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Fingerprints verification based on their spectrum

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ABSTRACT

The goal of this paper is proposing a novel fingerprint verification approach to increase the accuracy and robustness of fingerprint verification process. The proposed approach is based on spectrum features extraction from the fingerprint image. In the proposed approach, the two dimensions (2-D) fingerprint image after enhancement is transformed into one dimension (1-D) using lexicographic ordering by dividing the image into non overlapped square blocks, each block scanned column by column. The scanned block pixel values are combined into a 1-D signal, and then the spectrum features are extracted from this signal. Support Vector Machines (SVMs) have been used for matching the features to decide whether these features belong to the same person or not. Furthermore, minutia based fingerprint verification approach is carried out in five steps; enhancement, binarization, thinning, minutiae extraction and minutiae matching. The proposed approach is compared with the minutia based approach and with other published approaches. The international fingerprint verification competitions (FVCs) databases have been used for the evaluation. The results proved the superiority of the proposed approach to the minutia based approach.

1. Introduction

There are many methods which can be used for personal recognition, it may be based on fingerprint, signature, voice, face, eye, or hand; a comparison between these methods is shown in Table 1 [1]. Fingerprint based recognition is one of the most important methods that can be used for personal recognition because it has many advantages such as fingerprints remain unchanged during lifetime, no two fingers have identical ridge characteristics, and fingerprints based recognition offers a cheap solution for day to day activities. The limitations of using fingerprint in personal recognition are it is not suitable for high security implementation and more developing is required for the enhancement of this method.

Practically, fingerprint recognition can be used in two forms fingerprint identification or fingerprint verification. Fingerprint identification means matching one or more unknown fingerprints against a stored database for establishing the person's identity, it used for criminal identification. While fingerprint verification means matching the person's fingerprint with his stored fingerprint patterns, it can be used in the access control systems, attendance gates and ATM card verification. This paper is interested in the fingerprint verification; the common Automatic Fingerprints Verification (AFV) system consists of four main steps; image acquisition, image enhancement, features extraction and features matching as shown in Fig. 1. According to the published studies and research, AFV process has been studied by many researchers using various techniques and approaches since 1990 up to date. Most of published papers contain some or most stages of the common AFV system.

The fingerprint image acquisition may be carried out off-line, or on-line [2], the off-line acquisition is done by spreading the finger with the ink and pressing it against a paper card, then the paper card is scanned, resulting in a digital image. The online acquisition is done by pressing the finger against a flat surface of an electronic fingerprint sensor; the sensors may be optical, ultrasound or silicon sensors. For biometrics researches, there are many publicly available fingerprint databases that can be used such as International Fingerprint Verification Competitions (FVCs) databases [2–4], NIST database [5], MCYT Bimodal database [6], BIOMET Multimodal Database [7], and BioSecure Multimodal Database [8]. In this paper the FVCs databases have been used for evaluating and comparing the proposed approach.

Fingerprint image enhancement is an important process for a good performance of AFV, where the performance of AFV relies heavily on the quality of the fingerprint images. Fingerprint image enhancement has been carried out using many approaches and filters such as adaptive histogram equalization [9–11]. A survey of the fingerprint image enhancement process is presented in [12]. In this paper image enhancement is carried out using AHE and Gabor filter.

Feature extraction from the fingerprint is an essential step in fingerprint verification. Although many approaches have been developed for improving the performance of the fingerprint verification

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technique, the extraction of the fingerprints and the verification accuracy still main challenges face this technique. Support Vector Machines (SVMs) have been used as a classifier for fingerprint verification by many researchers [13–15], others used neural networks [16,17]. In this paper SVMs have been used for features matching in the proposed approach.

Previously, many efforts have been made by many researchers for improving the fingerprint verification process. Maio and Nanni [18] presented an approach for fingerprint verification; in this approach, the fingerprint image enhancement has been carried out using Fourier domain based block wise contextual filter, the image based features were extracted and feed the Parzen window classifier. This approach achieved a substantial improvement (with FVC2002 database) in the overall performance of the fingerprint verification process but core point was detected. Lumini and Nanni [19] improved the approach in [18] by extracting the features from subimages around the core permits for improving the representation of the local information. Also, they used the minutiae based features and the Support Vector Machines for fingerprint verification [20].

Table 1
Comparison between personal recognition methods.

Recognition method	Matching 1 to 1	Matching 1 to many	Recognition performance	Size	Cost
Fingerprint	Yes	Yes	Very good	Very small	Medium
Signature	Yes	No	Variable	Small	High
Voice	Yes	No	Variable	Very small	Low
Face	Yes	No	Fair	Small	High
Eye	Yes	Yes	Very good	Large	Very high
Hand	Yes	No	Good	Medium	High

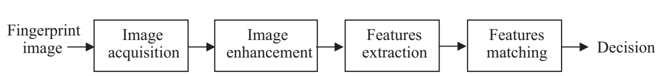

Fig. 1. Block diagram of the common AFV system.

Nanni and Lumini [21] presented another approach similar to [18] but the feature vector is projected onto a one dimensional Karhunen Loeve space and then classified into one of two fingerprint classes (genuine or impostor). Also, they used minutiae based features with Support Vector Machines [22]; the results show a remarkable performance improvement. Also, they presented and compared between the image based and minutiae based fingerprint matching in [23]. Another approach has been presented by Leng et al. using a discretization technique [24], this approach achieved accuracy rate 100% for FVC2000, 93% for FVC2002 and 89.7% for FVC2004. Kaur et al. presented fingerprint recognition approach using Fast Fourier Transform with minutiae extraction, this approach improved the ridge clarity and valley structures of the fingerprint images based on the frequency of the local ridges and thereby extracting correct minutiae [25].

Fingerprint verification based on minutiae matching and the image enhancement process based on the orientation have been developed by He et al. [26]. Yang and Zhou [27] combined multiple enrolled impressions and used fusion scheme for combining the feature fusion and the decision fusion to improve the fingerprint verification systems. Yang and Park [28] presented a fingerprint verification algorithm using a set of fixed length moment features, and the invariant to the affine transform extracts from tessellated cells. The eigenvalue weighted cosine distance was used for evaluating the similarity between the input image and the template image in the database. Cao et al. [29] used the finger placement direction feature which is extracted from the fingerprint foreground and the ridge compatibility features which are determined by the singular values of the affine matrix estimated by some matched minutiae and their associated ridges. Also, they proposed the minutia handedness (right-handed, left-handed and non-handed) based features for enhancement the matching probability of the minutiae from different regions of different fingers [30]. Shalaby and Ahmed [31] introduced fingerprint recognition technique by decomposing the fingerprint image into regions based on the global features and then formulating multi level feature vectors to represent the fingerprint by employing both the global and local features. Peralta et al. [32] used two different filtering approaches based on the convex hull of the minutiae and the segmentation of

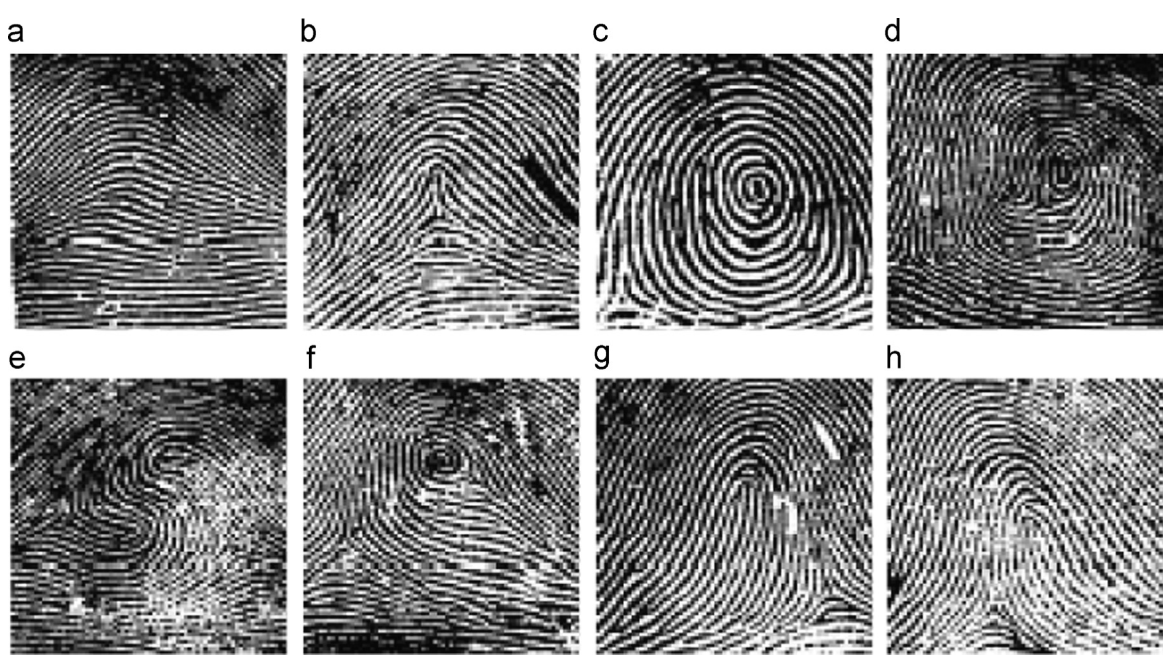

Fig. 2. Common fingerprint classes. (a) Plain arch, (b) tented arch, (c) plain whorl, (d) accidental whorl, (e) double loop whorl, (f) central pocket loop, (g) radial loop, and (h) ulnar loop.