Journal of Engineering Sciences
Vol 12, Issue 01, April /2021
ISSN NO:0377-9254

FACE RECOGNITION USING TEXTING FEATURES

Soora Narshima Reddy[1], Gande Ramya Sree [2]

1 Assistant Professor, Department of Computer Science and Engineering, KITSW (Affiliated to Kakatiya University), Warangal,India-506015, snr.cse@kitsw.ac.in

2 PG scholar, Department of Computer Science and Engineering, KITSW (Affiliated to Kakatiya University), Warangal, India-506015, ganderamya@gmail.com

Abstract:

Human gradient progression in automatic face recognition affects overall recognition rates and accuracy. Face Recognition (FR) technology is a relatively new area which is a challenging and critical area of research work. The conventional methods are struggles in achieving high accuracy due to improper features. Thus, to overcome these problems, multiple descriptors with modified dimensionality reduction based FR with gradient variation approach are developed by using Kirsch edge detection. The dimension of the extracted feature space is reduced using the Principal Component Analysis (PCA) method. Finally, Chi-square classified is performed to classify the given test image by comparing with the training database. The proposed method increases the accuracy, specificity and sensitivity compared to the existing methods.

Keywords: *Face Recognition, Kirsch edge detection, PCA*

1. INTRODUCTION

Human gradient progression in automatic face recognition affects overall recognition rates and accuracy. Face Recognition (FR) technology is a relatively new area which is a challenging and critical area of research work. It is widely used in several applications such as law enforcement, missing child identification, passport verification, etc. Recognizing the face image with gradient is highly complicated due to the facial region changes with an increase in age. Besides, the existing face recognition techniques have issues such as large feature space, low accuracy and recognition rate.

Face Recognition (FR) technology is a relatively new area which is a challenging and critical area of research work. It is widely used in several applications such as law enforcement, missing child identification, passport verification, etc. Recognizing the face image with gradient is highly complicated due to the facial region changes with an increase in age. Besides, the existing face recognition techniques have issues such as large feature space, low accuracy and recognition rate. The history of biometric based human recognition emerged with the development of the Bertillon system. Generally, there exist six biometric traits to predict the human are face, finger, hand, eye, and nose and ear signatures. Among all biometric attributes for human recognition, face based recognition system [1] is most convenient due to its natural nonintrusive and easy usage purposes. Over recent decades, face recognition has great growth in computer vision technology owing to its applications in security, commercial, law enforcement, surveillance and so on. Face is the general biometric used by humans for recognition and typically, face recognition is a multiclass classification which is characterized asface identification and verification [2]. Face identification is used to categorize a face image with a particular identity. Meanwhile, face verification defines

whether a pair of face belongs to a unique identity or not. Face recognition concerning testing is estimated under two different processes that are open and close set. In general, face recognition comprises of four major steps are Image acquisition, preprocessing, feature extraction, classification and recognition.

Face recognition is a massively researched topic among researchers due to its widespread application areas. In recent years, face recognition technology is majorly used in security and law enforcement related scenarios. However, face recognition suffers from more factors challenged in routine, such as pose variations, illuminations, and noise and age variation. The faces with intra-subject variations in illumination, pose expression, occlusions, accessories, brightness and color which will degrade the working of the automated Face Recognition Systems (FRS).

As yet, there is an issue in enhancing the accuracy and recognition rate in discussed approaches due to the available face recognizing databases. Many of the face modeling techniques requires face images with the normalized illumination and frontal pose to achieve better results in face recognition. The motivation behind the proposed approach is to tackle aforesaid issues in face recognition across different age modeling. The main intention is to enhance the accuracy and recognition rate. To resolve the above issues, the proposed method concentrated on the novel feature extraction and classification techniques and its performance is validated with the aid of the upcoming metrics: i) Accuracy ii) Specificity iii) Sensitivity iv) False Acceptance Rate v) False Rejection Rate vi) Rank-1 score vii) F-score viii) Recognition rate. The objective is to design an effective Face Recognition (FR) system that is robust under erratic conditions with noise level, pose and illumination variations. The objectives of the proposed research are enumerated as follows:

- To enhance the performance of face recognition across different age modeling by reducing discrepancies in the FR databases such as noise, illumination, lighting condition, age variation and pose variations
- To reduce face recognition time while processing the facial image by considering significant regions such as nose, and mouth and to extract effective features from the selected region using the novel feature descriptor algorithm that improves the performance of classification accuracy.
- To increase the accuracy in recognition of the images using feature reduction techniques
- To enhance the recognition rate using a SVM learning algorithm that recognizes the face accurately.

Rest of the paper is organized as follow: Section 2 deals with detailed analysis of various conventional approaches and their drawbacks. Section 3 deals with the implementation details of the proposed method. Finally, section 4 deals with the simulation analysis of the proposed method with subjective and objective analysis. Section 5 concludes the proposed method with possible future enhancements.

2. Literature Survey:

The gradient issue in face recognition is noteworthy and an important part of the biometric domain of research. In [11] authors presented the preprocessing and face recognition approaches Preprocessing is performed before entry into the face recognition processes and it comprises of three steps that are illumination normalization, anisotropic

smoothing and Difference of Gaussian (DoG). In [12] authors presented Patterns of Oriented Edge Magnitude (POEM) descriptors and Monogenic Binary Coding (MBC) descriptors are employed to derive the features from the images after the preprocessing stage and classification is achieved using the distance rule. Noise removal is not performed in preprocessing which results in low classification accuracies. In [13] authors presented the discriminating ability of the periocular region with better recognition rates. The periocular area is the most discriminative region of the human face which is not affected by the gradient process. Features are extracted from the periocular region using the global and local descriptors. In [14] authors introduced a discriminative model based on sampled location feature description technique with SIFT and MLBP descriptors. Feature extraction is performed on the normalized image using the hybrid descriptors. The limitation of the MLBP based feature extraction is that it provides inaccurate results in face recognition.

In [15] authors presented the feature extraction procedures, the face recognition process is beginning where features are analyzed using the matching method. The facial image of each subject is verified with the use of the feature matching procedure. If the features of the test and train image are matched, the given face image is recognized as a correct image. In [16] authors proposed a face recognition across age variations. Multi-Level Local Phase Quantization method is used to derive the features from the given image. The local phase information is extracted with the aid of Short Term Fourier Transform (STFT).The MB-LBQ algorithms is used to derive the features and are proceeded to the SVM classifier to recognize the face image. In [17] authors proposed the Gabor filter based face recognition across gradient. It is used to detect the edges in the facial image and captures the relevant frequency spectrum to extract features. The extracted features are used to recognize the RoI using the Gaussian Kernel function. The extracted features are classified to identify the face images accurately. In [18] authors presented face recognition with age progression with feature extraction and classification. The features are extracted using the center symmetrical Local Discrimative Analysis (LDA). The recognition rate is less due to a lack of feature extraction.

In [19] authors implemented a feature extraction based face recognition model. It utilizes the new sparse FFT based feature extraction. The compressive sampling theory is employed which is in executed two steps. It is executed in the feature extraction process and in the classification process to select the correct classes and it attains the substantial dimensionality reduction of the extracted features using the sparse representation classification method. It has a tedious computation process to classify the given image and it achieves less classification accuracy in face recognition. In [20] authors proposed the feature extraction based face recognition across gradient using the hybrid feature descriptor which is the integration of a Gabor and LBP feature descriptor called as the GLBP. Initially, LBP features are extracted which compares the center pixel with the 8 adjacent pixels. After extracting the LBP features from the image, Gabor features are extracted. The features are utilized to represent the given image via executing the convolution operation with the use of a group of Gabor kernels. By using the descriptors, features are extracted from the given image effectually and it is given to the K-NN

classifier which utilizes the Euclidean distance. Euclidean distance is used to 32 distinguish the different features of the provided images. The Gabor feature descriptor has a complex computation process thus reduces the efficiency of face recognition.

Table 1 Comparison of Existing methods

Method	Description	Main Geometry	Merits/ Demerits
SD	It recognizes the facial image with texture discrimination	The key objective of SD is to detect gray level differences of the facial image	Merit: The SD discriminate texture features effectually. Demerit: It generates less accuracy in classification
LBP	It classifies the facial image with the aid of texture features	The main contribution is to extract texture features using LBP descriptor to detect face image	Merit: It follows a simple computation process. Demerit: High false-positive rate. Less accuracy in feature extraction
Gabor	It recognizes the facial image with local features.	The core objective is to retrieve the image with the use of texture information	Merit: It extracts features with less error Demerit: It generates high dimension feature vectors reduces the performance
MHFA	The modified version of HFA for recognition	A new latent feature model is utilized to decompose the face image into a sequence of component for face recognition	Merit: It decomposes the image accurately. Demerit: Less accuracy in recognition due to lack of feature extraction.
LFD	Extracts local features from the facial image	The main intention is to extract features and recognize the extracted features to identify the face image	Merit: It decomposes the image accurately. Demerit: It generates incorrect results for non- linear features It cannot support a small scale dataset
SNLDA	It uses a sparse model to reduce the feature space	parse model [5] reduces the complex classification process	Merit: Easy to implement the face recognition model Demerit: It is not scalable for face recognition due to frequent updating of the features. Updation of the model is highly difficult.
DLDA	The direct LDA model is	The key intention is to transform	Merit: Learn features easily

	used to reduce the under sampling problem in face recognition	the feature from one domain to another domain.	without using trained data Demerit: Consumes more time to recognize the image
CARC	It recognizes the face image using the cross age model	The foremost intention is to encode the low level feature with age invariant feature space	Merit: Scalable to large size dataset Demerit: The high false-positive rate in face recognition that tends to ineffective results in identifying the person
SRC	It identifies the image with a sparse representation model	The prime aim is to recognize the facial image with sparse representation classification	Merit: Enhances the quality of the image **Demerit:** Feature extraction is not effective due to invalid feature validation

3. Proposed Face Recognition model:

The main problem faced in the existing FR is the high dimensionality of the features due to consideration of the whole face region for recognition. The high dimensionality of the features induces difficulties in classification. Therefore, achieving a high recognition rate and accuracy in FR is a challenging issue. The proposed method discovers problems in the individual existing works related to the FR are discussed as follows: A discriminative model is introduced for face recognition across different age variations. The feature extraction is performed using the Kirsch edge detection based descriptors. The feature reduction is performed through PCA approach. PCA based feature reduction consumes more time that tends to degrade the performance of the system. Furthermore, the discriminative model doesn't concentrate on the effective classification mechanism thus reduces the accuracy in FR. A new descriptor Local Pattern Selection (LPS) is introduced in FR to derive the low level discriminant features from the facial images. The extracted features are further refined using the framework of high level feature refinement. The feature extraction phase only extracts a low level feature that reduces the recognition rate of face recognition across gradient variations. Furthermore, the method is not robust to image scale and rotations. Principal Component Analysis (PCA): PCA is the popular statistical feature reduction method which correlates the set of observed correlated variables to a set of values of linearly uncorrelated variables with the aid of orthogonal transformation. Kernel Principal Component Analysis (KPCA): KPCA is a non-linear extension of the PCA algorithm that uses kernel methods to learn the non-linear manifolds. KPCA introduces the kernel which is used to map the higher dimension and original dimension of the features in the facial image. KPCA doesn't compute the principal components itself instead it projects the input data onto the element directions.

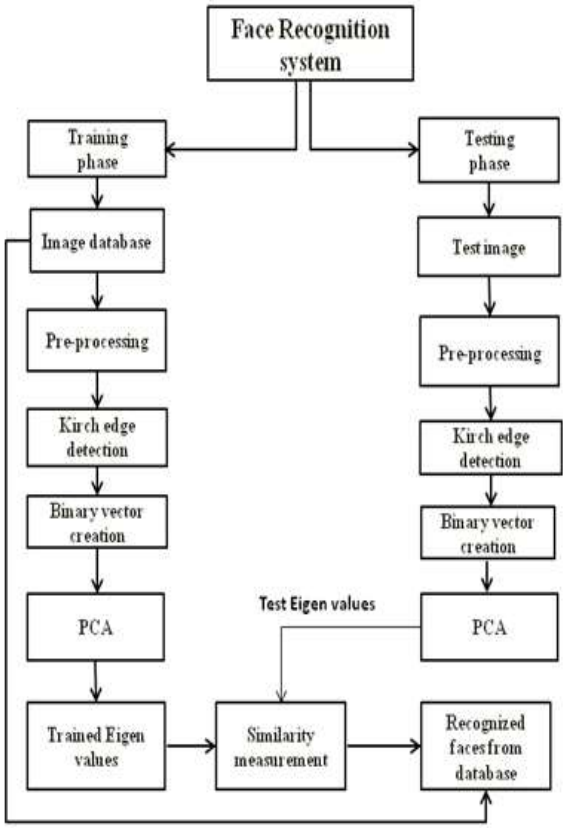

Figure 1: Proposed Block Diagram

The proposed method addresses the limitations present in the existing FR techniques and improves performance as follows:

Feature extraction from the image accurately to achieve better accuracies and Reduce the dimension of the feature space invariant face recognition, Enhance the quality of the facial image to increase classification accuracy, Increase the feature extraction accuracy using descriptors, Minimizes the dimensionality of the feature space to decrease the complex classification process and Increase the recognition rate by proposing an effective classifier. Figure 1 presents the block diagram of proposed method and the detailed analysis of proposed method is as follows:

Step 1: perform the database training operation on real-time databases.

Step 2: Apply the Test Face input image to the system for FR.

Step 3: Preprocessing: Preprocessing is a primary step in the proposed FR to enhance the accuracy in the classification process. The pre-processing stage is an important and vital step for denoising, size and intensity standardization of the image. The Gaussian filter is employed to eliminate noise from the normalized input face and particular region. Convert the image into gray scale image. It executes preprocessing to enrich the quality of the image and recognition rate in facial recognition across age variations.

Step 4: Detect the Face region from the input image using bounding box method. It will draw the Bounding boxes on input face image and it also detects the properties of eyes, mouth regions also.

Step 5: Crop the test face image by using the above detected Boundaries and resize the resultant image to 60X60 size.

Step 6: The whole image is subdivided into covered and uncovered images i.e. training and testing phases via exploiting the local matching method. In the present section, the mixture of the MB-LBP and WLD descriptors are utilized for recognition across different age variations of face.Perform the feature extraction operation using Kirsch Edge detection. This edge detection generates the 8-directional edge responses for each pixel of resized image. The Eight directional vectors are indicated as follows:

$$m_0 = \begin{bmatrix} -3 & -3 & 5 \\ -5 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix}, m_1 = \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & 5 \\ -3 & 5 & 5 \end{bmatrix}, m_2 = \begin{bmatrix} -3 & -3 & -3 \\ -3 & 0 & -3 \\ 5 & 5 & 5 \end{bmatrix}, m_3 = \begin{bmatrix} -3 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & 5 & -3 \end{bmatrix}$$

$$m_4 = \begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix}, m_5 = \begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}, m_6 = \begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}, m_7 = \begin{bmatrix} -3 & 5 & 5 \\ -3 & 0 & 5 \\ -3 & -3 & -3 \end{bmatrix}$$

Step 7: Consider a random 3x3 Kernal values from the cropped image as shown in figure 3.

20	55	220
67	180	35
151	203	77

Figure 3: 3x3 cropped values of image

Step 8: Now Perform the Matrix multiplication between the 3x3 cropped values of image to the kirsch edge responses $m_0, m_1, m_2, m_3, m_4, m_5, m_6$ and $m_7$individually and generates the Kirsch edge based features as $M_0, M_1, M_2, M_3, M_4, M_5, M_6$ and M_7 respectively.

$$M_o = m_0 * I_{3x3}$$

$$M_o = \begin{bmatrix} 20 & 55 & 220 \\ 67 & 180 & 35 \\ 151 & 203 & 77 \end{bmatrix} .* \begin{bmatrix} -3 & -3 & 5 \\ -5 & 0 & 5 \\ -3 & -3 & 5 \end{bmatrix} = 172$$

By performing the same dot matrix multiplication operation remaining matrix values $M_1, M_2, M_3, M_4, M_5, M_6$ and M_7 also.

Step 9: Now calculated the average of $M_0, M_1, M_2, M_3, M_4, M_5, M_6, M_7$ and generates the average value as follows:

$$M_{avg} = \frac{M_0 + M_1 + M_2 + M_3 + M_4 + M_5 + M_6 + M_7}{8}$$

Step 10: Generate the binary map by comparing the average directional vector (M_{avg}) with the $M_0, M_1, M_2, M_3, M_4, M_5, M_6$ and M_7 individually and generate the binary value as follows:

$$B_x = \begin{cases} 1, & M_{avg} < M_x \\ 0, & M_{avg} \geq M_x \end{cases}$$

If $M_{avg} < M_x$, then update B_x with 1 else 0. And the binary feature-map B_x contains the following coefficients.

$$B_x = [B_0, B_1, B_2, B_3, B_4, B_5, B_6, B_7]$$

Step 11: Convert the Binary value into the Decimal format to know the effect of edge responses.

Step 12: Repeat the process for remaining all other 3x3 pixel combinations of cropped image. So, the resultant image contains the size as 58x58, respectively.

Step 13: Now apply the Principal component analysis (PCA) to reduce the number of features.

Dimensionality reduction for extracted features is a significant process in face recognition since high feature space degrades the performance of the classifier. In the proposed method, the magnitude of the feature space is compacted using the PCA which is the modification of the conventional LDA. The extracted features from the descriptors are illustrated as

$\boldsymbol{x} = \{\boldsymbol{x_1}, \boldsymbol{x_2}, \ldots, \boldsymbol{x_c}\}$

Here, $\boldsymbol{x_c} \in \boldsymbol{F}^{s1 \times \ldots \times sN}$ represents the input feature points along with the size $\boldsymbol{s1} \times \ldots \times \boldsymbol{sN}$. The proposed EPCA key intention is to define a multi-linear transform that maps the original scale space $\boldsymbol{F}^{s1 \times \ldots \times sN}$ into a scale space $\boldsymbol{F}^{g1 \times \ldots \times gN}$ ($\boldsymbol{sN} \leq \boldsymbol{gN}$). The multi-linear transform is established as below,

$\boldsymbol{U}^{(N)} \in \boldsymbol{F}^{sN \times gN}$; $\boldsymbol{N} = \boldsymbol{1}, \boldsymbol{2}, \ldots$

Then, $\boldsymbol{y_n} \in \boldsymbol{F}^{g1 \times \ldots \times gN}$ that can be demarcated as below,

$\boldsymbol{yc} = \boldsymbol{x_c} \times \boldsymbol{U}\ (\boldsymbol{1})^{T} \times \boldsymbol{U}\ (\boldsymbol{2})^{T} \ldots \ldots \times \boldsymbol{U}\ (\boldsymbol{N})^{T} \in \boldsymbol{F}^{g1 \times \ldots \times gN}$, $\boldsymbol{c} = \boldsymbol{1}, \boldsymbol{2} \ldots \boldsymbol{C}$

The PCA objective is to normalize the N prediction matrices that achieve the total tensor scatter $\boldsymbol{\varphi}\ (\boldsymbol{y})$:

$\boldsymbol{U}\ (\boldsymbol{N}) = \boldsymbol{arg}^{\max}{}_{(1)\ldots(N)}\ [\boldsymbol{\varphi}\ (\boldsymbol{y})]$

In the above equation, the initial matrices are the $\boldsymbol{g_N}$ Eigen vectors following to the leading $\boldsymbol{g_N}$ Eigen-values of the matrix is given as follows,

$$\boldsymbol{\varphi}^{(n)} = \sum_{c=1}^{C} \boldsymbol{x}_{c(n)} . \boldsymbol{x}_{c(n)}^{T}$$

For each value n, the dimension of the $\boldsymbol{g_N}$ is constant related to the following ratio,

$$\boldsymbol{G}^{(N)} = \frac{\sum_{b_N=1}^{g_N} \gamma_{b_N}^{(N)}}{\sum_{b_N=1}^{s_N} \gamma_{b_N}^{(N)}} \geq \boldsymbol{0.97}$$

In the above equation, $\gamma^{(N)}$ is the b_Nth Eigen-values of the n-mode total scatter matrix. Using these steps, the proposed PCA reduces the dimension of extraction features.

Step 14: Create the database of features for all images by using the above Eigen values.

Step 15: Consider a test image and perform the same process from step 3 to step 14 and extract the Eigen features values.

Step 16: Now compare the Test image features with database of features by using Chi-square classifier. It acts the distance metric, if the pixels are similar distance then the then the recognized images will be generated from the trained database. The chi-square distance between the two feature vectors C_n^f and C_n^t is expressed as,

$$(a_n^2)^f = \sum_{l=1}^{v \times L_1 \times L_2} \frac{C_n^t(l) - C_n^f(l)}{C_n^t(l) + C_n^f(l)}$$

Where, = 1,2, … F, It and I_f are training and testing face image. I_f the feature vector is indicated as C_n^f and I_t feature vector is indicated as C_n^t. The matching results of the feature vector are represented as the,

$$C_n^2 = \sum_{i=1}^{n} \min((C_n^2)^2)$$

Here, C_n^2 is the similarity index of the two feature vectors of the testing and training face image.

4. Simulation Results

The proposed method is implemented in the MATLAB simulation tool. The FERT dataset is used for recognizing face image across different age variations. It comprises of facial images of 82 subjects as 1002 which includes high resolution or grayscale images in it. The average age variation between the images of a similar person is high compared to other facial gradient datasets. The age of the subjects is between newborn and 69 years. For each subject in the database, the work considers ten images for evaluation.

Test images	Recognized output images

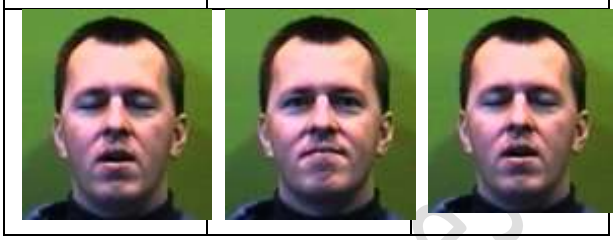

Figure 2: Test and Equivalent images

Figure 2 shows the testing and its equivalent images, the resultant images are accurately extracted by the proposed system for various illuminations and poses of input face image.

Comparative Analysis and Discussion

The proposed approach performance is evaluated using the five performance metrics that are accuracy, specificity, sensitivity, false acceptance rate and false rejection rate. The existing methods considered for results comparison are Multiple LDA and LPS. The performance metrics are described briefly as follows:

Accuracy: Accuracy is one of the essential metrics to assess the performance of the proposed approach. It defines the quantity of correctly classified images to the total images. It is mathematically expressed as follows:

$$Accuracy = d\frac{TPR + TNR}{TPR + TNR + FAR + FRR}$$

Where, TPR indicates the True Positive Rate (TPR), False Acceptance Rate (FAR), True Negative Rate (TNR) and False Rejection Rate (FRR).

Accuracy is a metric to validate the performance of the proposed work since it demarcates the efficacy of the proposed work in terms of recognizing a face across facial images with different age patterns

Sensitivity The sensitivity metric is used to measure the appropriately recognized known images to the total number of images and it is referred as the True

Positive Rate (TPR). This metric must be high to achieve healthier efficiency in face recognition. Sensitivity is measured through the below equation,

$$Sensitivity = \frac{Number\ of\ True\ positive}{Number\ of\ True\ positive + Number\ of\ False\ negative}$$

Specificity The specificity metric defines the correctly recognized unknown images to the total number of images and it must be high compared to the existing methods in order to achieve better results in recognizing face images. The mathematical form of the specificity is described as follows:

$$Specificity = \frac{Number\ of\ True\ negative}{Number\ of\ True\ Negative + Number\ of\ False\ positive}$$

False Rejection Rate (FRR) It is used to estimate the number of incorrectly identified known images to the total number of images. The functioning of the proposed FR is predicted with the number of incorrectly identified images with the aid of a false rejection rate. This metric must be low to achieve a better recognition rate in face recognition across the different gradient images.

False Acceptance Rate (FAR) It is used to estimate the number of correctly recognized unknown images with respect to the total number of images. These metrics provide the efficiency of the proposed FR in terms of accepting the unknown image.

The present section compares the capabilities of the proposed method with the existing ones. The comparison is attained using the estimated performance metrics for both proposed and existing methods including Multiple LDA and LPS.

Accuracy: The accuracy of the proposed system is high compared to the existing methods LPS and multiple LDA. It is due to the fact that the proposed method reduces the feature space by extracting features only from the periocular region of the facial image. It is by reducing the feature space during feature extraction is a significant process to increase the performance of the classifier. Since a high dimensionality of the features induces difficulties in a classifier that tends to reduce the accuracy results. In contrast, multiple LDA method achieves less accuracy in FR since it extracts features from all parts of the facial image which enlarges the size of the feature space thus, in turn, increases the difficulties in the classifier. As a result, multiple LDA method achieves less accuracy compared to the other methods.

Table 2: Performance comparison

Metric	LDA[18]	LBP [14]	Proposed
Accuracy (%)	79.51	89.87	99.97
Sensitivity (%)	79.9	94.1	98.3
Specificity (%)	91.75	93.93	99.98

Meanwhile, the LPS method achieves high accuracy compared to the multiple LDA methods since it reduces the extracted feature dimension using the feature refinement methods. It achieves less accuracy compared to the method since it extracts low level features for face recognition that leads to reduce in accuracy results. The results acquired from the simulation are listed in table 1. From the comparison results, it is concluded that the proposed method has better results compared to the existing methods of multiple LDA and LBP.

Sensitivity: The sensitivity metric comparison of both proposed and existing methods including multiple LDA and LBP. It is perceived that the proposed method achieves high sensitivity in FR set

against the existing methods as it proposed two feature descriptors such as SIFT and SURF for FR. The feature descriptor used in the work is robust to both scale and rotation that tends to increase the sensitivity of the face recognition. It extracts the features effectually from the periocular region to recognize the given face image accurately. The features extracted from the facial image are highly significant to increase the sensitivity of the image since it increases the possibility to recognize the given face image correctly. As a result, the method achieves high sensitivity compared to the existing multiple LDA and LPS approaches.

In the meantime, the existing method multiple LDA achieves less sensitivity compared to the proposed method. It is due to the poor feature extraction procedure used in multiple LDA method since it utilizes the Local Binary Pattern (LBP) descriptor for feature extraction which generates a long pattern of the histogram that slows down the recognition speed of the classifier. Thus results in low sensitivity compared to the other method. Likewise, the LPS method also achieves less sensitivity compared to the proposed method since it doesn't extract all features from the facial image. The features are the substantial parameter to increase the classification performance. The lack of feature extraction processes reduce the sensitivity result and from the comparison results the proposed method accomplishes high sensitivity value i.e. the correctly classified images is high. Table 1 illustrates the sensitivity results comparison of proposed and existing methods of multiple LDA and LPS. From the comparison results, it is concluded that the proposed method has better results compared to the existing methods of multiple LDA and LBP.

Specificity: The specificity metric is used to measure the number of correctly recognized unmatched images for a given test image. This metric must be high as much as possible in order to achieve better performance in age invariance based face recognition. The specificity comparison of proposed and existing methods such as multiple LDA and LBP. The performance of the proposed work concerning the specificity is high compared to the existing method. This is achieved by proposing an EPCA based feature reduction. Since the feature reduction process reduces the unwanted features from the feature vector that easies the process of classification. In addition, the proposed method also utilizes a modified version of the PCA algorithm that reduces the feature space effectually compared to the other feature reduction methods. The way of classifying the images results in high specificity i.e. number of correctly identified unknown images is high. In contrast, the existing method multiple LDA attains less specificity compared to the proposed method. It is because of LDA based feature reduction technique since the assumption made by this technique is not applicable for real-time problems which lead to reduce the specificity of the face recognition across different age models.

Similarly, LPS also achieves less specificity compared to the proposed method due to a lack of feature reduction performance. Hence, it cannot reduce the unwanted features accurately from the feature space which resulted in the degraded functioning of the classifier that tends to reduce the specificity value. Table 1 illustrates the comparison of results specificity with respect to the proposed and that the proposed method has better results compared to the existing methods of multiple LDA and LPS.

5. Conclusion: This work summarizes the proposed face recognition approach across gradient variations.

The key contribution of the proposed work is to reduce the feature space in FR and it extracts features only from the periocular region of the facial image using the Kirsch Edge descriptors. These descriptors are robust to the rotation and scale variations of the facial image to increase the accuracy in face recognition. It utilizes PCA that reduces the feature space effectually to easier the process of classification. The classification of the features is carried out using the Chi-Square algorithm which performs faster and better in recognizing a face across different age variations. The performance validation is accomplished with the aid of five sequential parameters that are accuracy, sensitivity, specificity, FAR and FRR. The proposed FR outperforms the existing methods of multiple LDA and LPS in its performance. Performance metrics of the proposed work are evaluated and compared with the existing works LDA and LPS. Accuracy (99.97%), sensitivity (98.3%) and specificity (99.98%) of the proposed work have been improved compared to the previous works.

References:

[1]. Parmar, Divyarajsinh N., and Brijesh B. Mehta. "Face recognition methods & applications." *arXiv preprint arXiv:1403.0485* (2014).

[2]. Zhao, XueMei, and ChengBing Wei. "A real-time face recognition system based on the improved LBPH algorithm." *2017 IEEE 2nd International Conference on Signal and Image Processing (ICSIP)*. IEEE, 2017.

[3]. Al-Dabagh, Mustafa Zuhaer Nayef, MH Mohammed Alhabib, and F. H. Al-Mukhtar. "Face recognition system based on kernel discriminant analysis, k-nearest neighbor and support vector machine. " *International Journal of Research and Engineering* 5.3 (2018): 335-338.

[4]. Qu, Xiujie, et al. "A fast face recognition system based on deep learning." *2018 11th International Symposium on Computational Intelligence and Design (ISCID)*. Vol. 1. IEEE, 2018.

[5]. Kumar, PriyanMalarvizhi, et al. "Intelligent face recognition and navigation system using neural learning for smart security in Internet of Things." *Cluster Computing* 22.4 (2019): 7733-7744.

[6]. Bah, SerignModou, and Fang Ming. "An improved face recognition algorithm and its application in attendance management system." *Array* 5 (2020): 100014.

[7]. Wandzik, Lukasz, Gerald Kaeding, and Raul Vicente Garcia. "Morphing detection using a general-purpose face recognition system." *2018 26th European Signal Processing Conference (EUSIPCO)*. IEEE, 2018.

[8]. Xu, Weitao, et al. "Sensor-assisted multi-view face recognition system on smart glass." *IEEE Transactions on Mobile Computing* 17.1 (2017): 197-210.

[9]. Rekha, E., and P. Ramaprasad. "An efficient automated attendance management system based on Eigen Face recognition." *2017 7th International Conference on Cloud Computing, Data Science & Engineering-Confluence*. IEEE, 2017.

[10]. Wati, Dwi Ana Ratna, and Dika Abadianto. "Design of face detection and recognition system for smart home security application." *2017 2nd International conferences on Information Technology, Information Systems and Electrical Engineering (ICITISEE)*. IEEE, 2017.

[11]. Bong, Kyeongryeol, et al. "Low-power

convolutional neural network processor for a face-recognition system." *IEEE Micro* 37.6 (2017): 30-38.

[12]. Medapati, Prema Kumar, P. H. S. Tejo Murthy, and K. P. Sridhar. "LAMSTAR: For IoT based face recognition system to manage the safety factor in smart cities." *Transactions on Emerging Telecommunications Technologies* 31.12 (2020): e3843.

[13]. Boyko, Nataliya, Oleg Basystiuk, and Nataliya Shakhovska. "Performance evaluation and comparison of software for face recognition, based on dlib and opencv library." *2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP)*. IEEE, 2018.

[14]. Ouyang, Aijia, et al. "A hybrid improved kernel LDA and PNN algorithm for efficient face recognition." *Neurocomputing* 393 (2020): 214-222.

[15]. Mocanu, Bogdan, RuxandraTapu, and Titus Zaharia. "Deep-see face: A mobile face recognition system dedicated to visually impaired people." *IEEE Access* 6 (2018): 51975-51985.

[16]. Meena, Mahendra Singh, et al. "A robust face recognition system for one sample problem." *Pacific-Rim Symposium on Image and Video Technology*. Springer, Cham, 2019.

[17]. Zeng, J., Li, C., & Zhang, L. J. (2018, June). A face recognition system based on cloud computing and AI edge for IOT. In *International Conference on Edge Computing* (pp. 91-98). Springer, Cham.

[18]. Raghavendra, R., Raja, K. B., Venkatesh, S., Cheikh, F. A., & Busch, C. (2017, February). On the vulnerability of extended multispectral face recognition systems towards presentation attacks. In *2017 IEEE International Conference on Identity, Security and Behavior Analysis (ISBA)* (pp. 1-8). IEEE.

[19]. Kutlugün, Mehmet Ali, Yahya Sirin, and MehmetAliKarakaya. "The effects of augmented training dataset on performance of convolutional neural networks in face recognition system." *2019 Federated Conference on Computer Science and Information Systems (FedCSIS)*. IEEE, 2019.

[20]. Qiao, Shijie, and Jie Ma. "A Face Recognition System Based on Convolution Neural Network." *2018 Chinese Automation Congress (CAC)*. IEEE, 2018.