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Common Feature Discriminant Analysis For Matching Optical Face Images to Sketch Photos

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Abstract— **In the field of biometrics research and industry, it was critical yet a challenge to match infrared face images, optical face images to sketches. The most challenging problem in heterogeneous face recognition is that face images associated with the same person may be different because they are taken with different imaging devices. Here the image modalities mean optical image, infrared image and sketch photos, which is referred to as modality gap. The major complexity lies in the fact that a great incongruity exists between the infrared face images, corresponding optical face image because they are captured by different imaging devices. In this paper we aim on the approach which defines cross modality face reorganization problems such as sketch-photo and high-low resolution face matching. In this method, new learning-based face descriptor was first proposed to extract the common features and an effective matching method is then applied to the resulting features to obtain the final result. our method can be used in law enforcement.**

Index Terms— **face recognition, optical image, sketch photo,**

I. INTRODUCTION

Due to the increasing demands in such application areas as law enforcement, video surveillance, banking, and security system access authentication, automatic face recognition had attracted great concentration in recent years. The advantages of facial identification over alternative methods, such as fingerprint identification, are based primarily on the fact that face recognition did not necessitate those being checked to oblige. Moreover, face recognition systems are more convenient to use and are more cost-effective, since recognition results can be corrected in uncertain cases by people without widespread training. Conventional optical imaging devices require appropriate illumination conditions to work properly, which is difficult to achieve satisfactorily in practical face recognition applications. To combat low illumination at nights or indoors, infrared imaging devices have been widely applied to much automatic face recognition (ARF) systems. The task of infrared-based ARF systems is to match a probe face image taken with the infrared imaging device to a gallery of face images taken with the optical imaging device, which is considered to be an important application of heterogeneous face recognition (also known as *cross-modality face recognition*). The most challenging issue in heterogeneous face recognition is that face images associated with the same perso n but taken with different devices may be mismatched due to the great discrepancy between the different image modalities (optical and infrared), which is referred to as *modality gap*. The infrared photos are usually blurred, low contrast, and have significantly different gray distribution compared to the optical photos. The infrared photos are usually vague, low contrast, and have significantly different gray distribution compared to the optical photos.

In common feature discriminant analysis (CFDA) method, a new learning-based feature descriptor is first developed to learn a set of optimal hyper-planes to quantize continuous vector space into discrete partitions for common feature extraction, and an effective discriminant analysis technique is then applied for feature classification. We conduct extensive experiments on two large and challenging optical, infrared and face sketch datasets to investigate the effectiveness of our new approach. It is of great interest to investigate whether automatic recognition of sketches using computers can achieve similar performance as human beings.

II. EXISTING METHODS

There exist a lot of methods to compare optical images infrared images and sketch photos. One method to convert an image from one modality to the other by synthesizing a pseudo-image from the query image such that the matching process can be done within the same modality. For example, in [1] a holistic mapping method is applied to convert a photo image into a corresponding sketch image, and in [2]–[4] the authors used local patch-based mappings to convert images from one modality to the other for sketch photo recognition. In [5] authors synthesized VIS face images from NIR face images with pose rectification. The second category of approaches is to design an appropriate representation that is insensitive to the modalities of images.

For example, [6] used SIFT feature descriptors and multi-scale local binary patterns to represent both the sketch and photo images. Reference [7] proposed a learning based algorithm to capture discriminative local face structures and effectively match photo and sketch. In [8], designed a multi-scale common feature descriptor to combat the large intra-class difference incurred by the modality (VIS-NIR) difference. The third category of approaches is to compare the heterogeneous images on a common subspace where the modality difference is believed to be minimized [9]–[11]. For example, in [12] applied the Bilinear Model (BLM) by Singular Value Decomposition (SVD) to develop a common content (associated with identity) space for a set of different styles (corresponding to modalities). In [11], they used the Canonical Correlation Analysis (CCA) technique to construct a common subspace where the correlations between infrared and optical images can be maximized. In [12], the authors applied the CCA to cross-pose face recognition. In [13], Sharma applied the Partial Least Squares (PLS) method to derive a linear subspace in which cross-modality images are highly correlated, while at the same time preserving variances

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more effectively than the previous CCA method. In [13], Lei and friends proposed an effective subspace learning framework called coupled discriminant analysis for heterogeneous face recognition. In [14], a generic HFR framework was proposed in which both probe and gallery images are represented in terms of non-linear kernel similarities to a collection of prototype face images to enhance heterogeneous face recognition accuracy.

III. PROPOSED METHOD

In this new method, we are dealing with three different modalities infrared face image, optical face image and sketch image. Here we proposed a new approach called Common Feature Discriminant Analysis. A new learning based face descriptor is first developed where the vectors of continuous space is converted to discrete code representation in order to convert the image into an encoded image. Vectors of continuous space is converted to the decimal code with the help of pixel normalization techniques like K-min and Random Forest Algorithms where, center pixel value is normalized with respect the neighboring pixels.

In this method the following steps are performed to obtain the result.

- Our input image is converted into its corresponding grey image and binary image
- Preprocessing step is performed to obtain the cropped image ie. Hair portion is removed and the correct face portion is obtained
- Vector quantization is performed and encoded image is obtained.
- Encoded image is divided into a set of non overlapping patches with size k x k
- Then computed the histogram over each patch
- Concatenate the outputs of each patch into a long vector to form the final face feature
- The matching frame work is conducted. Principle component analysis is performed.
- Class scatter matrix is also calculated. Then we will get the face image and the matched sketch photo

Vector quantization is an effective technique in mapping vectors of continuous space into discrete code representations, and has been widely used to create discrete image representations for object recognition. An image can be turned into an encoded image by converting each pixel into a specific code using the vector quantization technique

Here, we designed a hyper plane-based encoding method for effective feature representation for heterogeneous face images. In feature extraction stage we use our CFDA approach for image encoding purpose. For image encoding purpose the image has to go through pipeline for feature extraction. For each pixel, we first sample its five d-neighbor (Radii = d) pixels for each direction and then subtract the center pixel value. Finally the centered vector is normalized into the unit L2-norm to form the associated pixel vector of that direction. Each pixel is associated with four vectors, forming four sets of training vectors that are used to train four encoders. Each encoder consists of two sets of mutually orthogonal hyper-planes which divide the vector space into four partitions. Vectors of each direction are encoded into a 2-bit value, according to the Partition in which the vector lies (i.e. 00 for the first partition, 01 for the second partition, and so forth). Finally, the four 2- bit values are concatenated to form an 8-bit value that will be converted into a decimal value (from 0 to 255) as the code.

With the face image encoded the image we can use densely sampling technique in order to extract the features. For this the whole encoded image is divided into a set of overlapping patches with the size c x c pixels (the step between adjacent patches). Then compute the histogram over each patch of the frequency of each code occurring which gives a feature vector for each patch. Concatenate the outputs of each patch into a long vector to form the final face feature. The matching Framework involves two levels of subspace analysis. In the first level, the large feature vector is first divided into multiple segments of smaller feature vectors. Discriminant analysis is performed separately on each segment to extract the discriminant features. The goal for the first level is to generate more discriminative projections to reduce intraclass variations and avoid over-fitting. In the second level, projected features from all the segments are then combined, with PCA for efficient recognition.

The CFDA approach is proposed specifically for handling the optical-infrared face recognition problem. In the feature extraction stage, a learning-based feature descriptor is developed to maximize the correlations between the optical face images and corresponding infrared images. In this way, the modality gap between the two kinds of face images can be significantly reduced; hence, it is expected that the resulting features will be well-suited to the optical-infrared sketch face recognition problem. Our new feature descriptor differs significantly from State-of-the-art descriptors, such as the widely used HOG and LBP in the literature. Instead of encoding the images using a hand crafted encoding scheme, our feature descriptor learns a new encoding scheme to encode the common micro-structure of both the optical and infrared face images for effective feature representation. Our experimental results also support the effectiveness of our new descriptor over state-of-the-art descriptors. Our new feature descriptor also differs significantly from the CITE (coupled information tree encoding) in [8]. The major difference between them is s summarized as follows. (1) CITE is inherently a tree based encoding method, while our feature descriptor is inherently a binary encoding scheme. (2) Unlike CITE, we encode a pixel
with four directions to make full use of the geometry information. This also reflects the significant difference between them.

IV. CONCLUSION

In this proposed paper we introduced a new approach called common feature discriminant analysis (CFDA), for matching infrared face images , optical face images and sketches. In CFDA, we will first develop a new descriptor to effectively represent optical, infrared face images and sketches to reduce the modality gap, and then a two-level matching method will be subsequently applied for fast and effective matching as a part of our proposed system. Extensive experiments on two large and challenging optical-infrared face datasets will be used to find the significant improvement of our new approach over the state-of-the-art.

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