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Personal recognition using finger knuckle shape oriented features and texture analysis

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Abstract Finger knuckle print is considered as one of the emerging hand biometric traits due to its potentiality toward the identification of individuals. This paper contributes a new method for personal recognition using finger knuckle print based on two approaches namely, geometric and texture analyses. In the first approach, the shape oriented features of the finger knuckle print are extracted by means of angular geometric analysis and then integrated to achieve better precision rate. Whereas, the knuckle texture feature analysis is carried out by means of multi-resolution transform known as Curvelet transform. This Curvelet transform has the ability to approximate curved singularities with minimum number of Curvelet coefficients. Since, finger knuckle patterns mainly consist of lines and curves, Curvelet transform is highly suitable for its representation. Further, the Curvelet transform decomposes the finger knuckle image into Curvelet sub-bands which are termed as 'Curvelet knuckle'. Finally, principle component analysis is applied on each Curvelet knuckle for extracting its feature vector through the covariance matrix derived from their Curvelet coefficients. Extensive experiments were conducted using PolyU database and IIT finger knuckle database. The experimental results confirm that, our proposed method shows a high recognition rate of 98.72% with lower false acceptance rate of 0.06%.

1. Introduction

Hand based biometrics has drawn considerable attention of researchers due to (i) its low cost in acquiring data, (ii) its reliability in identifying individuals and (iii) its degree of acceptance by the user (Hand-based Biometrics, 2003). Most commonly used hand biometric traits are finger print, palm print, hand geometry, hand vein patterns, finger knuckle print and palm side finger knuckle print (Bolle et al., 2000). Among these biometric traits, finger print is known to be the first modality used for personal identification. Apart from its most beneficiary features, finger print also possesses certain

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drawbacks such as, it has greater vulnerability toward intrusion of acquired finger print image and its feature like minutiae, singular points, delta points etc., are highly distractible by wounds and injuries created on the finger surfaces (Ribaric and Fratric, 2005). On the other hand, palm print recognition system captures a large area for identification, which contains only limited number of features like principal lines, wrinkles, etc., (Sun et al., 2005). In case of finger geometry and hand geometry, the features extracted are not distinctive enough to identify the individuals, when the number of users grows exponentially (Kumar et al., 2003; Malassiotis et al., 2006). In hand vein system, the vein structures present in the dorsum and the palm area of the hand are captured by means of high resolution devices, which are found to be more expensive (Kumar and Venkataprathyusha, 2008).

Finger knuckle print is one of the emerging hand based biometric traits. Basically, finger knuckle surface is defined as the skin pattern that is present in the finger back region of the hand. Each finger back region of the hand has three phalangeal joints. The joint that connects the finger with the hand surface is called as Metacarpophalangeal joint, the joint that is formed in the middle surface of the finger is called as Proximal Inter Phalangeal (PIP) joint and the joint that is present in the tip surface of the finger back region is known as distal joint. The presence of these joints in the finger dorsum surface forms the flexion shrinks on the outer region of the skin which creates the dermal patterns consisting of lines, wrinkles, contours etc. The pattern generated by the PIP joint on the finger back region is referred as finger knuckle print (Zhang et al., 2009a). Unlike finger print, finger knuckle print patterns are very difficult to scrap because it concentrates on the inner surface of the finger regions which are captured in a contactless manner. Moreover, the area of the captured finger knuckle print is very small when compared to the area captured for palm print recognition and further it also possess highly unique features which are well suited for a potential biometric system (Loris and Alessandra, 2009).

Woodard and Flynn were first to introduce FKP as a biometric trait in the year of 2005 by capturing it in a 3D sensor (Woodard and Flynn, 2005). Other researchers have also contributed many effective methods for representing the features of FKP images for effectively classifying them. However, finger knuckle print biometric recognition requires high degree of exploration for establishing its suitability in large scale real time applications. In this paper, we recommend a novel approach which simultaneously extracts shape oriented features and texture feature information from finger knuckle print. In the literature the geometrical analysis performed on any hand based biometric trait including FKP yields only magnitude based feature information. In contrast, this paper incorporates angular geometric analysis method, which results in both magnitude and orientation based shape feature information of FKP. For effective representation of texture features of FKP images, the multi-resolution analysis is required since it could handle distorted FKP images due to scaling, rotation and transformation variant properties. A multi-resolution transform known as Curvelet transform which effectively represents the curved singularities than the wavelets is highly suitable for representing finger knuckle print texture feature since the texture pattern of FKP images are lines, curves and contours (Mandal et al., 2009). Hence, we incorporate Curvelet transform along with principle component analysis 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.

Rest of the paper is organized as follows. Section 2 details about the feature extraction methodologies for various hand biometric traits available in the literature. Section 3 presents the proposed system model of the finger knuckle personal recognition system. Section 4 illustrates the methods used for preprocessing and ROI extraction from the acquired finger knuckle print image. Sections 5 and 6 present the feature extraction methodology based on geometric analysis and texture analysis respectively. Section 7 presents the fusion process and various rules implemented for generating the final score. Section 8 presents the experimental analysis carried out to evaluate the performance of the proposed system along with its results' discussion. Section 9 concludes the paper with possible recommendations.

2. Related work

In the literature, researchers have proposed various methods for feature extraction on hand based biometric traits. These techniques can be broadly categorized into geometrical analysis and textural analysis. The geometrical analysis methods extract shape oriented features from the biometric trait whereas textural analysis methods extract feature information by analyzing the spatial variations present in the captured image (Kumar and Zhang, 2006; Kumar and Zhou, 2009). Generally, the texture analysis methods for feature extraction are categorized as three types, viz., (i) model based texture analysis method, (ii) transform based texture analysis method and (iii) statistical texture analysis method. The model based texture analysis methods quantify the characteristics of image texture using fractal and stochastic models, while the transform based texture analysis methods represent the image in a spatial coordinate system with interpretations in the characteristics of texture. Whereas, in statistical texture analysis methods image texture patterns are represented using the parameters that are related to the distribution and relationship among the gray level pixels of the image (Aoyama et al., 2013). Some of the geometric analysis methods and transform based texture analysis methods that are incorporated to extract feature information from the hand based biometric traits are discussed below.

Kumar et al. contributed nearly three geometrical approaches for personal authentication using hand biometric traits. In their first work, (Kumar and Ravikanth, 2009) the finger knuckle features are extracted using knuckle texture analysis and finger geometrical analysis. Finger length, finger width etc., are some of the geometrical features extracted from the finger knuckle surface by means of geometric analysis. The authors also used three appearance based methods such as principal component analysis, independent component analysis and linear discriminant analysis for generating matching scores from the knuckle images. In their second work, (Kumar and Venkataprathyusha, 2009) the authors introduced a new modality known as hand vein structure for personal authentication. In this system dorsum surface of the hand is captured using infra-red imaging system. The captured image