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A finger-knuckle-print recognition algorithm using phase-based local block matching

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ABSTRACT

This paper proposes a Finger-Knuckle-Print (FKP) recognition algorithm using Band-Limited Phase-Only Correlation (BLPOC)-based local block matching. The phase information obtained from 2D Discrete Fourier Transform (DFT) of images contains important information of image representation. The phase-based image matching, especially BLPOC-based image matching, is successfully applied to image recognition tasks for biometric recognition applications. To calculate the matching score, the proposed algorithm corrects the global and local deformation between FKP images using phase-based correspondence matching and the BLPOC-based local block matching, respectively. Experimental evaluation using the PolyU FKP database demonstrates the efficient recognition performance of the proposed algorithm compared with the state-of-the-art conventional algorithms.

1. Introduction

Biometric authentication has been receiving extensive attention with the need for robust human recognition techniques in various networked applications [1]. Biometric authentication (or simply biometrics) is to identify a person based on the physiological or behavioral characteristics such as fingerprint, face, iris, voice, and signature.

Among many biometric techniques, hand-based biometrics has been attracted lots of attention. Fingerprint [2], palmprint [3–6], hand geometry [7], Finger-Knuckle-Print (FKP) [8–22], and combinations of the above traits [23,24] have been used as biometric traits related to a hand. In this paper, we focus on recognizing a person using FKP patterns. An FKP is a pattern of outer finger knuckle surface which contains many fine ridge patterns and texture, and is expected to be one of the distinctive biometric traits.

So far, the FKP recognition algorithms have been proposed by many researchers as shown in Table 1. Woodard and Flynn [8] have proposed a curvature-based recognition algorithm using 3D finger surface taken by a 3D sensor, where this is the first attempt to use FKPs for biometric authentication. The use of the 3D sensor is not acceptable for the practical use due to its size, cost, weight, processing time, etc. On the other hand, the use of 2D FKP images makes it possible to realize compact and powerful biometric authentication systems. Ferrer et al. [9] have proposed a ridge feature-based algorithm which extracts ridge features from FKP images and evaluates their similarity using Hidden Markov Model (HMM) or Support Vector Machine (SVM). Kumar and Zhou have proposed a coding-based algorithm called KnuckleCode generated by using local Radon transform [12] and subspace-based algorithms such as Principal Component Analysis (PCA), Independent Component Analysis (ICA) and Linear Discriminant Analysis (LDA) [13]. Kumar [20] has proposed to use not only the finger knuckle pattern on the second joint, i.e., the metacarpophalangeal joint, but also the finger knuckle pattern on the first joint, i.e., the distal interphalangeal joint. Xiong et al. [15] have used Local Gabor Binary Patterns (LGBP) combining Gabor wavelet and

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Table 1
Summary of conventional FKP recognition algorithms.

Author	Trait	Feature	Similarity
Woodard and Flynn [8]	3D knuckle	Surface curvature	NCC
Ferrer et al. [9]	FKP	Ridge	HMM or SVM
Kumar and Zhou [12]	FKP	Localized Radon transform	Distance
Kumar and Ravikanth [13]	FKP	texture	PCA, ICA and LDA
Kumar [20]	Major and minor knuckle	LBP, Log-Gabor	Distance
Xiong et al. [15]	FKP	Local Gabor binary patterns	Distance
Morales et al. [16]	FKP	Gabor filter and SIFT	Distance
Zhang et al. [10]	FKP	Competitive code	Distance
Zhang et al. [11]	FKP	BLPOC	Correlation
Zhang et al. [14]	FKP	Improved competitive code and magnitude code	Distance
Zhang et al. [17]	FKP	Competitive code and BLPOC	Distance
Zhang et al. [18]	FKP	Phase congruency and BLPOC	Distance
Zhang and Li [22]	FKP	RCode1 and RCode2	Distance
Zichao et al. [19]	FKP	Orientation	Distance
Mittal et al. [21]	FKP	DAISY	Distance
Michael et al. [23]	Palmprint and FKP	Directional code	Distance
Zhu and Zhang [24]	Finger geometry, palmprint and FKP	Gradient	Correlation

Local Binary Patterns (LBPs) which are successfully applied to face recognition. Morales et al. [16] have used Orientation Enhanced Scale Invariant Feature Transform (OE-SIFT) which applies a Gabor filter to enhance the FKP images and perform SIFT-based matching to evaluate the similarity. Zhang et al. have proposed some FKP recognition algorithms using the competitive code generated by using Gabor filter bank [10], Band-Limited Phase-Only Correlation (BLPOC) [11], a combination method of improved competitive code and magnitude code [14], a combination method of competitive code and BLPOC [17], a combination method of phase congruency and BLPOC [18], and the Riesz transform based coding scheme [22]. Zichao et al. [19] have proposed a feature extraction method using steerable filters which can extract local orientation from FKP images. Mittal et al. [21] have proposed an FKP recognition algorithm using DAISY [25] which is one of the famous feature descriptors. In addition, the multi-modal hand-based recognition algorithms have been proposed [23,24]. Michael et al. [23] have developed a hand recognition system using palmprint and FKP, while Zhu and Zhang [24] have used finger geometry, palmprint and FKP. The recognition performance of the conventional FKP recognition algorithms may be degraded for FKP images having nonlinear deformation due to the movement of a finger, since these algorithms consider only rigid body transformation of FKP images.

In this paper, we propose an FKP recognition algorithm using BLPOC-based local block matching. POC is an image matching technique using the phase components in 2D Discrete Fourier Transforms (2D DFTs) of given images [26,27]. BLPOC is a modified version of POC which is dedicated to evaluate similarity between images [28] and has been used in various biometric recognition algorithms [29,30,11]. Most of POC-based biometric recognition algorithms cannot handle the nonlinear deformation of images, since the phase information obtained from the entire image is employed. In order to handle the nonlinear deformation of FKP images, the proposed algorithm employs local block matching using BLPOC, since the nonlinear deformation is approximately represented by the minute translational displacement between local image blocks. First, we correct the global transformation between FKP images which is estimated using phase-based correspondence matching. Next, we correct the minute translational displacement between each local image block pair using the BLPOC-based local block matching. Finally, we take the average of a set of the BLPOC functions calculated from each local image block pair and obtain the correlation peak value of the average BLPOC function as a matching score between the FKP images. Experimental evaluation using the PolyU FKP database [31] demonstrates efficient recognition performance of the proposed algorithm compared with the state-of-the-art conventional algorithms.

The rest of the paper is organized as follows: Section 2 describes the fundamentals of POC, BLPOC and phase-based correspondence matching. Section 3 describes FKP recognition algorithms using phase-based image matching and the proposed algorithm. Section 4 shows experiments for evaluating the performance of the proposed algorithm using the PolyU FKP database. Section 5 ends with some concluding remarks.

2. Phase-based image matching

This section describes the fundamentals of phase-based image matching, i.e., Phase-Only Correlation (POC), Band-Limited POC (BLPOC) and phase-based correspondence matching.

2.1. Phase-Only Correlation (POC)

We introduce the principle of a Phase-Only Correlation (POC) function (which is sometimes called the "phase-correlation function") [26,27].