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LEDTD: Local edge direction and texture descriptor for face recognition ☆

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ABSTRACT

A good image representation is critical to face recognition task. Recently, eight-direction Kirsch masks based image descriptors, e.g. local directional pattern (LDP), local sign directional pattern (LSDP), have been devised and shown competitive results than conventional LBP descriptor. However, these methods may lose or do not fully explore valuable texture information of the image. To remedy this drawback, a novel discriminative image descriptor, namely local edge direction and texture descriptor (LEDTD) is proposed in this paper. LEDTD differs from the existing Kirsch based methods in a manner that it not only considers image edge direction information but also extracts image texture feature by encoding the edge response directions of center and its neighborhood pixels by employing local XOR binary coding strategy. Finally, edge direction and texture features are integrated to form the image feature vector. Extensive performance evaluations on four benchmark face databases show that the proposed approach yields a better performance in terms of the recognition rate as well as robustness to the noise compared with the state of the art methods.

1. Introduction

Face recognition, as one of the most focused research topic in image processing, pattern recognition and computer vision, has been widely applied in many fields, such as information security, smart cards, entertainment, law enforcement, video surveillance and human–computer interaction. Image feature extraction serves as one of the most critical steps for face recognition. Although numerous approaches have been proposed and tremendous progress has been made, during the past decades, it is still could not perform as well as desired under uncontrolled conditions. Therefore, how to extract discriminative and robust features is of vital importance to face recognition.

Generally, the two-dimensional image feature extraction methods in image representation could be broadly summarized into two categories based on their properties, i.e., holistic methods and local methods. The holistic methods generally extract features from a facial image by treating the image as a whole. Principal component analysis (PCA) [1], linear discrimination analysis (LDA) [2], independent component analysis (ICA) [3], locality preserving projection (LPP) [4], local linear embedding (LLE) [5], local discriminant embedding (LDE) [6], marginal Fisher analysis (MFA) [7], discriminant simplex analysis (DSA) [8], nonnegative graph embedding (NGE) [9], clustering-guided sparse structural learning (CGSSL) [10] and robust structured subspace learning (RSSL) [11] are the typical ones of this kind. These methods are liable to

☆ Fully documented templates are available in the elsarticle package on CTAN.

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be influenced by face image pose, illumination, scale and so on, and variations in these factors can largely degrade its recognition performance. The local methods usually consider several regions or sets of isolated points, from which features for classification are extracted. Classical methods such as local binary pattern (LBP) [12,13], scale-invariant feature transform (SIFT) [14,15], speeded-up robust features (SURF) [16], weber local descriptor (WLD) [17], Weber local binary pattern (WLBP) [18], monogenic binary coding (MBC) [19], histograms of local dominant orientation(HLDO) [20], enhanced local directional pattern (ELDP) [21], farthest point distance (FPD) descriptor [22], rotation-invariant fast feature (RIFF) [23], edge orientation difference histogram (EODH) [24] have been widely examined. Compared with holistic methods, local methods are distinctive and invariant to many kinds of geometric and photometric transformations, and have been gaining more and more attention because of their promising performance.

Being one of the representative local image descriptors, local binary pattern (LBP) was first introduced by Ojala et al. [12], and it has shown a high discriminative ability for texture classification due to its invariance to monotonic gray level changes. Afterwards, many variants of LBP have been introduced to further improve its performance. However, the feature of all these methods being coded into the bit-string is prone to change due to noise or other variations.

Considering that Kirsch compass mask enhances the useful information like edge texture and meanwhile suppresses the external noise effect, recently it has been widely used for image feature extraction. Jabid et al. [25] proposed local directional patterns (LDP), which is an eight-bit binary code calculated by first comparing the absolute edge response values derived from different directional Kirsch masks. Then the top k prominent values are selected and the corresponding directional bits are set to 1, the remaining $(8-k)$ bits are set to 0. Finally, convert the binary number into a decimal one, and the decimal value is the corresponding image pixel LDP expression. Zhong and Zhang [26] proposed the enhanced local directional patterns (ELDP), which improved the LDP in the following two aspects. First, take the sign of the Kirsch edge response into consideration, which means two opposite trends (ascending or descending) of the gradient and contain some more discriminant information. Second, only the most and the second most prominent edge response directions are take into the local pattern coding. Kang et al. [27] proposed the structured local binary kirsch pattern (SLBKP), which quantify the eight edge responses into two four-bit binary codes according to the predefined threshold. Rojas Castillo et al. [28] proposed local sign directional pattern (LSDP), similar to the ELDP, the only difference is that it codes the most and the least prominent edge response directions. Rivera et al. [29,30] proposed local directional texture pattern (LDTP), which is the mixture coding of direction number of local most prominent Kirsch mask edge response and intensity differences along two greatest edge responses directions.

In this paper, we propose a novel discriminative and robust image descriptor, local edge direction and texture descriptor (LEDTD), for face recognition. The main novelty of our descriptor can be summarized as follows. (1) Compared with image gray-scale value, the edge direction is more stable than intensity, and the use of edge direction feature makes our descriptor more robust against illumination variations and noise by operating in the gradient domain. (2) Edge responses are not equally important for image feature extraction. We choose directions of the maximum and minimum response, which explicit the gradient direction of bright and dark areas in the neighborhood, to represent local image pixel edge information. (3) Apart from the directional features, local XOR operator is applied to encode image edge direction texture features, which convey power image discriminative information. (4) Our LEDTD makes full use of the center pixel edge direction and surrounding eight neighbor pixels texture information while existing image descriptor LDTP only utilizes four neighbor pixels to encode image local structure. Therefore, LEDTD retains more local structure information than the LDTP. Experimental results demonstrate

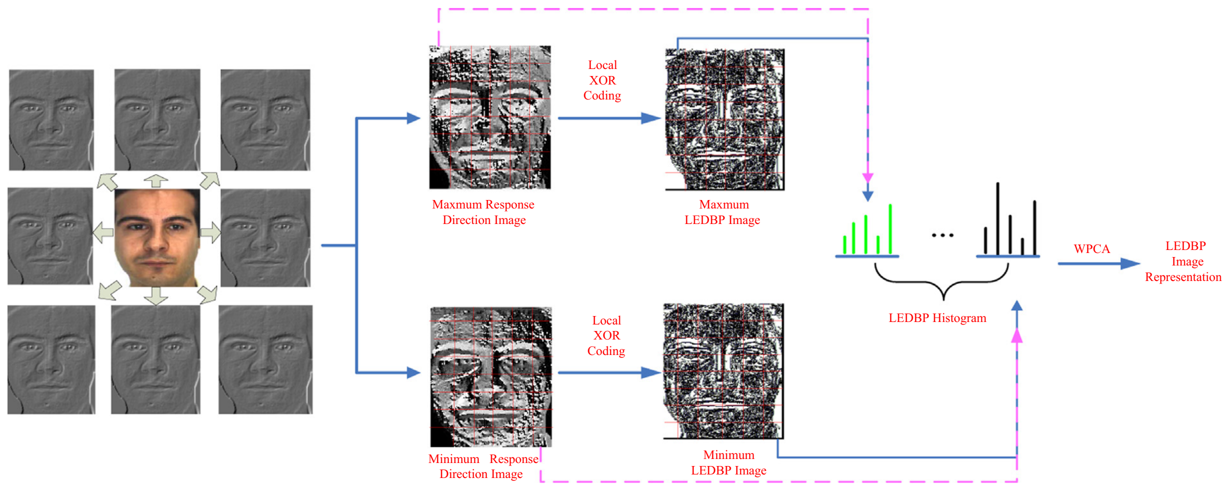

Fig. 1. Flowchart of face image representation using LEDTD.