Infrared Face Recognition Based on DCT and Partial Least Squares

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Abstract. Infrared face imaging, being light- independent, and not vulnerable to facial skin expressions and posture, can avoid or limit the drawbacks of face recognition in visible light. However, to obtain the compact and discriminative feature extracted from infrared face image is a challenging task. In this essay, infrared face recognition method using Discrete Cosine Transform (DCT) and Partial Least Square (PLS) is proposed. Due to strong ability for data de-correlation and compact energy, DCT is studied to obtain the compact features in infrared face. To make full use of the discriminative information in DCT coefficients, the final classifier formulates PLS regression for accurate classification. The experimental results show that the proposed algorithm outperforms Principle Component Analysis (PCA) and DCT based infrared face recognition algorithms.

Keywords: Infrared face recognition, Partial least square, feature extraction, discrete cosine transform.

1 Introduction

As we know, the resolution of the infrared image is lower than the visible image. This is to say that the infrared image has little local discriminative information.

For this reason, the compact and discriminative feature extraction from the infrared face image is a challenging task [4, 8]. In previous research, Discrete Cosine Transform (DCT) based on the feature extraction method is applied to extract compact information for face recognition [5]: Zhang et al [7] improved the classical face features extraction method (Principle Component Analysis (PCA) +Linear Discriminant Analysis (LDA)) and proposed DCT and LDA based on features extraction algorithm; Yin et al [6] improved DCT and LDA face recognition method using Feature Selection (FS) in DCT domain. As for infrared face recognition, Xie et al [8] applied DCT and FS to find a compact features extraction method. However, the discriminative performance of DCT features received less attention. The main idea in this essay is that different DCT coefficients do have different ability to discriminate various classes. In other words, some coefficients, namely discriminant coefficients, should have bigger weights than others. Therefore, how to make full use

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of the discriminative information in DCT coefficients is a key step in order to obtain good performance of DCT based infrared face recognition method [5].

Partial Least Squares (PLS) is a supervised effective discriminative dimension reduction technique [11, 12] and has been successfully applied to many vision applications including face recognition [2, 9, 10]. In this essay, we use PLS to find a much smaller number of discriminative factors in DCT features. Experimental results show that PLS further improves the recognition performance based on DCT+LDA features. This is because PLS basis projects the feature vectors into a latent space in which feature vectors corresponding to the same subject are closer than the feature vectors corresponding to different subjects.

2 Discrete Cosine Transformation

The discrete cosine transformation (DCT) is a popular image compression method [5]. The nuclear transformation of the discrete cosine transformation is the cosine function of real, thus the calculation complexity of DCT is simple and its information packing ability closely approaches PCA. Another merit of the DCT is that it can be implemented efficiently using the Fast Fourier Transform (FFT).

For a M × N digital image $f(x, y)$, its two-dimensional DCT, $C(u,v)$ is shown in the following equation:

$$C(u,v) = a(u)a(v)\sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)\times\cos\left[\frac{(2x+1)u\pi}{2M}\right]\cos\left[\frac{(2y+1)v\pi}{2N}\right] \tag{1}$$

$$u = 0,1,\cdots,M-1; v = 0,1,\cdots,N-1$$

where $C(u,v)$ is the result of DCT which is the DCT coefficient that represents the purpose of study in this essay. Please be aware that $a(u)$、$a(v)$ are defined respectively as:

$$a(u) = \begin{cases} \sqrt{1/M}\ , & u = 0 \\ \sqrt{2/M}\ , & u = 1,2,3,\cdots,M-1 \end{cases} \qquad a(v) = \begin{cases} \sqrt{1/N}\ , & v = 0 \\ \sqrt{2/N}\ , & v = 1,2,3,\cdots,N-1 \end{cases} \tag{2}$$

Based on high-compression characteristics and valuable information packing ability of DCT, it can be used for feature extraction of infrared face recognition to reduce the relevance of infrared face data [6, 7]. When reconstructing the image using DCT coefficient, retaining few low-frequency component of DCT and rounding down mostly high-frequency component, still get the restore images that is similar to the original images using anti-transformation. The original infrared face, corresponding to the DCT coefficients and the reconstructed image using 1 / 25 of the DCT coefficients are shown in Figiure1. As we can see, the majority of important figure (including nose, mouth, cheeks, etc.) in the restore infrared face is preserved.