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A digital signature system based on hand geometry - Survey

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ABSTRACT: In recent years large number of emerging automated applications faces the need to have recognition abilities of persons using their own self biometrics, before they can access the applications services. Nowadays, Biometric recognition is used, it can be used as automatic identification or automatic verification of persons based on their physiological or behavioral characteristics. There are no perfect biometric measurements; each biometry has its advantages and limitations. Each biometry requires specific vital identity to answer the identification or verification question. The suitability of a particular biometry for a particular application depends on many factors. Hand geometry/shape is a very simple biometric technology that uses the measurements of human hand to verify the identity of the individuals. The measurements include the distance between certain mark points, shape and width of fingers and size of palm. The biometric systems that employing hand geometry become widely used since they have high public acceptance. This article aims to survey several articles found in literature about hand based biometric system, and to compare different methods of biometric recognition that based on hand geometry.

Keywords: Hand geometry, Biometric, Pattern recognition, Artificial neural network

1. INTRODUCTION

Today's life is highly intervened by information technology and digital devices. These devices also need to recognize human being to protect physical and logical resources as well as to automate things. Peoples have used different systems to identify an individual. Traditional identification systems are based on knowledge. People need to remember some passwords, and the system people must own some of them Image ID or coded card. These systems recognize things, not humans, so these systems can fail due to some shortcomings like card duplication, forgotten password or Loses identity card [1]. Therefore, protection systems based on the use of biometrics have become increasingly widespread, due to their accuracy and ability to easily distinguish between the real personality of the user and impersonators - Due to their dependence on personal biometric characteristics, these are their unique physiological-behavioral characteristics. Physiological characteristics in which we are born, including: iris, retina, face, ear shape, fingers, and hand geometry [2].

A biometric system is divided into various modules, namely the sensation, feature extraction, feature selection, matching and decision making modules [3].

Hand Geometry, as the name suggests, refers to the geometric structure of the hand. This structure includes width of the fingers at various locations, width of the palm, thickness of the palm, length of the fingers, etc. Although these metrics do not vary significantly across the population, they can however be used to verify the identity of an individual. Hand geometry measurement is non-intrusive and the verification involves a simple processing of the resulting features. Unlike palmprint verification methods this method does not involve extraction of detailed features of the hand (for example,

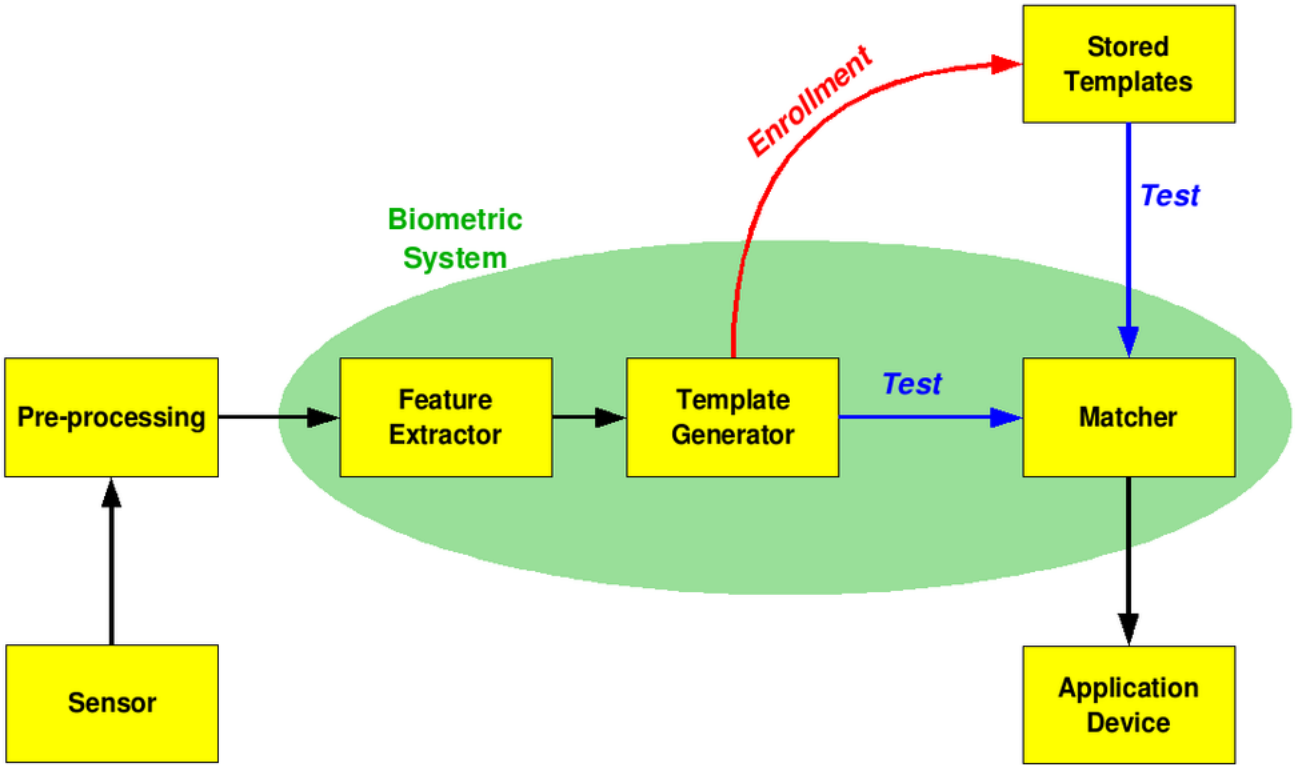

FIGURE 1. **Scheme of a Typical Biometric System [4]**

wrinkles on the skin) [5]. The human hand has enough anatomical features It offers a personal identification mechanism, but it isn't It is unique enough to provide a complete mechanism for identification. The hand geometry is time sensitive and the shape of the hand can vary due to illness, or age to change Weight change. In fact, it's based on everyone having an infinitely different hand which will not drastically change in the future [6].

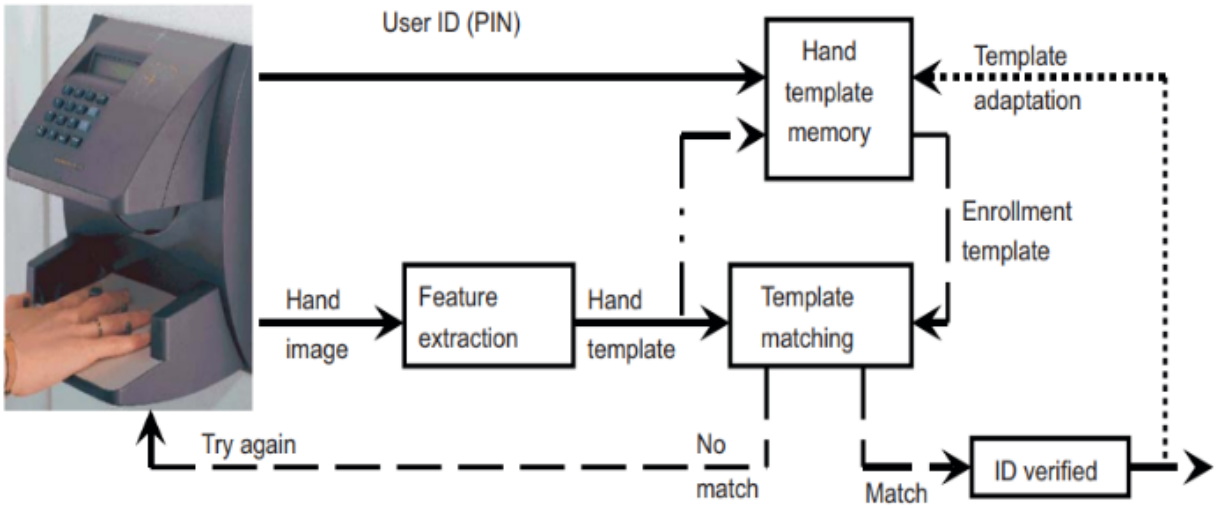

FIGURE 2. **Biometric based hand shape system [6]**

The human hand not only has the characteristic feature of gender information, but is also considered to be one of the most important biometric identifiers to identify a person. Unlike face shots, which are not usually restricted, handheld

shots have the advantage that they are usually taken in a controlled position [7]. In addition, show less variation than the characteristics which are generally represented by, for example, distorted patterns Appearance changes [8].

The rest of the paper is organized as follows, Literature review, basic modules of hand based biometric system such as image acquisition, image processing, extraction of features, comparison with the biometric template and decision, followed by hand dataset used.

2. LITERATURE REVIEW

Hand geometry has a great popularity as a biometric method in recent decades. Several researchers have published many articles in this field. Here we describe: some of the successful studies conducted in this area.

In 2015, Mr. S.Velmurugan and Dr.S.Selvarajan presented a bio-model using iris and hand geometry images based on Linear Binary Pattern approach. Preprocessing, Image enhancement using Discrete Curvelet Transform and Feature Extraction Using Segmentation, LBP are various stages implemented. This work aims to develop the person identity and develop system able to work with large set of data base. The proposed model extract 11 features of iris and hand geometry are Length, Finger Start to the reference point, Area, Breadth, center point, perimeter, Point Distance and circumference of iris. The proposed system worked on 500 images (5 images for each person). The system achieved accuracy about 94% for hand images, 95% for iris images. While achieved 100% accuracy rate for fusion hand geometry and iris image [9]. Authors [10] presented Identification of persons by using Wavelet features of hand geometry. Support vector machine (SVM) used as classifier. The hand image graph represented by weighted adjacency matrix. The wavelet energy features from the weighted adjacency matrix of hand image graph are extracted. This model produced feature vector contains twelve features for hand images. The system tested on 144 users (10 images of each person). The accuracy of identification rate is 97.92%.

In 2017, Hussein et al. have presented an efficient hand geometry Identification and verification purposes based measurable of hand geometrics such as length, width and area of fingers. This system focuses on noise reduction by using a low-pass filter for hand images after entering it, calculate curvature of hand by simple method to find points of hand. Then, extracted Twenty-four measurements that representing feature vector of hand and in the matching phase was used Artificial neural network and k-nearest neighbor's algorithm as classifier. They have worked on 35 persons (10 images (for each person was tested and validated in MATLAB. The Classification accuracy of matching was been 95.3% accuracy for artificial neural network and 91.2% for k-nearest neighbor algorithm [11], and Also in the same year, Song et al. proposed a simple, fast and secure authentication method applied on multi touch screen devices. The system recognized persons based on hand geometry and behavioral characteristics to face problem of changing hand behavior and against common smartphone authentication threats by develop a secure authentication method to protect the daily use of smartphones in particular. This approach achieved EER of 5.84% but become 1.88% with enough training [12]. The proposed system in [13] based on palm and hand geometry features. The algorithm used to feature extraction is discrete cosine transform (2D-DCT) to. This approach extracted hand length and three measurement of width and one measurement of length for each finger. In addition to width of palm and length of palm, palm ratio also extracted by suggested algorithm. This system has been tested on 30 users. They achieved 95.5% accuracy with 0.06% FAR and 0.03% FRR, While in [14], presented a model to verify the identity of the user based on both in-air-handwriting and hand geometry. The goal of this model to produce a better security than password authentication system by combined three methods including passcode, handwriting convention, and hand geometry in one frame. The system asked users to write pass-code and put hand to authenticated by observing the shape of the user's hand. This process was implemented on 100 users and used score fusion algorithms for matching. The results achieved 0.6% Equal Error Rate (EER) without spoofing attack and 3.4% EER with spoofing data. And also in 2018, Khaliluzzaman et al. proposed verification system based on the small size feature vector of hand geometry. The purpose of this approach is to improve the performance of the system based on eliminated features by extracting important points on the palm, two corner valley points with top four fingertip points, and then use these points to form three triangles, the area of these triangles are used as features for recognize persons. The proposed system used dataset for 250 different peoples, each one having at least 5 images. The recognition rate is 100% with the normal conditional of images while in different conditional of images obtained 97.88% of recognition rate, the FRR is 1% and FAR is 2% [15].

In 2019, Shawkat et al. presented a system can recognize persons rely on hand geometry. The system has focused on improvement a neural network classifier based on back-propagation with different methods of exercise. The goal of this system was to improve the security of application such as Check border and transfer payments of employees. The feature was extracted are different points of the finger's length, finger's width as well area of palm. The system worked on 50 persons (10 images for each person tested. The experimental results of accurate recognition about 96.41 % for the matching used artificial neural network [16].

The approach [17] produced model for hand authentication in bank application based on convolutional neural networks

to verify the person's identity. The aim of this model is to increase security in banking by using new approach of convolutional neural networks. Suggested using CNN for both feature extraction and validation. Three techniques of CNN Applied for process of recognition. This experiment perform method on 114 persons (5 images) for each person. This proposed model learned and validated. The accuracy reached in Res net about 100% with FRR about 0%, while in Alex net about 94.74% with FRR 5.20%, and in google net about 99.90% with FRR 0.10%. After the accuracy test, it was found that the best technique on which the experiment was conducted is Res net with 100% reliability on dataset. In the other work [18], they offered a modern way to encode any audio file according to the characteristics of the hand for added privacy and reliability. The researchers suggested using the hand geometry measurements as a key to encoding and decoding the audio file and improving the encoding with Discrete Wavelet Transform (DWT). The aim of this work is to merge the encryption process and biometrics into a high security system. The drawing function contains 50 functions available, such as finger width and length, palm width, large and small finger diameters, fingertip points, reference lines and reference point angles. The authors encoded the audio file with two keys after converting it to the frequency. This work was tested on 20 persons of different ages. The evaluation results for each audio file are Excellent. On the other hand, the paper [19], presented a gesture recognition system that interprets the American language has been introduced. This system helps people to understand communication as ordinary people. New fixed motions with MATLAB based on existing systems. Our camera system inputs use preprocessing. All features were checked by PCA. The comparison of functions is based on Euclidean distance using training sets. The nearest neighbor algorithm is used to classify the regression process. After all, it determines the optimal movements - text production or audio output. This frame app is designed to provide a scene with high definition for character interpretation, giving ordinary people a motion test of 19 people. The Accuracy rate is 95%. While in [20], introduced an improved intrinsic hand based on multimodal biometric recognition. These three methods are combined using a rule-based blurring system that provides 92% accuracy in NIR images. In this study, hand geometry is an inherent biometric method that uses near-infrared images of human hands. They also proposed to determine the biometrics of finger veins using convolutional neural networks (CNN). CNN achieved 90% accuracy in the NIR image data set. This system used three biometric methods to detect a live human body to improve the effectiveness of anti-counterfeiting attempts. This system achieved accuracy about 92% with 1 equivalent error rate (EER) and 0.113 FRR. Authors [21], proposed an authentication System by using palm print and hand geometry. The proposed method provides an effective solution for a low-cost authentication system. Feature extraction include Fingertip Detection, Wrist Point Detection, Finger Valley Detection, Region of Interest (ROI) Extraction and Palm line Extraction. The palm print principal lines are used for ROI alignment and palm print matching as well, which results in a simpler implementation of a palm print recognition system. Experimented on 14 persons. FAR is 4.6%, and FRR is 14.2%. They have proposed in the future to develop a matching algorithm of hand geometry and palm print features. In the meantime, the article [22], introduced a reliable approach for biometric system based on measurements of hand geometry. Objective of this work is to increase the efficiency by enhanced reducing Magnitude of features like length of the finger, the finger width, and palm width. The proposed system extracted 21 features for right hand image. Then used multi model of neural networks algorithms for recognition which are cascade forward neural network, feed forward back propagation, and Elman. The system work on 10 persons (10 images) for each person was tested and validated in MATLAB. The accuracy recognition rate for the matching were 88% for CNN with 9.98 % EER, 95% for FFBB with 9.99 % EER, and 92% for Elman with 9.97 % EER. And also in the same year , the authors [23], a proposed design framework for the hand geometry system is implemented in MATLAB environment. The first step is to extract images from the database using pre-image technology. The second step is the biometric properties of hand-extracting images. The third and final stage is the introduction of a neural network rely on healing system. ANN, which they proposed, is the most extensive learning controlled neural network. The system was installed on 20 people from the CASIA database. The properties are derived from the hand, such as the length of the finger the width, the span of the diameter the circumference. Recently Research in 2022, introduced a new method of user authentication based on the analysis of finger movements recorded by the motion recorder. They also suggested an effective method of job reduction based on Hotel ling's T2 statistics to select the best differentiators. Researchers of this work focus on selecting features to properly prepare the input data for the classification stage. The number of features extracted is 94 items. The article presents an effective method of user authorization by analyzing hand and finger movements on all fingers. The accuracy result rate about 99.88% [24]. While in [25], presented a comprehensive model of hand gesture and fingertip detection. The proposed algorithm uses a convolutional neural network to predict finger class and finger position to combines gesture classification and fingertip regression. The proposed method includes direct regression and heat map structure. The tested work on the SCUT-Ego-Gest database is used to conduct experiments with eleven different datasets for one-handed motions, in which hand is recognized by Yolo objects using a recognition algorithm. This system obtained Accuracy about 99.90%.

The human hand, according to researchers, has specific traits that can be utilized for personal identification and verification. The majority of studies focused on neural network methods like SVM, KNN, and CNN. People are classified and distinguished depending on their hand traits.Some of them demonstrated a multi-standard method based on the

hand and other important metrics that improves the system's security. We also highlight the differences in accuracy rates amongst studies, with the lowest accuracy rate in [22] being about 88 percent. In [15] [9], the greatest accuracy rate is around 100 percent. In addition to their suggestion to build matching algorithms in the future, these researchers concentrated on the utilization of genuine databases such as CASIA, Poly U, and others. They also stated that manual approaches have various benefits, including being extremely precise for identification, using usually low-cost technology, being rapid to match and requiring very tiny template sizes, resulting in a small memory footprint, and being less susceptible to imaging circumstances. Furthermore, hand-based modalities are more durable since they are unaffected by emotions and other personality factors such as weariness, tension, and so on.

3. BASIC COMPONENTS OF HAND-BASED BIOMETRIC SYSTEM

The biometric system of hand shape uses the geometry of the hand (width, length, angle) or the silhouette [26]. In the first step, the system collects data from the images from the user's hand and performs the recovery process. The registered user model is stored in the database. The second step is authentication, where: the system takes a picture of the user's hand and extracts a number of functions. Feature sets are compared with one or more models in the database. Based on the comparison, the person was accepted or rejected [27].

3.1 ENROLMENT

It is involved with two sub stages:

A Image Acquisition: it is the essential and initial step in biometric identity Authentication which is obtained from normal 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 [22]. The biometric sample is most often obtained by a CCD camera or by a scanner. Most hand-based biometric systems work with 2D hand images [9]. During capturing the image, there should be no gaps between the fingers and the fingers should not be overlapped [10]. The captured images are stored to keep away from any effects on image parameters such as dimensions changes (pixels), values in texture changes due to different sources, and bmp formats for potential image processing on the computer [16]. In another systems, records hand movements used an optical module (LMC) that records hand movements [24].

B Image processing: after obtaining the image of the hand, Pre-processing is done 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 [28]. In 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 using image thresholding procedure as follows [22]:

Input image(i,j)>Threshold then SetOutputImage(i,j)=1

Otherwise SetOutputImage(i,j)=0

Almost no captured image is completely noise free, not entirely focused, obtained in optimal lighting conditions. For this reason, filters are used to sharpen the image or to remove noise. It is also possible to change the brightness using geometric transformation methods [11]. A morphological filter is employed to fill-in all small gaps to blacken the isolated white pixels and to reduce the blurring of edges [20] [23]. Some preprocessing applied in order to remove the effects of shadow and light by enhancement filters that applied to image [18], also Erosion removes the unwanted part dots or pixels. Dilation is used to filter the image after the fingers part removed. This process separates the hand part and finger parts [19].

Segmentation another step of preprocessing image. In order to derive a contour from the processed binary image, canny edge detection technique is used [15]. Also, it can be performed using edge detection methods. The aim of segmentation in hand-based biometric systems is to separate the hand from the rest of the image automatically [13]. In particular, the on-the-fly data collected process images by applying random rotation, translation, shear transformation, illumination variation, scaling, cropping, additive Gaussian noise, and salt noise [25]. The canny edge detection method. This algorithm is more efficient because it will not be affected by any kinds of unnecessary noise detect the exact true values [19].

C Features Extraction: The succeeding segment of biometrics of geometry of hand is the extraction of features. Extraction of features is a distinctive form of reduction of dimensionality in image processing and pattern verification. The primary feature that can be extracted is a finger's length while the secondary can be dug out the finger's width. At different points of the finger, more than one measurement can be taken for the width. The length of the lines on the finger can also be used as a measure of the width of the finger, Area of the largest inscribed circle, Angels, thickness (with respect to the area of the hand) [16] [10] [14] [22] [18] [23].

Various features are Length, Breadth, center point, Area, Perimeter, Finger Start to the reference point (i.e., Distance from Hand geometry and Area), also extract the additional features as Binary pattern using linear binary pattern [9].

In [11] the features extracted by compute curvature of shape by Fourier transform property and the distance among many points are calculated using Euclidian distance. Recent research uses deep neural networks, such as convolutional neural networks, to extract features of the hand [16] [24]. In [24] worked on behavioral features and the novelty of the solution is the analysis of the movement of all fingers and the reduction of biometric features by selected the most important features on the basis of Hotel ling statistics. Several studies have identified other types of features that describe the shape of the hand. In fact, several features have been extracted from both shape information and texture information [14] [12], namely the independent component analysis (ICA) function. The principal component analysis (PCA) function, and the radial-angular transformation component analysis function (ART). Principle Component Analysis (PCA) is used to calculate the Fisher Linear Discriminant (FLD) features to evaluate the most discriminating features between images [19]. Some researchers have proposed using ROI finger segmentation to separate segmentation of each finger. To remove the finger from the hand, you need to find the fingertips and fingerprints. Therefore, the method described in [13] was used to find the minimum and maximum contours in order to find the fringes of the hand silhouette. Each finger and hand are treated as separate objects. For each object, a bounding box is called from which the length and width are measured.

3.2 MATCHING

This module compares a user feature vector against the user's template(s) stored in the database in order to generate matching scores. Since the feature vectors are usually points in an N-dimensional Euclidean space, any metric distance can be used for computing a matching score: Euclidean distance [15], absolute distance [16], correlation coefficient [18]. In some studies, individual fingers are matched separately and the matching scores are subsequently fused into a single score [14] [21]. In training a collection of two-class statistical classifiers (e.g. support vector machine—SVM [10], k-nearest neighbors algorithm [12] and artificial neural network k-nearest neighbors algorithm) [11] [19] to predict a person's identity. In order to verify that a sample feature vector belongs to the identity claimed, the classifier trained to learn that identity is used to produce a matching score. In the SVM case, the matching score is the distance to the hyper-plane which separates the claimed identity from the other enrolled identities. While a classifier approach may have a better discrimination power, it also requires that a separate classifier is trained for each of the enrolled persons [29]. In [24] more than five classifiers used to classify the verified gesture such as Bayesian Network, Logistic regression, REP Tree, Hoeffding Tree. The idea is to train a classifier for each declarer by treating the set of attribute vectors associated with the dispatcher as positive patterns and the other attribute vectors as negative patterns. Conformity assessment is performed using a trained classifier [30].

3.3 DECISION-MAKING

In most systems, the final decision on a user's identity is based on a threshold that is chosen so that the biometric system meets security and throughput requirements. The score calculated in the previous system module is compared with the threshold value. If the score is higher than the threshold, the user is identified or verified, but if the scores lower than the threshold, the user is not identified or verified The outcome of decisions for hand-based biometric systems is significantly influenced by user training, with the right habits of users, the score increases (agreement of the compared samples) [31, 32]. There are two different modes in which the biometric system can operate: verification or identification.

In verification mode, which is a one-to-one matching process, the matching score obtained in the previous module is compared with a predefined threshold (0.1). If the matching score is higher than the defined threshold, the user's identity is accepted otherwise it is rejected [33]. In identification mode, which is a one-to-many matching process, the system compared the presented biometric sample with the templates for each user. The algorithm will determine the highest match between the feature vector and the template. If the matching score assigned to a template is higher than the defined threshold, the user's identity is accepted, otherwise it is rejected [34]. The selected threshold is the valid percentage (i.e. equivalence of false acceptance rate (FAR) and false rejection rate (FRR)), which is the same. In the process of cognition, they influence characteristics and inputs. A copy of the closest identity stored in the database. If the distance is less than the verification threshold, the presumed identity is considered authentic, otherwise it is considered fraud [35].

Table 1. Summarizes the basic Technique of the latest systems and methods that appeared in journal and conferences used in verification and identification of hand biometric system.

Authors	Features	Techniques	Subjects	Database	Performance
Mr. S.Velmurugan and Dr.S.Selvarajan [9]	11 features	MIN-MAX Algorithm	144	CASIA v.4	Acc=100%

Continued on next page

Table 1 continued

Angadi and Hatture [10]	12 features	SVM Classifier	144	GPDS150	Acc=97.92%
Hussein et. al. [11]	24 features	ANN with SEE K-NN	35	———-	Acc=95.3% for NN Acc= 91.2% for KNN
Song et al. [12]	12 features	K-Nearest Neighbor, SVM Classifier	161	multi-touch dataset	EER=1.88%
Abdullah [13]	20 features	Cumulative similarity	30	IIT Delhi	95.5% accuracy rate
Duo Lu et al. [14]	22 components	Threshold-then-vote (TTV)	100	———-	EER=0.6% without spoofing EER=3.4% with spoofing
Khaliluzzaman et al. [15]	3 features	Euclidian distance metric	250	———-	Acc=100%
Shawkat et al. [16]	3 features	artificial neural network based back-propagation architectures	50	———-	Acc= 96.41 %
Prihodova et al. [17]	20 features	CNN Alex Net CNN google Net CNN Res Net	114	HKPU v.0.1	FRR=5.20% FRR=0.10% FRR=0%
Al-kateeb and Mohammed [18]	50 features	Mean Square Error(MSE),Correlation (Cor), Mean Opinion Score (MOS)	14	————	————
Mohmmad et al. [19]	———-	Euclidean Distance	18		Acc=95%
Haider et al. [20].	———-	CNN	185	NIR image	Acc= 92%
Oldal and Kovács [21]	5 features	Distance transform	14	———-	FAR= 4.6% FRR=14.2%.
Mohammed et al. [22]	21 features	CNN, FFBB, Elman,		———-	Acc=88% Acc=95% Acc=92%
Malik et al. [23]	30 features	Artificial NeuralNetwork (ANN)	20	CASIA	———-
Doroz et al. [24]	94 features	Statistical Bayesian Signed-Rank test.	50	———-	Acc=99.88%
Alam et al. [25]	5 features	CNN		SCUTEgo-Gesture	Acc=99.90%

4. HAND DATABASES

Each of the datasets is divided into test, validation and training sets. In [13], the IITD Hand Database was used, which is based on photos of hands collected by students and employees of IIT Delhi. IITD is a public contactless hand database with 1,150 hand images. They were recorded with a digital CMOS camera 235 times. Although the GPDS150 hand database was used in [12], It is a public database where images of 150 users' hands are collected from 10 different acquisitions using a desktop scanner. These photos were taken with the subjects' right hand. In [25] the SCUT-Ego-Gesture database [16] is used for experiments with eleven different data sets of one-handed gestures. Eight of these gesture recordings are observed in the experiments because they represent number-type hand gestures. Eight datasets contained 29,337 RGB

hand images in an egocentric view at 640 × 480 resolution. The CASIA hand geometry image database was used in standard databases [9] [23]. The dataset was collected from 100 people. NIR imaging dataset used in [22], the dataset was collected from 185 subjects. Two hundred images were collected for each subject. After collecting the images, data was supplemented with any values of translation, angular rotation, size and horizontal inversion of the images. A contactless 3D/2D hand image database at Hong Kong University version 1.0 (HKPU, 2019) was used. This database contains 570 pictures of hands. The database contained photos of the right hand of 114 people, each person provided five photos of the hand.

5. CONCLUSIONS

The Biometric recognition systems uses the physical characteristics of a person for the automatic recognition systems. Biometric recognition systems have proven to be highly accurate and effective in a variety of applications. Among all biometric systems, a manual engineering authentication system can be used to control access in medium and low security areas and can also be combined with other forms of biometrics such as fingerprints to increase confidence in very high security areas. Some researchers and developers of commercial biometric systems believe that the shape of the hand allows for medium to high discrimination. On the other hand, the authors of some recent search systems have shown high rates of verification and identification that are comparable to fingerprint-based systems. Only in the presence of an individual can biometric identifiers be easily captured and quantified for processing. Biometrics researchers have discovered that human hand features that can be used for identification/verification of identity, such as thickness and width of the palm, the length and width of the fingers, the corners, etc., the most stable for users. Each user is extracted and encoded in a biometric reference or template, which is a mathematical representation of an individual's biometric property. These templates are stored in a database or smart card. This pattern is then used for comparison in identifying people. Much of the manual work so far has focused largely on the use of machine learning in the model, either at the feature extraction stage using artificial neural networks and convolutional neural networks, or at the classification stage as in backpropagation. It is based on auxiliary vector machines and artificial neural networks. Experimental results demonstrate superior system performance for medium-sized security environments.

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CONFLICTS OF INTEREST

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