Review of palmprint biometric recognition systems and their feasibility

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***Abstract*— With the development of more and more systems which provide service based on the identity of a person, the importance of personal identification is growing. Providing authorized users with secure access to the services is a challenge to the personal identification systems. There are several conventional means for personal identification which include passports, keys, tokens, access cards, personal identification number (PIN), passwords. Unfortunately, passports, keys, access cards, tokens, can be lost, stolen or duplicated, and passwords, PINs can be forgotten, cracked or shared. These drawbacks cause a great loss to the concerned. Biometric systems are proving to be an efficient solution to this problem.**

A biometric identity verification system tries to verify user identities by comparing some sort of behavioural or physiological trait of the user to a previously stored sample of the trait. The recent developments in the biometrics area have lead to smaller, faster and cheaper systems, which in turn has increased the number of possible application areas for biometric identity verification. Palmprint can be one of the biometrics, used for personal identification or verification. As a small central part of the palmprint image is used for this purpose, so it is important to find that region of interest.

In this paper, review of the palmprint analysis and the methodology used in the literature has been discussed. Various biometric has been critically analysed and way of choosing the applicable methods has been discussed.

***Keywords*— Image Processing, biometric, texture, recognition, palmprint, fingerprint, authentication, Collectability, extraction**

I. INTRODUCTION

In our daily lives, there is a frequent need in identifying people correctly and verifying their identities. To illustrate, reliable identification mechanisms are required when people board an aircraft, perform financial operations, desire to enter secure places etc. For higher efficiency and increased security, this identification mechanism should be automated. Obviously, high accuracy is required during the identification and this hardens the automation of identification. But once automated, it gives us the opportunity that tasks performed by computers and other devices can be widened and this results in easing our lives. It is here worth noting that, tasks performed by these devices are based on two separate mechanisms, namely authentication and authorization. Authentication is known as identity verification, whereas authorization defines particular rights of authenticated people. Therefore, authorization follows authentication.

There are three fundamental modes of authentication:

1. What you know, which generally refers to information to be kept secret such as passwords and pass phrases or some non-secret private information such as mother's maiden name.
2. What you have, which generally refers to physical possessions such as keys and smartcards.
3. What you are, which generally refers to biometrics, physical appearances or behavioral characteristics of individuals such as fingerprint, hand geometry and signature.

These entire authentication methods depend on the same basic principle, which can be summarized as follows [1]:

- User provides an authenticator, a data item that cannot be provided by anyone else.
- Authentication system contains a verifier, a data item that can verify the correctness of the authenticator.
- Authentication system uses a verification procedure, an algorithm that compares an authenticator with a verifier.
- There is generally a base secret, a data item in user's possession that produces the authenticator.

II. BIOMETRICS IN AUTHENTICATION

Because biometric based authentication is emerging as a powerful method for reliable authentication, which is of great importance in our lives, biometrics is becoming increasingly popular. In 2001, the highly respected MIT Technology

Review announced biometrics as one of the "top ten emerging technologies that will change the world" [1]. Also Rick Norton, the executive director of the International Biometric Industry Association (IBIA), pointed out the increase in biometric revenues by an order of magnitude over the recent years. Biometric revenues, which were $20 million in 1996, increased by 10 times and reached $200 million in 2001. Rick Norton expects a similar increase in biometric revenues in next 5 years period, from 2001 to 2006, thereby expecting them to reach $2 billion by 2006[1]. Similarly, International Biometric Group, a biometric consulting and integration company in New York City, estimate biometric revenues to be around $1.9 billion in 2005[1]

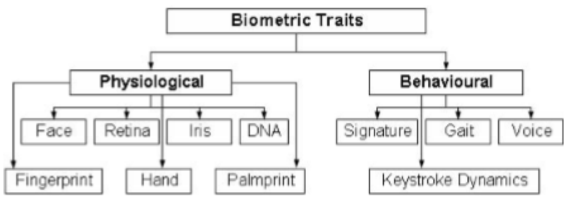

Figure 1: Different Biometric Traits

II.I Properties of Biometrics

Researchers noticing the increase in biometric revenues are trying to develop better algorithms for existing biometrics and\or to find new biometrics for authentication. Whether new or existing, all practical biometrics should possess five properties described below [2]:

1. **Universality:** All individuals should possess the biometric characteristics.
2. **Uniqueness:** The biometric characteristics of different individuals should not be the same.
3. **Permanence:** The biometric characteristics of individuals should not change severely with the time.
4. **Collectability:** The biometric characteristics should be measurable with some practical device.
5. **Acceptability:** Individuals should not have objections to the measuring or collection of the biometric.

II.II Biometric System Block Diagram

After the biometric that is to be utilized is decided, the question how a biometric system can be implemented naturally arises. Figure 2.1 shows the general block diagram of a biometric system. As shown in Figure 2.1, biometric systems generally consist of the following components:

- **Data Acquisition Block:** This is the block in which biometric data is captured and is transferred to feature extraction and coding block. The biometric data may also be compressed in this block, especially when the data acquisition is performed at a remote location.
- **Transmission Channel Block:** This is an optional block in the sense that some biometric systems do not consist of this block. Although transmission channels are internal to the device in self-contained systems, some biometric systems may be distributed and may have central data storage and many remote data acquisition points. The transmission channel for distributed systems might be a local area network (LAN), a private Intranet, or even the Internet. [1]
- **Feature Extraction and Coding Block:** This is the block in which acquired biometric sample is processed. Processing consists of segmentation, the process of separating relevant biometric data from background information, and feature extraction, the process of locating and extracting desired biometric data. After segmentation and feature extraction, a biometric template, a mathematical representation of the original biometric, is obtained by encoding extracted features.
- **Distance Matching and Decision Policy Block:** This is the final block in a biometric system, where the final decision is made. The biometric template obtained in feature extraction and coding block is compared to one or more templates in the data storage by selected matching algorithm, which determines the degree of similarity between compared templates. The final decision is usually made based on the result of the matching algorithm and empirically determined thresholds.

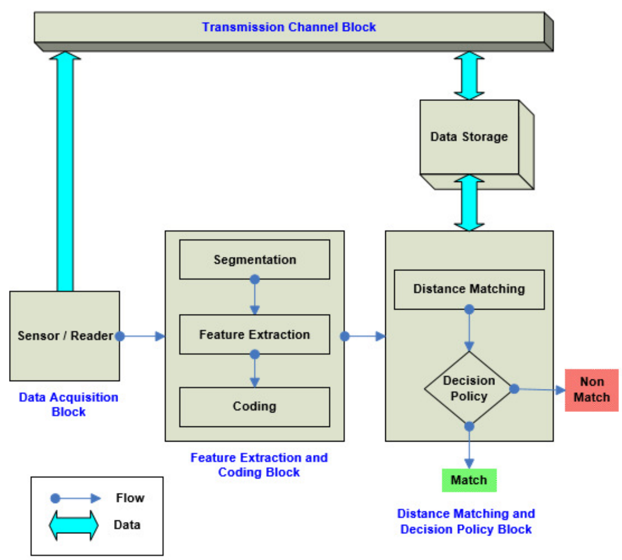

Figure 2: General Block Diagram of a Biometric System

III. LEADING BIOMETRIC TECHNOLOGIES

III.I Finger-Scan

Finger-scan is a well-known biometric technology which is used to identify and verify individuals based on the discriminative features on their fingerprints. Many finger-scan technologies are based on minutiae points, which are irregularities and discontinuities characterizing fingerprint ridges and valleys. [3]

Advantages of Finger-Scan Technology

- It is proven to have very high accuracy.
- It does not require complex user-system interaction; therefore little user training is enough to ensure correct placement of fingers.
- It provides the opportunity to enroll up to 10 fingers.

Disadvantages of Finger-Scan Technology

- High resolution images are required to be acquired due to the small area of a fingerprint and this results is in more expensive acquisition devices.
- Small percentage of users; elderly populations, manual laborers and some Asian populations; are shown to be unable to enroll in some finger-scan systems according to International Biometric Group's Comparative Biometric Testing. [3]
- As mentioned before, some people may tend to wear down their fingerprints in time because of their physical work.
- Individuals may have objections to collection of their fingerprints because they may have doubts about usage of their fingerprints for forensic applications.

III.II Facial-Scan

Facial-scan is a biometric technology which is used to identify and verify individuals based on the discriminative features on their faces. Nonetheless, it is generally used for identification and surveillance instead of verification. Facial-scan technologies use some of many discriminative features on face such as eyes, nose, lips etc. [3]

Advantages of Facial-Scan Technology

- It is the only biometric which provides the opportunity to identify individuals at a distance avoiding user discomfort about touching a device.
- It can use images captured from various devices from standard video cameras to CCTV cameras.

Disadvantages of Facial-Scan Technology

- Changes in lighting conditions, angle of acquisition and background composition may reduce the system accuracy.
- The face is a reasonably changeable physiological characteristic. Addition or removal of eyeglasses, changes in beard, moustache, make-up and hairstyle may also reduce the system accuracy.
- In order to take changes in environmental conditions and user appearance into account, facial-scan technologies usually store many templates for each individual and these results in higher memory requirement for each individual compared to many other biometrics.
- Because face of users may be acquired without their awareness, users may have objections to facial-scan deployments.

III.III Iris-Scan

Iris-scan is a biometric technology which is used to identify and verify individuals based on the distinctive features on their irises. Iris-scan technologies use the patterns that constitute the visual component of the iris to discriminate between individuals. [3]

Advantages of Iris-Scan Technology

- It is proven to have smallest FMR among all biometrics, therefore; iris is the most suitable biometric for applications requiring highest level of security.
- Iris does not change in time, therefore; it does not require reenrollment which other technologies require after a period of time due to changes in the biometric.

Disadvantages of Iris-Scan Technology

- It requires complex user–system interaction, particularly precise positioning of head and eye. Some systems even require that users do not move their head during acquisition.
- Very high resolution images are required to be acquired due to the small area of an iris, therefore; acquisition devices are quite expensive.
- There is a public objection to using an eye-based biometric even though many people are not aware of the fact that infrared illumination is used in iris-scan technology. Were they aware, they might be a much stronger reaction to this technology.

III.IV Voice-Scan

Voice-scan is a biometric technology which is used to identify and verify individuals based on the distinctive aspects of their voice. Voice-scan technologies use different vocal qualities such as fundamental frequency, short-time spectrum of speech and spectrograms (time – frequency – energy patterns).[3]

Advantages of Voice-Scan Technology

- Various acquisition devices including microphones, land and mobile phones can be utilized and these devices are relatively cheaper than acquisition devices used in other biometrics.
- Users are prompted to select a pass phrase during enrollment and they are asked to repeat the same pass phrase during verification and identification. The probability that imposters guess the correct pass

phrase adds an inherent resistance against false matching.

Disadvantages of Voice-Scan Technology

- Poor reception quality, ambient noise and echoes may degrade the system accuracy.
- The voice is also a changeable biometric characteristic. Changes in voice due to illness, lack of sleep and mood may reduce the system accuracy.
- Voice-scan is subject to possibility of recording and replay attacks.

III.V Palmprint Recognition

The palmprint of a person can be also taken as a biometric as different persons have different palmprints. A palmprint scanner is used to scan the palm and store in a database. A digital camera can also be taken as an image acquisition device for collecting samples of palmprints from a person in different ways. Line features and Texture analyses are used for feature extraction for palmprint verification or identification [5–11].

IV OVERVIEW OF PALMPRINT RECOGNITION SYSTEM

Palmprint, the inner surface of our palm normally contains three flexion creases, secondary creases and ridges. The flexion and secondary creases are also called principal lines and wrinkles, respectively. The flexion creases and the main creases are formed between the 3rd and 5th months after conception and superficial lines appear after birth. These creases are not genetically deterministic. Even identical twins who share the same DNA sequences have different palmprints. These non-genetically deterministic and complex patterns have rich information for personal identification. There are two types of palmprint recognition research, high resolution and low resolution approaches.

A palmprint recognition system generally consists of five parts: palmprint scanner, preprocessing, feature extraction, matcher and a database. Palmprint scanner is to collect palmprint images. Preprocessing is to setup a coordinate system to align palmprint images and to segment a part of palmprint image for feature extraction. Feature extraction is to obtain effective features from the preprocessed palmprints. Finally, a matcher compares two palmprint features. All the images, templates generated are stored in a local or remote database.

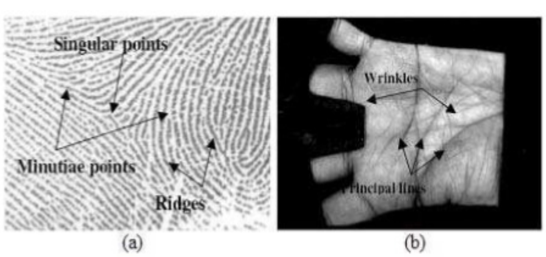

Figure 3: Palmprint features in (a) a high resolution image and (b) a low resolution image

IV.I Palmprint Image Acquisition

It is the first process in palmprint recognition systems. Researchers utilize four different types of sensors to collect palmprint images, CCD-based palmprint scanners, digital cameras, digital scanners and video cameras. Figure 1.4 shows a CCD-based palmprint scanner developed by the Hong Kong Polytechnic University [21].

Figure 4: A CCD-based palmprint scanner

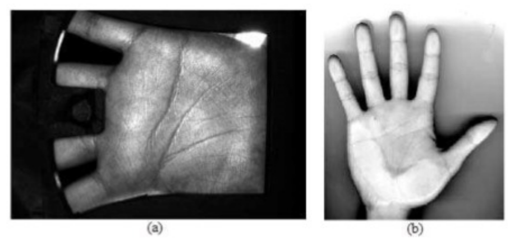

Figure 5: Two palmprints collected by (a) a CCD-based palmprint scanner, (b) a digital scanner

IV.II Palmprint Preprocessing

Preprocessing is used to align different palmprint images and to segment the central parts for feature extraction. Most of the preprocessing algorithms employ the key points between fingers to set up a coordinate system. Preprocessing involves generally five common steps:

1. Binarizing the palm images,
2. Extracting the contour of palm and/or fingers,
3. Detecting the key points
4. Establishing a coordination system and
5. Extracting the central parts.

The first and second steps in all the preprocessing algorithms are similar. However, the third step has several different implementations including tangent-based [21] and wavelet-based [8]. All these approaches utilize only the information on the boundaries of fingers. After obtaining the coordinate systems, central parts of palmprints are segmented. Most of the preprocessing algorithms segment square regions for feature extraction.

IV.III Palmprint Feature Extraction

A lot of work has been done for developing feature extraction algorithms. D. Zhang et al. have used datum point and line features for palmprint verification system [5]. Li et al. have used Fourier transform for feature extraction of palmprints [6]. Kong et al. have proposed palmprint feature extraction using 2-D Gabor filters [9].

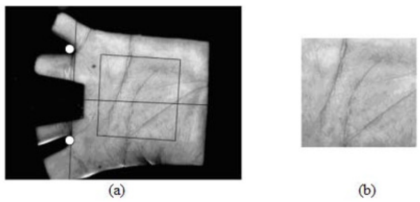

Figure 6: Illustration of pre-processing, (a) the key points based on finger boundary and (b) the central parts for feature extraction.

IV.IV Palmprint Matching

Also there has been lot of works on palmprint matching. Many existing classifiers including neural networks [8], various measures including cosine measure, weight Euclidean distance, Euclidean distance, hamming distance and nearest neighborhood distance have been examined [5–11].

V LITERATURE SURVEY

Bouchemha Amel et al. [14] proposed a robust framework for multispectral palmprint recognition based on feature fusion level. Different components appear when the skin is illuminated by light sources of different wavelengths. They perform the verification process using KNN and SVM, and conducted the identification with OAO-SVM. They validate the robustness of the proposed biometric system on the multispectral images of CASIA database. Effectively, their Authentication/Identification system gives good results in term of accuracy and a low computational complexity in the feature extraction phase, even though the images were acquired with several modalities.

Xin Wu et al. [15] proposed an improved edge detection method to solve the global features of the palmprint texture. a novel palmprint recognition algorithm based on binary horizontal gradient orientation and local information intensity (referred BHOG-LII) has been proposed. First, they use the horizontal gradient template for palmprint image to obtain the gradient image in the horizontal orientation and binarization. Then, the image is divided into some girds, and we statistic information intensity of each block as a statistical feature, which are paralleled integration to generate the final feature vector.

At last, the chi-square distance is used to classification. Experimental results on PolyU palmprint experiment shows that the proposed method can obtain recognition accuracy up to 99.50%.Compared with some traditional methods, the recognition rate improved significantly. In addition, the proposed algorithm has important significance on the rotation, translation, scaling issues of palmprint recognition.

Ruifang Wang et al. [16] presented anatomically inspired regional fusion while using SMC for palmprints. Firstly, they applied SMC to region-to-region palmprint comparison and studied regional discriminability when using the SMC method in the three different regions of the palmprint, that is, interdigital, thenar and hypothenar. Evaluated on a subset of 680 palmprints from the public high-resolution palmprint database THUPALMLAB, the best EER results using regions segmented automatically were 8.95% for the interdigital region, 16.43% for the thenar region and 4.08% for the hypothenar region.

Then, aimed to improve the performance further, we implemented regional fusion at score level using region-to-region comparison score sets and obtained results with two fusion methods, that is, sum rule and logistic regression. Using regions segmented automatically, The EER results of 2.4% for sum rule fusion, and 1.77% for logistic regression based fusion were achieved on the subset of 680 palmprints from THUPALMLAB. The results show that: (i) The hypothenar and interdigital regions outperform the thenar region; and (ii) regional fusion using both fusion methods significantly improves the performance of spectral minutiae matching for palmprints.

Faegheh Shojaiee et al. [17] presents a novel method for palmprint recognition and focuses on the micro-pattern based image representation which extracts the effective texture features from images. They exhibit that the LBP descriptor just extracts the first order derivatives among central pixel and local neighbors along the radial directions. LBP uses a simple threshold function with static threshold value to compute all LBP micro-patterns of the input palmprint image. A Local Composition Derivative Pattern (LCDP) is proposed to capture the both radial and directional local derivatives of spatial images. LCDP uses the threshold function encodes the composition of radial and directional derivatives information.

To get the more detailed discriminative features from an image, the threshold value of threshold function obtains by directional first-order derivative information. Distribution of LCDP micro-patterns is modelled by using spatial histograms as the representation of the image. Palmprint recognition based on LCDP is performed by using histogram intersection as the similarity measurement.

Shervin Minaee et al [18] proposed a set of textural features based on co-occurrence for palmprint recognition. This method senses the textures of the images and extracts 14 features from them. Two different classifiers, weighted majority voting and minimum distance classifiers, are also used to perform the recognition. The proposed scheme has advantages over many older popular methods. It has a very high accuracy rate as well as a low processing time, making it possible to use in real-time applications. The calculation of the features is also straightforward.

To analyze a new point of view, they extracted textural features and used them for palmprint recognition. Co-occurrence matrix can be used for textural feature extraction. As classifiers, they have used the minimum distance classifier (MDC) and the weighted majority voting system (WMV). The proposed method is tested on a well-known multispectral palmprint dataset of 6000 samples and an accuracy rate of 99.96-100% is obtained for most scenarios which outperform all previous works in multispectral palmprint recognition.

R. Raghavendra et al. [19] introduced a novel approach for the palmprint recognition based on B-BSIF and SRC. The main idea of the proposed method is to use multiple BSIF filters with various size and length to constitute an ensemble (or bank of BSIF filters). Since each of these BSIF filters are learned on the natural images using the independent component analysis (ICA), they exhibit the property of statistical independence.

They proposed to build the B-BSIF with 56 different BSIF filters. Then, each of these filters is associated with the SRC that essentially perform the sparse representation of each BSIF filter. Thus, given a palmprint sample, they obtain its response on each of the BSIF filter and then obtain the corresponding comparison score using SRC. Finally, they select the best comparison score that corresponds to the minimum value of the residual error. The proposed method is validated by conducting extensive experiments on three different large-scale publicly available databases that indicated the outstanding performance.

V CONCLUSION

Today we are living in the information age, where because of advent of the technology there is a situation like information explosion. Images have giant share in this information. More précised retrieval techniques are needed to access the large image archives being generated, for finding relatively similar images. Here in this paper a novel image retrieval technique based on palmprint recognition is proposed. A survey on existing palmprint technology has been illustrated in this paper.

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