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ORIGINAL ARTICLE

Fusion of geometric and texture features for finger knuckle surface recognition

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Abstract Hand-based biometrics plays a significant role in establishing security for real-time environments involving human interaction and is found to be more successful in terms of high speed and accuracy. This paper investigates on an integrated approach for personal authentication using Finger Back Knuckle Surface (FBKS) based on two methodologies viz., Angular Geometric Analysis based Feature Extraction Method (AGFEM) and Contourlet Transform based Feature Extraction Method (CTFEM). Based on these methods, this personal authentication system simultaneously extracts shape oriented feature information and textural pattern information of FBKS for authenticating an individual. Furthermore, the proposed geometric and textural analysis methods extract feature information from both proximal phalanx and distal phalanx knuckle regions (FBKS), while the existing works of the literature concentrate only on the features of proximal phalanx knuckle region. The finger joint region found nearer to the tip of the finger is called distal phalanx region of FBKS, which is a unique feature and has greater potentiality toward identification. Extensive experiments conducted using newly created database with 5400 FBKS images and the obtained results infer that the integration of shape oriented features with texture feature information yields excellent accuracy rate of 99.12% with lowest equal error rate of 1.04%.

1. Introduction

Personal recognition based on hand biometric traits has been widely used in most of the modern security applications due to its low cost in acquiring data, its reliability in identifying the individuals and its degree of acceptance by the user [1]. Most of the research works proposed in hand based biometric authentication used different modalities viz., fingerprint, palm print, hand geometry, hand vein patterns, finger knuckle print and palm side finger knuckle print [2]. Among these biometric traits, fingerprint is considered to be the very old trait and known as the first modality used for personal identification. Apart from the various beneficial aspects, fingerprint also possesses some limitations such as its vulnerability toward intrusion of acquired image and its features such as minutiae, singular points, and delta points, are highly distracted by means of wounds and injuries [3] created on the finger surfaces.

On the other hand, palm print recognition system captures large area for identification, while it contains limited number of features such as principal lines, wrinkles [4]. In case of finger

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geometry and hand geometry, the features extracted are not distinctive enough to identify the individuals, when the number of users grows exponentially [5]. In hand vein system, the vein structures present in the dorsum area of the hand are captured by means of high cost devices [6].

In this paper, we contribute a new approach for personal recognition using Finger Back Knuckle Surface (FBKS) based on geometric analysis and texture analysis by considering both proximal phalanx and distal phalanx. Here, the proximal phalanx refers to the major bend surface of a finger and is found in the middle portion of the finger back region, whereas distal phalanx refers to minor bend surface found nearer to the tip of the finger back region. Even though, the distal phalanx is smaller in size, it has unique dermal patterns which when exploited along with proximal phalanx results in highly improved performance in finger knuckle print recognition. The rich set of patterns generated by each of these finger knuckle surfaces with lines, contours and creases is highly unique for distinctive identification of individuals, which could be easily acquirable in contact less manner. This FBKS biometric modality is highly accepted by the user, since it requires less cooperation from the subject and produces high speed authentication.

In the literature, the geometric based feature extraction methods implemented on hand-based biometric trait including finger knuckle print derive magnitude based feature information which has limited power of discrimination [7]. In contrast, this paper addresses this issue by recommending an Angular Geometric Analysis based Feature Extraction Method (AGFEM) capable of extracting angular based feature information from the finger back knuckle surface, which efficiently authenticates the individuals. For effective representation of texture features of FBKS images, the multi-resolution analysis is required since it could be able to handle distorted finger knuckle regions resulted due to scaling, rotation and transformation variant properties [8]. A multi-resolution transform known as Contourlet Transform which effectively represents the curved singularities than the wavelets is highly suitable for representing finger back knuckle surface texture feature since the texture pattern of FBKS images is lines, curves and contours [9]. Hence, we incorporate Contourlet Transform based Feature Extraction Method (CTFEM) to represent the texture features of the captured finger knuckle images. The extracted shape oriented and texture feature information is integrated to yield better accuracy results and makes it highly suitable for large scale personal authentication system.

The rest of the paper is organized as follows. Section 2 gives a brief survey on some of the feature extraction methodologies for hand biometric traits available in the literature. Section 3 demonstrates the proposed personal authentication system design using finger back knuckle surface. Section 4 presents the methods used for preprocessing and extraction of ROI from the acquired image. Section 5 introduces angular geometric based feature extraction methodology to extract angular feature information from the proximal knuckle and distal knuckle regions. Section 6 presents contourlet transform based feature extraction method to extract texture feature information from the proximal knuckle and distal knuckle regions. The various fusion rules related to matching score level fusion incorporated in this paper are illustrated in section 7. The thorough experimental analyses of the proposed methodologies are presented in Sections 8 and 9 concludes the paper.

2. Related work

In the literature, researchers have proposed various promising methods for hand based biometrics. These methods can be broadly classified into three categories viz., geometric based methods, texture based methods and statistical methods [10]. Generally, in geometrical based feature extraction methods, several edge detecting approaches were used for extracting features such as edge points, lines, creases, wrinkles , from various hand biometric traits [11]. The extracted edge information is either utilized directly or converted into the form of geometrical feature information to represent the feature vector for matching [12]. In texture based feature extraction methods, the Region of Interest (ROI) captured is categorized into blocks. From the ROI, the features extracted from the blocks or variations existing in different blocks are represented as feature information for matching [13].

2.1. Geometrical analysis based feature extraction method

Woodard and Flynn [14] were the first to propose the Finger Knuckle Print (FKP) as a biometric trait in 2005. In their work, the FKP image was acquired by means of a 3D sensor and the feature extraction process is done by means of geometrical analysis by exploiting the curvature shape features of FKP. The complexity toward 3D data processing which is computationally expensive is the main drawback of this scheme. Later in 2009, Kumar et al. have proposed number of techniques for personal authentication using hand biometric traits. In the first work, Kumar et al. [15] proposed a new personal authentication system using finger knuckle surface. The feature extraction from the finger knuckle surface was carried out by means of both texture and geometrical feature analysis methods. Finger length, finger width etc., were some of the geometrical features extracted from the finger knuckle surface by means of Finger Geometric Feature Extraction Method (FGFEM). The texture information of the finger knuckle surface is obtained by means of principal component analysis, independent component analysis and linear discriminant analysis. Scores are generated by means of computing Euclidean distance obtained from reference and input vectors.

Kumar et al. in the second work [16], introduced a new modality known as hand vein structure for personal authentication. In this biometric system, dorsum surface of the hand is captured using infra-red imaging. The captured image is subjected to histogram equalization for enhancement and the structure of the vein is studied using Key Point Triangulation Method (KPTM). This paper also focuses on incorporating the simultaneously extracted knuckle shape information to achieve better performance. Kumar et al. have further explored [17] the analysis of finger knuckle surface by incorporating the quality feature of the trait which highly depends on the capturing device. In this work, the entire hand image is acquired and feature extraction is done by means of palm print textural analysis, hand geometry analysis and finger knuckle print paternal analysis. The geometric method incorporated in this work is termed as Knuckle Geometric Feature Extraction Method (KGFEM). All the above described methods were taken as benchmark systems for comparing proposed AGFEM approach.