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A Survey on of Low Resolution Face Recognition based on Direct Approaches

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ABSTRACT: In case of face images taken from low resolution cameras or close-circuit television cameras, human facial features are not clearly visible or subjects are farther from cameras and face regions tend to be small. This issue is called low-resolution face recognition (LR FR). LR FR is a more difficult task due to the variability of human facial features. In this paper, we present a comprehensive survey on different direct methodology and discuss many issues related to LR-FR. Firstly, a brief description of FR and an overview on LR FR including various techniques, both direct and indirect, are presented. Secondly, various direct methods are reviewed and discussed broadly with their methodologies, findings, advantages / disadvantages. Their performances, limitations and important issues for future research are also discussed.

KEYWORDS: Face recognition, Low-resolution, Super-resolution, Feature extraction, Feature classification.

I. INTRODUCTION

Normally, face recognition problem is a two step process. First one is feature extraction from facial images and later one is a classifier step. It can be simply stated as: given a set of face images labeled with the person identity (learning set) and an unlabeled set of face images from the same group of people (the test set), identify each person in the test images[2].

From different work carried on FR it is seen that the recognition accuracy of face recognition in controlled environments with cooperative subjects is satisfactory. But, because of the practical importance and theoretical interest from cognitive scientists due to its great potential applications[3], face recognition have a natural place in these next-generation smart environments, wearable computers, and ubiquitous computing.

Different schemes and strategies have been proposed for the problem of face recognition with focus on dealing with complex conditions such as aging, occlusion, disguise, and variations in pose, illumination, and expression [1]. The holistic/non-holistic philosophy of the methods [1] is one of the popular classification schemes. In holistic methods, which are commonly referred to as appearance-based approaches, overall information that is, the face as a whole is used to recognize the face in the image. While non-holistic approaches are based on identifying particular features of the face such as the nose, the mouth, the eyes, etc[4] and their relations to make the final decision. Appearance based algorithms, feature based algorithms, and texture based algorithms are broad categories of face recognition algorithms with different approaches as Eigenface, Fisherface, Feature analysis, Graph matching, Neural networks, etc.

Image resolution determines the capacity to discriminate fine features of image to a great extent. Compared with high-resolution (HR) images, these LR images lose some discriminative details across different persons, as shown in Fig 1. Methods developed for high resolution (HR) face images do not perform well when face images have relatively LR for recognition.

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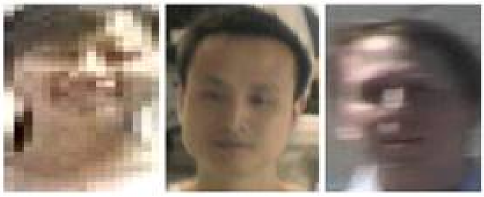

Fig 1. Some examples of LR face images

Similar to conventional HR FR system, LR FR system, as shown in Fig 2, also includes three main blocks. That is LR face detection or tracking, LR feature extraction and LR feature classification. In general, the latter two blocks are collectively referred to as LR FR[5]. LR face detection/tracking includes automatic pre-processing, detection, tracking and segmentation of the faces performed on LR images or videos.

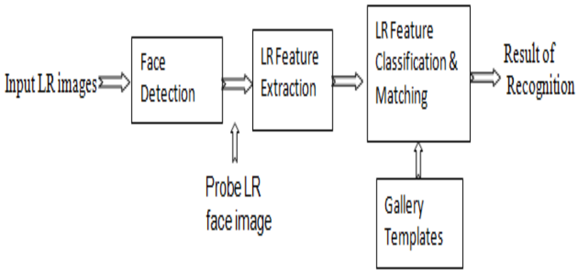

Fig 2. Block diagram of LR-FR

Aim of the Low-resolution face recognition (LR FR) is to recognize faces from small size or poor quality images with covariates such as occlusion, aging, disguise and variations in pose, illumination, and expression, etc. LR FR initially extracts resolution-robust features, and performs classification by matching the features to obtain the identity decision. This is a direct method on the original LR images for LRFR. However, as opposed to HR FR, LR FR needs to consider the particular problem of dimensional mismatch. Secondly, indirect way to solve LR FR problem is super-resolution (SR), which first reconstructs HR faces from several LR faces and then performs recognition with the super-resolved HR images.

(1) Indirect Methods: Based on Super Resolution the landmark works in this category are face hallucination and Simultaneous SR & recognition (S2R2). Generally, visual quality (Face Hallucination, Two step statistical Approach, Eigen Transformation, Extended Morphable Face Model) and recognition discriminability. (Simultaneous SR & Recognition (S2R2), Multi-Model Tensor SR (M2TSR), Discriminative SR(DSR), Support Vector Data Description (SVDD). However, most of these methods aimed to improve face appearance but failed to optimize face images from recognition perspective.

(2) Direct method: The landmark works, are color feature and coupled locality preserving mappings (CLPMs). These methods can be separated into two groups further. One is feature-based method (Color-based Feature, Texture-based Feature: Local Frequency Descriptor (LFD), Kernel Class-dependence Feature Analysis (KCFA)) in which the resolution-robust features, such as texture, and subspace information, are used to represent faces. However, some features used in traditional HR FR methods are sensitive to resolution. The other is structure-based method, e.g. Eigenspace Estimation (EE), Coupled Locality Preserving Mappings (CLPMs), Multi-Dimensional Scaling (MDS), Coupled Kernel Embedding (CKE).

In the next section, we will discuss about different direct methods of LRFR.

II. DISCUSSION

Yang-Ting Chou et. al. [6], reported kernel linear regression classification (KLRC) algorithm, which improves the limitation of the LRC by embedding the kernel method into the linear regression, to apply a nonlinear mapping function to twist the original space into a higher dimensional feature space for better linear regression. It proves robustness for very low-resolution face recognition under severe illumination variations.

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Hae-Min Moon et.al. [7], presented convolution neural network (CNN), where Face image size was normalized by bilinear interpolation, while histogram equalization was applied as image preprocessing. CNN was used for face recognition while Euclidean distance was used for similarity measurement. In general, since the long distance face recognition is conducted in an uncooperative user environment, if only one image is used, there is a limit to the recognition performance.

In a method, which was proposed by Daniel F. Smith et.al? [8], extracting the features from the reflection region i.e. a challenge-response method is the basis for FR. Here image reflection techniques are used to defeat simple replay attacks in face recognition systems. By extracting the features from the reflection region, it is possible to determine if the reflection matches the sequence of images that were displayed on the screen.

Huu-Tuan Nguyen and Alice Caplier [9], used Block-wise ELBP & LPOG method. This is an approach equipped with LPOG for feature extraction, unified, single sample per person FR framework called LPOG, Whitened Principal Components Analysis (LPOG WPCA) by using WPCA for dimension reduction, k-NN and weighted angle -based distance function for classification. It attains good performance on SCface database, whose probe images are extremely challenging.

Shih-Ming Huang et.al.[10], proposed Multiple-Size Discrete Cosine Transforms (mDCTs) and the recognition mechanism with Selective Gaussian Mixture Models (sGMMs) .The mdct method employs from narrow-to-wide dcts to extract sufficient visual features, which make the data distribution more suitable for statistical modelling While sGMM with the MSL algorithm could automatically exclude the unreliable observation vectors. Method is based on DCT features, which is sensitive to illumination variations.

Zhenyu Wang et. al.[11], presented Canonical correlation analysis (CCA) which is firstly applied on low-resolution degradation face recognition over long distance. Here the most correlated component between the low resolution and high-resolution images are extracted using CCA. CCA reduces the requirements of the same dimension of images and also avoids the mismatch between the low-resolution images and high-resolution images. Results reveal that CCA could be successfully used on low-resolution degradation face recognition over long distance.

Le An et.al. [13] proposed a dynamic Bayesian network for multi-camera face recognition. Videos from multiple cameras are effectively utilized to provide the complementary information for robust recognition results. In addition, the temporal information among different frames is encoded by DBN to establish the person-specific dynamics to help improve the recognition performance. Regarding the generality of method, the feature nodes in the DBN can be replaced with any choice of informative feature descriptors and the proposed framework can be extended to the camera systems with different number of cameras.

Wilman W. Zou et.al.[14] reported a GLF feature tracker to address the problem of tracking a low resolution face subject to illumination changes. This feature is a globally dense feature which is effective in low-resolution videos. The proposed GLF feature may not be robust to large changes in lighting direction.

Joshua C. Klontz and Anil K. Jain [12], in their study discussed many issues with regard to LR FR. Information provided from multiple viewpoints could be fused together to construct a single face representation of the suspect prior to searching against a large face database of known individuals. In particular, illumination, expression, and aging appear to be less relevant as sources of error than image resolution and occlusion. However, differences in head pose continue to challenge state-of-the-art commercial systems.

Sumit Shekhar et. al.[15], in joint sparse coding technique, by leveraging the information available in the high resolution gallery image, proposed a generative approach for classifying the low-resolution probe image. It can cope up with resolution change along with illumination variations. They also kernelized the algorithm to handle non-linearity in data and present a joint sparse coding technique for robust recognition at low resolutions. Even when a single HR gallery image is provided per person, this algorithm can provide good accuracy for LR face images. The limits of remote face recognition can be extended with idea of exploiting the information in a HR gallery image. Automatic alignment of LR faces using landmarks is a challenging problem, so to extend approach with a view to handle variations like pose, alignment, etc. may be the future scope. Discriminative framework for the proposed algorithms can also be explored as a future direction.

Chuan-Xian Ren et.al. [16] presented Feature extraction method called coupled kernel embedding (CKE) that addresses the problem of comparing multimodal data which is difficult for conventional methods in practice, due to the lack of efficient similarity computation. CKE solves this problem by minimizing the inconsistency between the similarity measures captured respectively by their kernel Gram matrices in the two spaces. The objective function aims to preserve the locality between neighbourhood in the reproducible kernel Hilbert space. The experiments using nonlinear kernel functions on real surveillance camera databases demonstrate the effective improvement in recognition accuracy.

III. CONCLUSION

We can conclude from the discussions above, that face recognition of LR images is a challenging and interesting area with great potential for different applications. There is no unified theoretical framework in particular. Besides, there are no standard databases and criteria to evaluate the performances of the existing LR FR methods. What are the effective features representing LR faces for recognition? All of them will motivate researchers to create more effective methods. Answers to these questions may lead to a clearer understanding of LR FR and even general LR object recognition, which are similar to the findings of nonlinear mappings in pose-invariant face recognition and linear subspaces in illumination-invariant face recognition.

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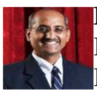
BIOGRAPHY



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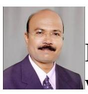

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