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An accurate slap fingerprint based verification system ☆

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ABSTRACT

A slap fingerprint based verification system generally is highly secure. But it cannot handle the problems of temporal deformation and pose variation. In this paper, a template update algorithm has been proposed to ensure better performance of the system. During verification, each single fingerprint is matched and matching scores of all fingerprints are fused using an adaptive score level fusion. The performance of the proposed system has been evaluated on a challenging database containing 1800 slap-images acquired from 150 subjects. Experimental results show that the accuracy is increased by more than 3.5%.

1. Introduction

In the modern era, the advent of large digital data and improved information technology require data protection or security, which allows the access to genuine users while restricting the impostor. Traditional methods like keys or passwords are not much used in this regard, because these can be easily stolen, lost or spoofed. On the other hand, a biometric based recognition system is proliferating because it satisfies the properties like universality, uniqueness, permanence and acceptability [1]. The fingerprint is one such biometric trait which is extensively studied for recognition purpose [2]. There exist various feature extraction and matching algorithms for fingerprints which perform accurately under different conditions. Thus, multiple classifiers representing complimentary information can be fused to enhance the performance of a fingerprint based recognition system [3]. In spite of this, effective usage of fingerprints in recognition is restricted due to (i) environmental conditions which can generate wet/dry fingerprints, (ii) creases, cuts and bruises on the fingertip, (iii) occupation or age, which sometime smoothen the ridge-valley structure; and (v) applying undue pressure during fingerprint acquisition which can introduce elastic deformation in the acquired fingerprint image. These issues can be handled if multiple fingerprints are used during recognition [4]. If multiple fingerprints are acquired one by one then it is highly user unfriendly and time consuming. Therefore, multiple fingerprints are acquired simultaneously by using a slap-image scanner [5]. A slap fingerprint device acquires all fingerprints of a hand simultaneously. Some example of the acquired slap image are shown in Fig. 1.

A slap fingerprint based verification system works as follows. Initially, each single fingerprint present in a slap-image is extracted. This process is referred as *slap-image segmentation*. Its example is shown in Fig. 2. Each single fingerprint is used for fingerprint matching. Matching scores of all the fingerprints are fused to obtain the slap-image matching score. Since multiple fingerprints are used in a slap-image, it has less intra-class variation and high inter-class variation [6]. But it is observed that sometime partial fingerprints or bad quality fingerprints are acquired. These unavoidable factors can lead to improper slap fingerprint segmentation [7] and large intra-class variation that can degrade the effectiveness of slap fingerprint matching [8]. Both these factors deteriorate the verification accuracy [9].

It is advisable to use accurate slap fingerprint segmentation and slap fingerprint matching algorithm to achieve better results [10]. Further, a user can be enrolled multiple times to handle the problems of partial fingerprints or bad quality fingerprints using data fusion or template improvement algorithms. A system based on data fusion requires multiple fingerprint images during enrollment to obtain the accurate features [11]. It is user unfriendly and cost expensive during acquisition, thus avoided. Further, it cannot handle the temporal variations which can be introduced in the fingerprint [12]. On the other hand, a template improvement can be useful to handle the intra-class variations. It fuses the matched samples with stored templates for accurate feature extraction.

In this paper, an accurate slap-image based verification system has been designed. Its main contributions are as follows:

1. It uses template update method to reduce the intra-class variation in the slap-image. The proposed template update uses various constraints on fingerprint quality to ensure that beneficial result can be obtained. It has improved the performance because it removes spurious minutiae and retrieves the missed one.

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0925-2312/

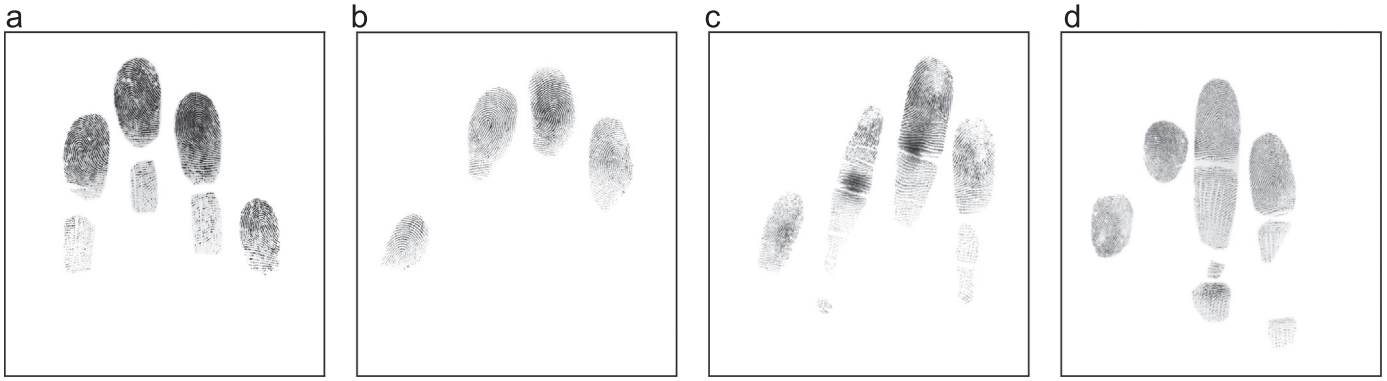

Fig. 1. Examples of slap-images.

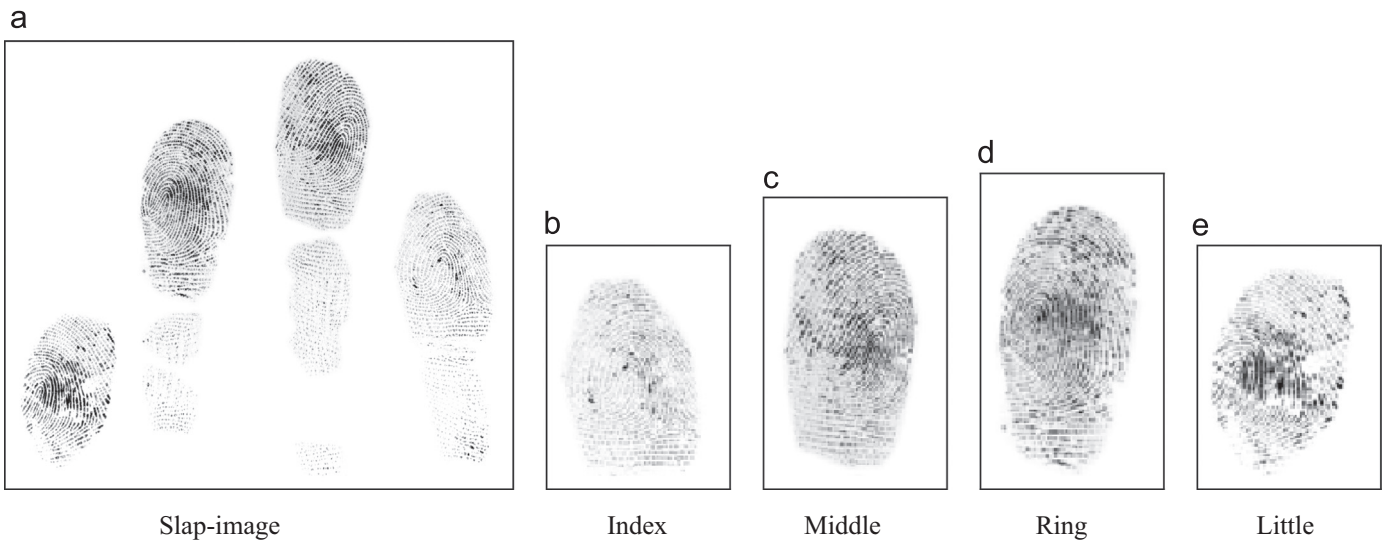

Fig. 2. Slap-image and its segmented fingerprints.

2. It proposes a line sweep algorithm to extract accurately the single fingerprints from the given slap image. This improves the slap fingerprint segmentation that eventually enhances the verification accuracy.
3. An adaptive score level fusion is used in this paper to fuse the matching scores of segmented single fingerprints. Adaptive weights are assigned based on the uniformity in ridge-valley structure. Symmetric filters are used to measure the uniformity in high curvature areas. Experimental results reveal that the proposed fusion is better than other existing fusion strategies.

This paper is organized as follows. Applicability of the template update, preliminary for slap fingerprint segmentation and slap fingerprint matching algorithms are discussed in the next section. In Section 3, the proposed template update technique has been presented. The design of slap-image based verification system along with the usage of the template update is presented in Section 4. Experimental results are analyzed in Section 5. Conclusions are given in the last section.

2. Literature survey

2.1. Template update

This section is divided into three subsections, viz., (i) requirement of template update; (ii) template improvement; and (iii) importance of classification in template update.

2.1.1. Requirement of template update

In the enrollment phase, a biometric sample is acquired, enhanced and processed to extract features. Extracted features are stored in the database corresponding to the user identity and are referred as enrolled templates. During the verification phase, a user claims an identity which is confirmed by matching the templates of acquired biometric sample with that of a claimed identity. Performance of a verification system is dependent on several factors and some of these are:

1. *Number of enrolled samples*: Templates stored in a database should capture all possible deformations that can be introduced in the biometric sample, for effective matching. It requires large data enrollment which is infeasible.
2. *Temporal variations*: Even though features in a biometric sample are assumed to be stable against time, there are some conditions introduced by time factor which can alter the features in a biometric sample [13]. As an instance, cuts or scars can be formed on fingerprints due to injury which can generate spurious minutiae.
3. *Sensor condition*: Sometimes due to improper interaction between a user and the acquisition sensor, partial fingerprints or highly deformed fingerprints can be acquired. This degrades the matching performance.
4. *Environmental condition*: The role of environmental condition in determining the verification performance is indispensable [14]. Sometime due to humidity and temperature, a normal fingerprint can be captured as a wet or dry fingerprint. Such a deterioration in