International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-1, November 2019

Low Resolution Face Recognition System Performance for Basic Feature Space Methods with Various Illumination Normalization Techniques

Manish N. Kapse, Sunil Kumar

Abstract*: *The Face recognition research identified with the field of automated surveillance systems in real life application has pulled in more consideration today with extensive use of vision cameras in biometrics and surveillance applications, globally. The small size images or poor quality images are generally Low Resolution images. Authenticating faces, with variation in pose, illumination, disguise and more, from such Low-resolution images, is the main purpose of Low Resolution Face Recognition (LR FR) system. We have assessed the LR FR system for various basic feature space techniques like PCA, LDA and Fisherface. Different illumination normalization techniques are applied on the cropped Yale face database prior to feature extraction and identification. In our work the low-resolution images, of size 32x32, are the down-sampled versions high-resolution facial images from cropped Yale face database. Our experiment demonstrates the encouraging performance, with recognition accuracy as 97.43%, on Low Resolution, Low quality face images.

Keywords: Feature space, Feature extraction, Illumination Normalization, Low Resolution Face Images, LRFR.

I. INTRODUCTION

Applications based on biometrics, computer vision, Artificial intelligence etc [1] have attracted tremendous consideration in recent decade. Robust face recognition system is need of an hour with the use of Close Circuit Television(CCTV) cameras in many application areas from banks to supermarkets to law enforcement applications in government offices, public streets etc. [2].

The development of numerous real world face recognition systems has witnessed consistent research on Face recognition over the last few decades with. It is revealed that the adequate information for recognition is available with face region[2] but, due to the variation in illumination, pose, aging, occlusion, distance and resolution etc., it still attract researcher to overcome these challenges.

Information carrying differentiating landmark features of the face may be lost, in case, the images are taken from surveillance cameras[2]. The resultant images from such cameras are generally low resolution-low quality images and lose some discriminatory detail in different faces compared to high resolution (HR) images. To recognize a person from such images is still an issue needs to be addressed [3] . Hence LR FR plays a major role in the active exploration and development of face recognition systems in today's smart environments.

In holistic methods, generally called appearance-based approaches, the whole face is considered for recognition. While the relation between local features, representing face landmarks, is explored for recognition in non-holistic approaches [4]. Various approaches like Eigenface, Fisherface, Feature analysis, Graph matching, Neural networks, etc. are used to develop face recognition algorithms.

The basic techniques like Principle Component Analysis (PCA) and Linear Discriminant Analysis (LDA) work on principle of dimension reductionality for subspace analysis [5].The distinctive information from face image is extracted by using few vectors in PCA[5] which are linearly distinct but correlated images[6]. These are the *Eigenfaces, the base of PCA*. LDA, with emphasis on extracting the most distinctive face features, looks for projection vectors with high degree of difference between a class and a minimum scattering matrix in a class at a time [5].

Distantly framed Faces in a real scene by CCTV cameras or camera phones are LR test images against HR gallery images [7]. Therefore, it is very important to select and effectively use distinctive features from such images with varying resolution [7]. The experiments by different researcher so far has shown that, extracting discriminative features from LR face images need to be explored more with consideration to a distortion in images, loss of important features, and limited gray levels representing illumination[8].

LRFR system comprises of the extraction of LR features and their classification [3]. The two ways of LRFR are,

Revised Manuscript Received on November 30, 2019.
* Correspondence Author
Manish N Kapse*, Research Scholar, Kalinga University, Naya Raipur, Chhattisgarh, India, Email: kapmani2014@gmail.com
Sunil Kumar, Professor and Head, Department of E and TC, Kalinga University, Naya Raipur, Chhattisgarh, India
Email:sunilbirla2004@gmail.com

(1) Indirect Methods: In these methods the captured LR faces are converted into HR face images for comparison with HR face gallery and is known as super-resolution (SR)[4]. Based on Super Resolution, the notable works in this category are facial hallucination and simultaneous SR and recognition (S2R2)[9]. Generally, visual quality (Face Hallucination, Two levels statistical Approach, Eigen Transformation, and Extended Morphable Face Model[9]) and recognition discriminability (Simultaneous SR and Recognition (S2R2), Multi-Model Tensor SR (M2TSR), Discriminative SR (DSR), Support Vector Data Description (SVDD)[9]) are the two base criterions for SR applications[9]. However most of these methods are intended to enhance the appearance of the face but could not represent face attributes for effective face recognition[9].

(2) Direct method: It is subdivided in two groups. First approach is feature-based approach (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[9]. However, some of the features used in traditional HR FR methods are sensitive to the resolution. Another is a structure-based approach, e.g. Eigenspace Estimation (EE), Coupled Locality Preserving Mappings (CLPMs), Multi-Dimensional Scaling (MDS), Coupled Kernel Embedding (CKE)[9].

In this work we have focused on the direct methods in use for LRFR. This paper features the research done in the LRFR based on direct methods till date, experimental results with various illumination normalization techniques and concluded with a summary of findings and future scope.

II. EXISTING RESEARCH WORK BASED ON DIRECT LRFR

The LRFR system, as shown in Fig. 1, incorporates three principle blocks as face detection or tracking, feature extraction and feature classification from input LR image[4][9]. LR face detection/tracking includes automatic pre-processing, detection, tracking and segmentation of the faces performed on LR images or videos[9].

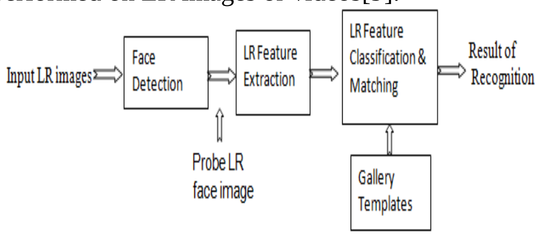


Fig 1: Block diagram of LR-FR

The purpose of the LR FR is to recognize faces from small size or poor quality images, captured from real scene[9]. Generally these images are impressed with covariates such as occlusion, aging, disguise and variations in posture, illumination, and expression, etc[9]. LR FR initially extracts distinctive features from LR image and try to recognize face by matching these features [9][4]. This is direct method on the original LR images for LRFR.

Most of the LRFR works were done on databases with facial images captured with HR cameras in an environment with set conditions. In most of the experiments LR face images, created by down-sampling the captured HR images, also have an impact of degradation (e.g. noise, blurring)[1].

Huu-Tuan Nguyen and Alice Caplier [10] used Block-wise ELBP and LPOG method. This is an LPOG enabled approach for feature extraction which resulted in good performance on SCface database.

Shih-Ming Huang et. al.[11] proposed Multiple-Size Discrete Cosine Transforms (mDCTs) with the Selective Gaussian Mixture Models (sGMMs) recognition mechanism. Here illumination variant DCT features are focused.

Zhenyu Wang et. al. [12] presented Canonical correlation analysis (CCA). In CCA LR and HR image features with minimum deviation is extracted. CCA demonstrated it's utility in recognition of low-resolution individuals over long distances.

Joshua C. Klontz and Anil K. Jain [13] discussed many issues regarding LR FR in their study. Converging information from multiple pictures taken from different cameras is discussed. This fused information represent suspect's characteristics and will be known before investigating database of known individuals. Image resolution, differences in face posture and occlusion are the gray areas need to cater for effective LRFR system at place.

Le An et.al. [14] proposed a dynamic Bayesian network for multi-camera FR system. Videos from multiple sources provide additional between frames information for robust recognition results. Use of any other classifier as DBN feature node and use of more or less than 3 cameras with the proposed framework to be explored further.

Wilman W. Zou et.al. [15] reported illumination independent GLF feature tracker. It is used to trace LR face from the images with significant lighting variation.

Chuan-Xian Ren et.al. [16] exhibited coupled kernel embedding (CKE). This is Feature extraction technique targeted on multimodal data comparison. The CKE Kernel in two spaces minimizes irregularities between the captured similarity measures. Experiments based on non-linear kernel functions, in real-world surveillance camera databases, demonstrated effective improvements in recognition accuracy.

Yang-Ting Chou et al. Al. [17] reported an improvement in LRC restriction with the use of linear kernel regression classification algorithm (KLRC). It is aimed at creating a high dimensional feature space with the application of nonlinear mapping function for effective linear regression. It demonstrated robustness to dominant light deviations.

Hae-Min Moon et.al. [18] presented convolution neural network (CNN). It used Euclidean distance as correlation measure. If only one image is used, there is a limitation on recognition performance in an uncooperative user environment.

In the method proposed by Daniel F. Smith et.al [19], reflection region characterisitics is the basis for FR. Image reflection techniques used here to identify non real time attempts in FR systems.

III. EXPERIMENTAL RESULTS

Cropped Yale face database B [20],[21] is explored for performance evaluation of LRFR system in our experiment. We transformed HR face images from database into LR Face images. We down-sampled the database images by various factors in order to get various sizes LR face images as 64*64, 40*40, 32*32. In this work, we investigated the performance of the basic feature space methods such as PCA, LDA, and Fisher for face recognition analysis on 32*32 pixel face images. Various illumination normalization techniques are applied on downsampled sample face images from Yale database. In our experiment, we investigated Multiscale weberface , Gradient face , Single Scale Self Quotient ,Weberfaces , DCT, Tan-Triggs, Single Scale Retinex, Multi sale Retinex and Multiscale Self Quotient methods of Illumination normalization . We analyzed the response of all these methods to the FR system for LR face recognition.

Our experimental results are based on LR face images of size 32*32 pixels, generated by downsampling the cropped Yale database B images of size 168*192. The parameters set for the experiment of LR FR system are, the number of training samples per person = 4 , test persons=38, test samples=2300 numbers, Rank= 1 We also applied diverse illumination normalization techniques as mentioned above for basic feature space methods as PCA, LDA, Fisherface. Some sample images before and after illumination normalization with different techniques are as shown in Fig.2.

With the mentioned parameters setup we noted the % Recognition Accuracy of the system for various illumination normalization techniques. The result is as shown in Fig.3 and

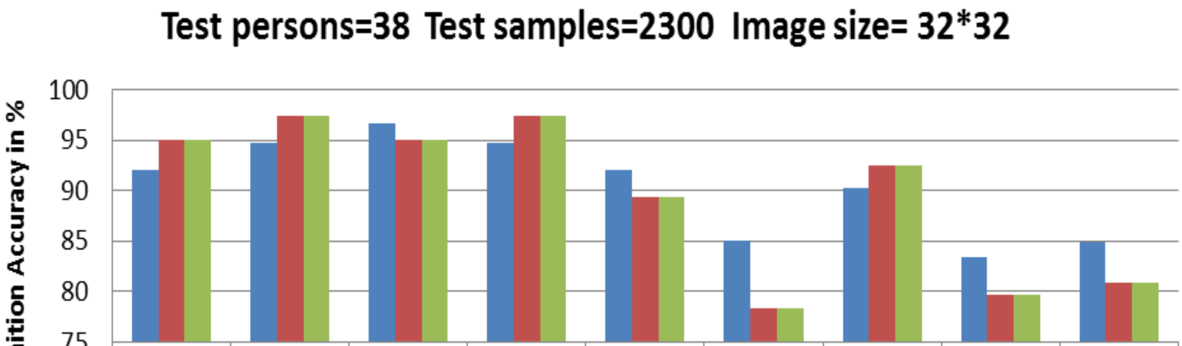
Fig.2: Sample original and illumination normalized images

LRFR accuracy is found to be in the range of 78.34 % to 97.43 %. LDA and Fisher methods with Weberfaces technique used for illumination normalization demonstrated promising results as 97.43 % recognition accuracy on image size of 32*32.

IV. CONCLUSION AND FUTURE SCOPE

Our experimental result shows that good recognition accuracy can be achieved using different illumination methods for PCA, LDA and Fisherface feature spaces. FR accuracy of 97.43 % is achieved using multiscale weberface based LDA and Fisherface techniques, applied on LR face samples. In our investigation we have produced LR face images from cropped Yale face database B by downsampling these face images and utilized as Testing and Training samples. We conclude that FR system for Low Resolution face images with standard database works well to the satisfaction.

For the real world Low Resolution face images, present Face recognition systems are yet to be demonstrated effectively on the high performance basis. For future work as opposed to utilizing downsampled standard database for Testing and Training, actual LR face images can be used for recognition.



	Gradient face	Multiscale weberface	Single Scale Self Quotient	Weberfaces	DCT	Tan-Triggs	Multi scale Retinex	Single Scale Retinex	Multiscale Self Quotient
PCA	92.087	94.7826	96.6951	94.7391	92.0435	85.0435	90.1739	83.4348	84.913
LDA	95.0435	97.4348	95.0436	97.3913	89.3043	78.3478	92.4348	79.7391	80.8261
Fisher	95.0435	97.4348	95.0436	97.3931	89.3043	78.3478	92.4348	79.7391	80.8261

Fig.3: LR Face Recognition Accuracy Vs Illumination normalization techniques for Feature spaces like PCA, LDA, Fisherface

REFERENCES

1. Xiang Xu, Wanquan Liu, Ling Li, " Low Resolution Face Recognition in Surveillance Systems", Journal of Computer and Communications, 2014,2,70-77.
2. Wilman W. W. Zou, and Pong C. Yuen, "Very Low Resolution Face Recognition Problem , IEEE Transactions On Image Processing", Vol. 21, No. 1, January 2012.
3. Srimanta Mandal, Shejin Thavalengal, Anil Kumar Sao, "Explicit and implicit employment of edge-related information in super-resolving distant faces for recognition", Pattern Anal Applic, Springer-Verlag , London 2015.
4. Manish N. Kapse Dr. Sanjay V. Dudul, "A survey on of Low Resolution Face Recognition based on direct approaches", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 4, Issue 11, November 2016
5. Vo Dinh Minh Nhat, SungYoung Lee, Hee Yong Youn, "Whitened LDA for Face Recognition" , CIVR'07,ACM, July 2007
6. Gheorghita Ghinea1, Rajkumar Kannan, And Suresh Kannaiyan, "Gradient-Orientation-Based PCA Subspace for Novel Face Recognition", IEEE Access, VOLUME 2, 2014
7. Jae Young Choi, Yong Man Ro, "Color Face Recognition for Degraded Face Images" , IEEE Transactions On Systems, Man, And Cybernetics—Part B: Cybernetics, Vol. 39, No. 5, October 2009
8. Samik Banerjee, Suranjana Samanta, Sukhendu Das, "Face Recognition in Surveillance Conditions with Bag-of-words, using Unsupervised Domain Adaptation", Association for Computing Machinery.ICVGIP '14, December.
9. ZhifeiWang, Zhenjiang Miao, Q.M. JonathanWu, YanliWan , Zhen Tang, "Low-resolution face recognition: a review", Vision Computing (2014) 30:359–386
10. Huu-Tuan Nguyen and Alice Caplier, "Local Patterns of Gradients for Face Recognition", IEEE Transactions on Information Forensics And Security, Vol. 10, No. 8, August 2015, pp 1739.
11. Shih-Ming Huang, Yang-Ting Chou, Jar-Ferr Yang, "Low-resolution face recognition in uses of multiple-size discrete cosine transforms and selective Gaussian mixture models", IET Computer Vision, 2014, Vol. 8, Iss. 5, pp. 382–390.
12. Zhenyu Wang , Wankou Yang , Xianye Ben, "Low-resolution degradation face recognition over long distance based on CCA", The Natural Computing Applications Forum 2015.
13. Joshua C. Klontz, Anil K. Jain, "A Case Study of Automated Face Recognition: The Boston Marathon Bombings Suspects" IEEE Computer Society November 2013.
14. Le An, Mehran Kafai, and Bir Bhanu," Dynamic Bayesian Network for Unconstrained Face Recognition in Surveillance Camera Networks", IEEE Journal on Emerging And Selected Topics In Circuits And Systems, Vol. 3, No. 2, June 2013, 155.
15. Wilman W. Zou, Pong C. Yuen, and Rama Chellappa, "Low-Resolution Face Tracker Robust to Illumination Variations", IEEE Transactions on Image Processing, Vol. 22, No. 5, May 2013.
16. Chuan-Xian Ren, Dao-Qing Dai, and Hong Yan," Coupled Kernel Embedding for Low-Resolution Face Image Recognition", IEEE Transactions on Image Processing, Vol. 21, No. 8, August 2012.
17. Yang-Ting Chou, Shih-Ming Huang and Jar-Ferr Yang, Chou, "Class-specific kernel linear regression classification for face recognition under low-resolution and illumination variation conditions", EURASIP Journal on Advances in Signal Processing (2016).
18. Hae-Min Moon, Chang Ho Seo, Sung Bum Pan, "A face recognition system based on convolution neural network using multiple distance face" Springer-Verlag Berlin Heidelberg 2015.
19. Daniel F. Smith, Arnold Wiliem, and Brian C. Lovell, "Face Recognition on Consumer Devices: Reflections on Replay Attacks", IEEE Transactions on Information Forensics And Security, Vol. 10, No. 4, April 2015.
20. Kuang-Chih Lee, Jeffrey Ho, and David Kriegman, "Acquiring Linear Subspaces for Face Recognition under Variable Lighting", IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. 27, No. 5, May 2005.
21. Athinodoros S. Georghiades, Peter N. Belhumeur and David J. Kriegman, "From Few to Many: Illumination Cone Models for Face Recognition under Variable Lighting and Pose", IEEE Transactions On Pattern Analysis And Machine Intelligence, Vol. 23, No. 6, June 2001.

AUTHORS PROFILE

Manish N. Kapse is a In-charge Center of Excellence, "R-Labs" SVPCET and Associate Professor in Department of Electronics and Telecommunication Engineering, St. Vincent Pallotti College of Engineering and Technology, Nagpur, M.S., India. He is having 21 years of teaching experienceand taught subjects like Digital Signal Processing, Digital Image Processing,Digital Electronics, Micorprocessors etc. He completed his graduation in Electronics & Telecommunication Engineering from Government College of Engineering, Amravati, M.S., India. He received Master of Technology degree in Electronics and Telecommunication from Dr. Babasaheb, Ambedkar Technological University, Lonere, Raigad, M.S. India with specialisation in DSP . He is currently pursuing Ph. D. from Kalinga Univeristy, Naya Raipur, Chhattisgarh, India.. His research interests are Image Processing, Digital Signal Processing, Robotics , AI , ML etc. He has presented and published six papers in National and International conferences.Five papers were published in the area of Image Processing specifically on Image Comresion.He has also published one paper on Low Resolution Face Recognition.He is a Life member of Institution of Electronics and Telecommunication Engineers(IETE) and Life member of Indian Society for Technical Education (ISTE).

Sunil Kumar is a Professor and Head of Department of Electronics and Communication Engineering, Kalinga University. Naya Raipur, Chhattisgarh, India. He received PhD from State Government University (B. N. Mondal University), India. MSc.(Radio physics &Electronics), Department of Physics Babasaheb B.R. Ambedkar University, India. He is having teaching experience of 26 years in different universities in India. His research interests are Image Processing and Optical communication. Two PhDs awarded under his supervision in Electronics & Communication Engineering. He is approved PhD guide & member of various universities of India. He is Editor of 11 international journal published in countries like India and USA. He has authored book " CSIR-UGC and GATE Physical sciences", Listed in seven best Book of India. He has published 24 papers in international journals and presented 5 paper at international conferences in different areas of wireless communication. He has taught courses like Laser Technology, Antenna and wave propagation, Optical Fibre , Opto Electronics Engg. Physics with special interest in areas like optical communication, Antenna .He is esteemed member of technical societies like Indian Society for Technical Education, Research Journal of Chemistry and Environment.