Rate (FRR) was minimized about 5.7692% .	2009
[3]	Image with gray-scale, with edge detection and noise removal.	Firstly, measuring finger's length. Secondly, measuring finger's width, and then performing different points measurement for each finger.	Matching.		2012
[5]	Transforming the gray image into a black and white with Gaussian median filters.	K-curvature uses as feature vectors. The hand geometry's first feature is the divided K-curvatures. The second feature is about the calculation of the finger valley's angle and length by the K-curvature. While, the third feature is the fingers length.	-Euclidean distance. - Polygonal curves measurement. -matching.	The multi-modal bio-metrics method showed more accurate results compared to the uni-modal biometrics.	Feb. 2013
[14]	Gray-Scale Image, Edge Detection and Noise Removal (Canny).	The study method includes 66 features which were extracted from the right hand, depending on the 2 points distance. The system of measurement of this method was extracted from two landmarks, termed as valley 5 and valley 6 respectively. Between those landmarks many sections were established to calculate the region, borders and angle points on it.	Back propagation NN (BPNN).	The recognition was about 93% and the mean squared error was 0.000001.	2014

[9]	Wiener adaptive filter, Otsu's auto-thresholding method, morphological filter and canny edge detection.	Graph representation and wavelet energy features.	Support Vector Machine (SVM) classifies	The correct rate of ID was about 97.92% by using the classification of SVM.	Nov. 2015
[10]	Median filter and opening and closing morphology.	Distance transformation to the palm contour.	The accurate matching between investigation and palmprint images references were found by using the distance map error.	The suggested procedure was successfully tested for personal ID. The recorded result was encouraging with an accuracy of 100%.	2018
[17]	The image was converted to the RGB and resized to 250x250. The RGB image was converted to YCbCr image, converting to the fillings, double image and gaps, right hand boundary extraction and Region of Interest (ROI) Detection.	Detection of six feature points from the pre-processed image. Among those 6 points, only 4 points were acted as the top points of all fingers except the thumb fingers.	Template matching	It had been showed that the recognition rate of the normal conditional images reached 100%. While, the different conditional images record was about 97.88%.	Oct. 2018
[11]	Turning the hued image into binary and gray scaled image.	The primary features extraction includes the finger's span length. While, the secondary ones were extracted the finger's width.	The absolute distance's function was used for the comparison of the vector features in the recommended scheme. The Back – propagation requires a training set.	The matching of synthetic neural system showed about 96.41 % of accurate recognition rate.	Sep. 2019
[13]	Turning the hued image into gray scaled image with binarization and canny filter.	Length and width of fingers and palm width or finger ratio,.. etc.	Artificial neural network (FFBB, Elman, CF).	The neural system RR after test accomplishments were 95%, 92% and 88% respectively.	2020
[12]	Gray-scaling, binarization (Otsu's) downsizing with removal of noise (median-filter) and detection of the morphological edges (erosion and subtraction).	The considered features during matching was as followed: -Proportions of the finger length (with respect to the middle finger length). • Largest inscribed circled area (with respect to the hand area). - Length of the Middle finger (with respect to the hand area). - ROI.	Template matching.	The results showed an accurate overview of the method, since the method was tested and evaluated on a large data set.	2021

[15]	The human hand images were obtained with 3D ultrasound recognition system.	The hand geography features measurements taken were, palm size, fingers lengths and widths. While, the palmprint was depended on principal lines and main wrinkles.	Template matching.	The results showed that the Equal Error Rate was 0.08%, and the ID rate was about 100%.	2022
[18]	The system method presented HSV color space, canny algorithm and gray-scale contrast enhancement.	Apply seven moment invariants.	FP-growth algorithm.	The system of hand-printed recognition achieved a rate of 92.70%.	2022

4. Conclusion

Within the limitation of this study, it had been reviewed that the timeline of a different ways of the biometric hand geometry recognition during the period (2005-2022) was to define the main characteristics of the performance of hand geometry recognition, and to obtain the results. The comparison was made on the basis of pre-processing stage, Feature Extraction (FE) stage, Methods of Classification stage and the Accuracy of the research results. The main advantage of geometrical hand authentication scheme is to simplify the image attainment in comparison to iris and fingerprint images attainment.

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