Engineering Science and Technology, an International Journal xxx (2018) xxx–xxx

HOSTED BY

ELSEVIER

Contents lists available at ScienceDirect

Engineering Science and Technology, an International Journal

journal homepage: www.elsevier.com/locate/jestch

Full Length Article

A collaborative representation face classification on separable adaptive directional wavelet transform based completed local binary pattern features

Mohd. Abdul Muqeet [a,b,*], Raghunath S. Holambe [b]

[a] Electrical Engineering Department, Muffakham Jah College of Engineering and Technology, Hyderabad, TS, India
[b] Department of Instrumentation Engineering, SGGS Institute of Engineering and Technology, Nanded, MS, India

ARTICLE INFO

Article history:
Received 17 August 2017
Revised 26 April 2018
Accepted 14 May 2018
Available online xxxx

Keywords:
Face recognition
Separable adaptive directional wavelet transform
Completed local binary patterns
Collaborative representation classification

ABSTRACT

Face recognition has emerged as the most active area of research in computer vision. A variety of face recognition methods were devised, though several challenges are imposed due to face variations such as facial expression, pose variation and illumination variation which generate great concern in developing efficient face recognition methods. It is desirable to extract robust local descriptive features to effectively represent such face variations. The essential attribute of the proposed method is to extract directional descriptive local features based on the face image characteristics. In order to extract the multi-resolution directional features as per the face variations, a 2-D interpolation-based separable adaptive directional wavelet transform (SADIWT) is proposed. For the implementation of 2-D SADIWT, a set of seven directions with an improved quadtree partitioning scheme is proposed. Completed local binary patterns (CLBP) superior to local binary patterns (LBP) in extracting local texture features are applied on top level's 2-D SADIWT sub-bands to obtain local descriptive features. Collaborative representation classification (CRC) takes benefit of these descriptive features and leads to a very competitive classification performance. Extensive experimental results on benchmark face databases such as ORL, FERET, CMU-PIE, and LFW demonstrate high classification accuracy of the proposed method. A comparison with numerous methods which include various holistic, LBP-based descriptors and representation methods demonstrate the efficacy of the proposed method. Experiments are also conducted to exhibit the robustness and discrimination capability of the proposed method for handling single image per person (SIPP) and random block occlusion problem.

1. Introduction

During the last three decades, numerous face recognition approaches have been devised which perform well under restricted conditions. Face images captured under uncontrolled practical scenarios are influenced by different facial variations such as expressions, poses, occlusions, and illumination [1]. Therefore extracting robust features is essential for efficient face recognition systems. Face representation and classification are the two most essential points in the development of any face recognition system. Face representation deals with the extraction of unique features from the face images and performs a noteworthy function in the improvement of performance of a face recognition system. A dominant face representation method must be discriminative for different subjects and invariant to different face variations. Prominent holistic-based face representation methods comprise of Eigenfaces using principal component analysis (PCA) [2], Fisherfaces using linear discriminant analysis (LDA) [3,4], and locality preserving projections (LPP) [5]. Generally, the holistic methods are sensitive to the aforesaid facial variations. Among local descriptors, local binary patterns (LBP) are successfully implemented for facial feature extraction [6,7] and offer simple implementation and tolerance against illumination. The limitation of the LBP-based method is its sensitivity towards the noise. To describe the local textures more in detail, Guo et al. [8] proposed completed local binary pattern (CLBP) and established its efficacy in texture feature extraction as compared to LBP. Weber local descriptors (WLD) [9] are other powerful local descriptors. Zhang et al. [10] used the WLD to extract local facial features from predefined facial landmarks and efficiently captured pose-invariant features. Wang et al. [11]

* Corresponding author at: Electrical Engineering Department, Muffakham Jah College of Engineering and Technology, Road No.3, Banjara Hills, Hyderabad 500034 TS, India.
E-mail address: ab.muqeet2013@gmail.com (M.A. Muqeet).
Peer review under responsibility of Karabuk University.

https://doi.org/10.1016/j.jestch.2018.05.008
2215-0986/

developed an effective classification method using Locality-constrained linear coding (LLC). Although LBP, WLD, and LLC show promising results, they still confront with many limits and challenges, such as the small sample size (SSS problem) and face misalignment induced by pose variations [10]. Researchers applied pre-processing methods prior to LBP computations to improve the face recognition performance. Numerous multi-resolution analysis (MRA) methods are combined with LBP to extract MRA-based local descriptive features. Local Gabor binary pattern (LGBPHS) [12] is one such eminent MRA-based local facial descriptor which combines the Gabor filters with LBP. However, LGBPHS generates large dimension feature vector. In [13], LBP coded image of curvelet transformed low-frequency approximation sub-band and normalized mid-frequency sub-bands are considered to form the feature set and later LPP is used for dimensionality reduction. But multi-region local feature details are not extracted to confront different face variations. Alelaiwi et al. [14] proposed a face recognition system based on SPT and LBP for e-Health secured login for patients. SPT sub-bands are generated with different scales and orientations. LBP is applied to each of the sub-band to extract histogram features. Later local learning based algorithm (LLB) is applied to reduce the dimensionality of generated features. Patil et al. [15] proposed a novel feature fusion technique and considered the contourlet transform and performed multi-block LBP and multi-block WLD histogram feature extraction. However, application of two local descriptors increases the complexity of this method. Moreover, these methods [12–15] use MRA methods which despite capturing the directional information lack the adaptation in selecting the directional details based on the face image characteristics and suffer from various issues such as high computational rate and complex filter design.

Adaptive MRA methods of approximation are regarded to be more compact than the non-adaptive ones since the optimal directions as per the image characteristics are selected adaptively through the approximation process [17]. The prominent adaptive MRA methods which adaptively decide filtering directions as per the description of images have been proposed in [16–18]. Chang et al. [16] developed a direction-adaptive discrete wavelet transform (DA-DWT) for image compression where only one pair of lifting step and non-interpolated integer samples are used to realized directional lifting and Neville filters [21] are used as the prediction and update filters. Ding et al. [17] suggested adaptive directional lifting (ADL) based separable wavelet transform which could be implemented with one or two pairs of lifting steps with 5/3 or 9/7 CDF wavelet filters [21]. Maleki et al. [18] proposed directional wavelets (DIW) with megaquad partitioning algorithm in the adaptive directional lifting based framework to efficiently capture edge features. Adaptive filter direction selection as per the image characteristics makes these methods efficient in approximating directional features. Moreover, as a result of lifting based factorization, perfect reconstruction is also assured and the resultant multi-resolution image is absolutely compatible with that of the conventional 2-D DWT multi-resolution image. Recently, Muqeet and Holambe utilize the DA-DWT [16] for facial feature extraction [19] and compared its effectiveness with famous subspace and non-adaptive MRA-based face recognition methods. Very recently in [20], LBP histogram features are extracted from the directional wavelet transform sub-bands. LDA is used as the dimensionality reduction method.

Classification using a robust classifier is a pivotal step to attain a superior performance for any face recognition method. Nearest neighbor (NN) classifier [23] is the most widely used classifier which classifies the testing face image according to the nearest training face image. But NN classifier is unstable as it uses less information of training set to assess the testing image. Recently, some classification methods such as sparse representation classification (SRC) [24], collaborative representation classification (CRC) [25], and linear regression classification (LRC) [26] have been devised which substantially improve the classification performance. Zhang et al. [25] verified that CRC attains a superior classification performance as compared to SRC. While performing classification, CRC not only considers the similarity between training samples but also considers the correlation among the training samples. Due to this CRC can be effectively utilized for face recognition even under uncontrolled environments. The performance of LRC is confined as it does not entirely utilize the discrimination information of the training samples. Both CRC and SRC and its variant have been extensively used in face recognition methods [27–31]. Cao et al. [27] used the sparse representation for extraction of illumination and pose-invariant features. Fan et al. [28] improved the SRC method by computing the weight of training samples and obtained superior results compared to SRC and CRC methods. Liu et al. [29] used hierarchical multi-scale LBP and performed classification using sparse coding with the application of a matching pursuit-based greedy search approach. Wang et al. [30] combined the Gabor wavelet transform (GWT) and CLBP features and carried out the SRC to perform classification.

The motivation of the proposed method is to develop an efficient facial feature extraction method which considers the different facial variations and captures significant directional information from the face images. Accordingly, considering the benefit of directional lifting and adaptation in direction selection based on the image characteristic, this paper proposes to develop a 2-D interpolation-based separable adaptive directional wavelet transform (SADIWT) to extract multi-resolution directional information from the face images. While implementing 2-D SADIWT, seven directions with an improved quadtree partitioning scheme are proposed. The contribution of the proposed work is threefold. At first, different multi-resolution sub-bands are obtained by applying the proposed 2-D SADIWT. Secondly, histograms features using sign-magnitude differences of the CLBP [8] are extracted from the selected top-level's 2-D SADIWT sub-bands. The 2-D SADIWT detects the edges adaptively as per image characteristics and the CLBP captures the distribution of various local micro-patterns from these sub-bands, for instance, edges, spots, and flats. Lastly motivated by the benefits offered by the collaborative representation for efficient face classification, it is utilized to perform robust classification. There are two benefits of the proposed method: firstly, it can fully utilize the CLBP functionality i.e. CLBP-based histogram features extracted from the 2-D SADIWT sub-bands are more descriptive, illumination invariant, and can significantly reduce redundant information and make the method computationally efficient. Secondly, CRC can perform efficiently on these local descriptive features and contribute to improving the overall classification accuracy. The remaining part of the paper is arranged as follows. Implementation of the proposed 2-D SADIWT using proposed seven directions with an improved quadtree partitioning scheme and associated theory of CLBP and CRC is explained in section 2. Further, the proposed facial feature extraction method is discussed in section 3. In section 4, parameter settings are discussed and experimental results are performed on four widely used face databases. Conclusions based on the experimental results are discussed in section 5.

2. Materials and methods

In this section, the implementation of the proposed 2-D SADIWT in the proposed seven directions using the improved quadtree partitionning scheme is illustrated. A related theory on CLBP and CRC is also explained and their individual contribution to the proposed method is also described.

Please cite this article in press as: M.A. Muqeet, R.S. Holambe, A collaborative representation face classification on separable adaptive directional wavelet transform based completed local binary pattern features, Eng. Sci. Tech., Int. J. (2018), https://doi.org/10.1016/j.jestch.2018.05.008