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A new approach for inner-knuckle-print recognition ☆

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ABSTRACT

Objective: This paper proposed a new approach for inner-knuckle-print (IKP) recognition. In traditional IKP recognition systems, the region of interest (ROI) is extracted from the image of the whole hand and the directions of the fingers being imaged are not restricted. The result maybe incorrect because that the shape and surface of the fingers may vary greatly. Moreover, if the direction of the finger being imaged is not restricted, there may be severe rotation transform between intra-class IKPs. To overcome these drawbacks, we develop a new data acquisition scheme as well as an efficient personal authentication algorithm.

Methods: The new scheme is designed to capture the image of the inner surface of the middle knuckles of the middle and ring fingers. The fingers being imaged are kept horizontal with two pegs, so that the rotation angle between different images obtained from the same hand can be minimized. The new personal authentication algorithm consists of the next four steps. Firstly, two regions of interest (ROI), each of which contains the inner surface of a knuckle, are cropped from the original image. Secondly, line features are extracted from the ROIs based on the combination of Gabor filtering and derivative line detection method. Then, binary line images are matched by using a cross-correlation-based method. Finally, the input data is classified through score level fusion.

Results: To evaluate the proposed IKP recognition system, a finger image database which includes 2000 images from 100 volunteers is established. The images are captured on two separate occasions, at an interval of around two months. Most of the volunteers are not familiar with the image acquisition process. The experimental results show that the proposed system achieves high recognition rate and it works in real time. Moreover, the proposed line feature extraction method outperforms traditional Gabor filter based line detection method and derivative line detection method in accuracy.

Conclusion: The proposed IKP system is robust and accurate. It may promote the application and popularization of IKP recognition.

1. Introduction

Recently, the image pattern of the knuckle surface has been found to be unique and can be used in personal authentication systems. Some of the relevant works are based on the outside surface of the knuckle. In [1], curvature-based knuckle surface features were extracted from the dense range image of a hand. The corresponding personal identification algorithm was combined with another personal identification algorithm using finger shape features at the score level. Soon after, Kumar and Ravikanth proposed a peg-free finger-knuckle-print (FKP) recognition algorithm where subspace methods are used for feature extraction [2]. Zhang et al. proposed to extract the region of interest (ROI) of the IKP from the image around a finger knuckle, and then identify it on the basis of the Gabor features [3–6].

The pattern of the inner surface of the knuckle, namely inner knuckle print (IKP), has also been used in biometric

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systems. Li et al. proposed to extract four IKP ROIs and a palmprint ROI simultaneously from the image of the whole hand, and then identify a person on the basis of the fusion of the information provided by the IKPs and the palmprint [7]. Gabor transform was used to extract line features in their algorithm. Ribaric et al. presented a new IKP recognition approach on the basis of the eigenfinger features and eigenpalm features [8]. In their algorithm, the IKP ROIs were also extracted from the image of the whole hand. Luo et al. proposed to detect line features of the IKP by Radon transform and singular value decomposition [9]. Nanni et al. developed an IKP recognition method on the basis of tokenized pseudo-random numbers and user specific knuckle features [10]. A contactless palmprint and knuckleprint recognition system was reported in [11]. In Ref. [12], the difficulty of matching the line features of the IKP was considered, and the binary line image was projected to the horizontal axis. However, some important issues in IKP recognition have still not been well investigated. First of all, to extract an IKP ROI from the image of the whole hand is a tough work because the shape and surface of the fingers may vary greatly. Moreover, if the direction of the finger being imaged is not restricted, there may be severe rotation transform between intra-class IKPs. As a result, matching scores between such FKPs may be quite small.

Our work is concerned with the recognition of the IKP. A new data acquisition scheme is designed to capture an image which contains a small region around the inner surface of two knuckles. Such a design greatly simplifies the ROI extraction procedure. Besides, the fingers being imaged are kept horizontal with two pegs so that the rotation variations between different images obtained from the same hand can be minimized.

Moreover, this paper presents an efficient personal authentication algorithm which consists of four steps. Firstly, the IKP ROIs of two fingers are cropped from the original image. Secondly, line features are extracted by the combination of Gabor filtering and derivative line detection. Then the binary line images are matched with a cross-correlation-based shape matching method. Finally, the input data is classified through score level fusion.

The rest of the paper is as follows: Section 2 introduces the IKP image acquisition scheme; Section 3 presents the ROI extraction method; Section 4 discusses the feature extraction method; Section 5 investigates the image matching method; Section 6 describes the score level fusion rule; Section 7 reports the experimental results; finally, Section 8 gives some conclusion remarks.

2. Inner knuckle print image acquisition

The image acquisition system we designed is shown in Fig. 1. The system is composed of a camera and a panel on which the user's hand can be placed. The two pegs on the panel serve as control points. In the process of data acquisition, the user only needs to put his (her) middle and ring fingers horizontally under the two pegs with the index and the middle fingers clipping the round peg.

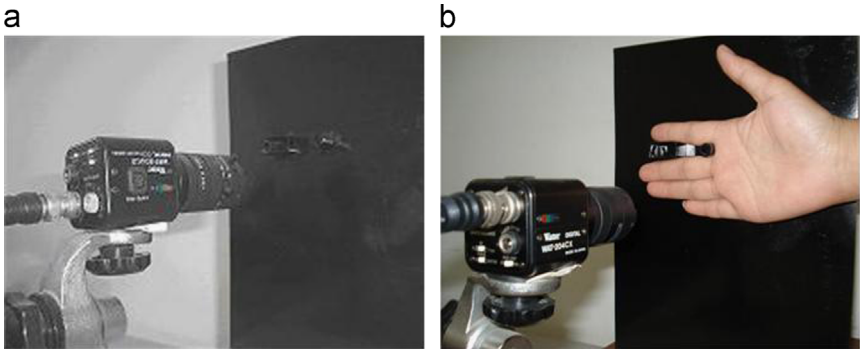

Fig. 1. (a) Arrangement of the IKP image acquisition system. (b) Illustration of the image acquisition process.

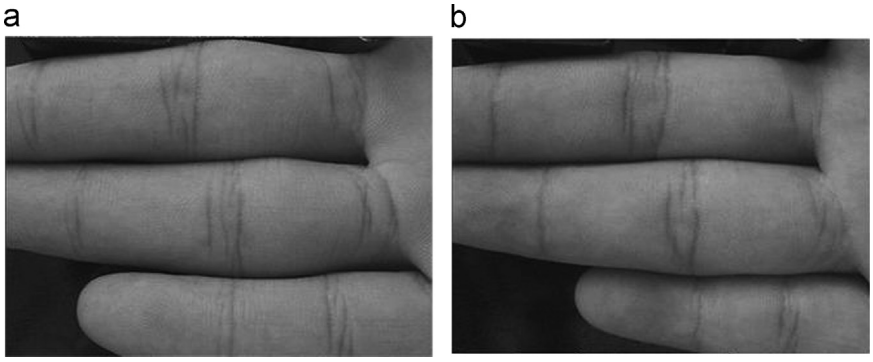

Fig. 2. Examples of captured knuckle print image.