A Summary of literature review on Face Recognition

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The methods of face recognition are having goal to detect faces in still image and sequence image from video have many method such as local, global, and hybrid approach. The main challenges of face recognition are intensity, illumination, pose, hard to controlling and large occlusion. In this literature the different aspects and techniques used for face recognition has been reviewed. There are four major categories as follows,

1) Knowledge based Method
2) Feature invariant Method
    - Local Binary Pattern
3) Template Matching Method
4) Appearance based Method

    In this method there are three sub methods
    - Eigenface based Method – PCA Algorithm
    - Distribution based Method – LDA Algorithm
    - Independent Component Analysis – ICA Algorithm

1. Knowledge based Methods

The pre decides rules are the base for this method and that encodes the knowledge about the human faces. The face will be translated into the set of rules to extract the knowledge of faces. The problem associated with this method is if the rules are very general it might give false results and match many false positives. The hierarchical knowledge based method solves this problem, but another hurdle is that it only works with simple input like image of human without accessories. The other possibility of feature extraction comes if the man is wearing goggles and changes his look. Its source is researchers' knowledge. For instance, the human features like two eyes, two ears, nose, mouth are fetched and separated and to be matched according to the relative position and distance. These coded rules can help to recognize the human face image. But there is still difficulty with this method is to convert the human knowledge into set of pre-defined rules. The Typical knowledge based method top to down is as below.

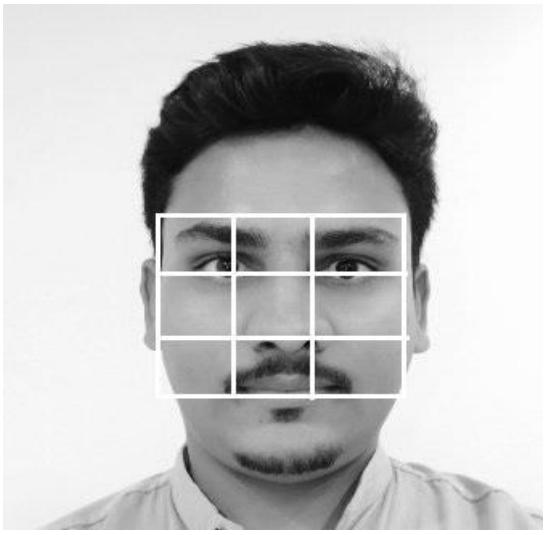


Fig. 1 Typical Knowledge based method top to down

Characteristics

- Implementation is Easy

Disadvantages

- Rules can be easily guess
- Difficult to construct set of rules
- Due to generalized rules, there were false positives
- Due to detailed explained rules, there was false negatives

2. Feature Invariant Methods

To cover more angles and positions of the face, these methods also find the features with it. It also extracts unique features like Eye, Nose, Chin, Cheekbones, Ears, and Forehead etc (25). It is a bottom up approach opposite to knowledge. With different pose and lighting conditions one can easily recognize the face and object with minimum efforts. This method is based on Statistical methods to describe the correlation between the input image and stored one. Due to noise and illumination the image can be corrupted which is the main hurdle of this method. Different edge methods are used in this method.

Characteristics

- It finds the other features of a face with different angles or positions

Disadvantage

- Facial Expression

2.1 Local Binary Patterns

It covert the image into grayscale and LBP operator describes the local texture of that image. From the image pixel the LBP generates the binary code which describes the neighborhood of that local pixel. In this Local Binary Pattern it works with total eight neighbors of a pixel. The center pixel is maximum than the center pixel value then assign 1 at the pixel place else 0. It will create binary code as below and converted in decimal value (32).

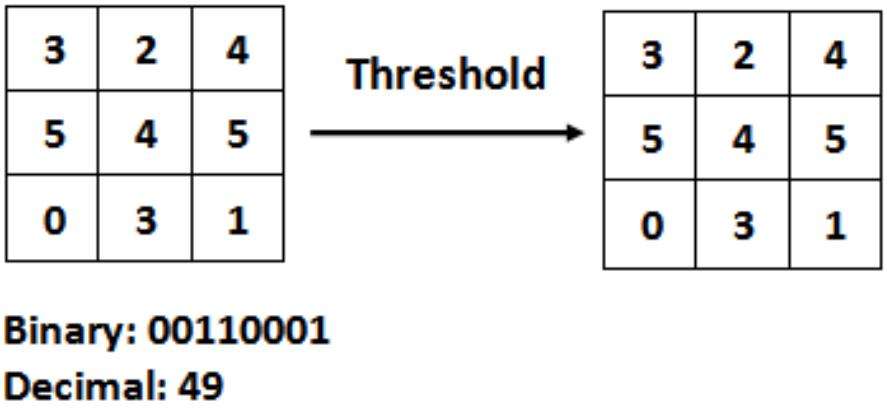


Fig. 3.2 The example of LBP Operator

Drawback

Here the problem is with LBP operator has 3*3 neighborhoods cannot extract main features in complex and large-scale structured image. And also deal with different scale and size image is not possible. So later on the LBP was generalized to utilize different neighborhoods of individual sizes so results into more problems with large scale images (5).

3. Template Matching Methods

These are dissimilar methods. It compares input image with stored rules of the images like the patterns and the features of the image face. Here also the division of the different parts of the face can be separated and defined like the face can be divided into segments like eyes, mouth, nose, ear, etc. It can be made by edges also. So, when we represent part as fixed shape, it will be different from the different angle in this method (25). The face pattern will be predefined manually in this method and the separated images of the parts works independently. And the correlation values between the face pattern and the parts like eyes, mouth and nose etc.

Characteristics

- Very easy to implement

Drawback

- A Face can be represented as frontal shape.
- The face area uses the templates for the brightness and darkness, But this is not working for the face detection.
- It fails with different poses, scales and shapes.

4. Appearance-based methods

These are methods based on statistics and machine learning. It finds the very valuable features of image of face (25). This method is based on earlier examples and methods. The statistical analysis and machine learning helps this method to find the relevant and accurate outcomes that results into a features to find from the face. Following are the some methods.

4.1 Eigenface Based Methods – PCA Algorithm

In 1901 Karl Pearson discovered the PCA. For the Face identification this method is well-organized. Today even it is the well-admired method. This method is used to reduce the dimensions of the face image. The main function of this method is that it helps to reduce the large dataset into small which is its best dimensionality reduction data tool of the PCA. It works on 2D and 3D both images. In this method there are

training set of images, which are stored and the unknown face is represented as eigenface and compared with each training set of image. Then the distance is calculated. And if the distance between above and specified threshold is matched then identify the unknown face as that person. This method considers each pixel of that image as a unique dimension. We have to generate the dataset or a training set of the face images for the face reorganization. Firstly all the input images are compulsorily of same dimension or size. It does not work directly on the image. It converts the image into the vector form or matrix form as first step. It illustrates variations of the image data. The face image data will be stored into feature space. And those features are in eigenvectors or in principal component format of face which is called the Eigenfaces.

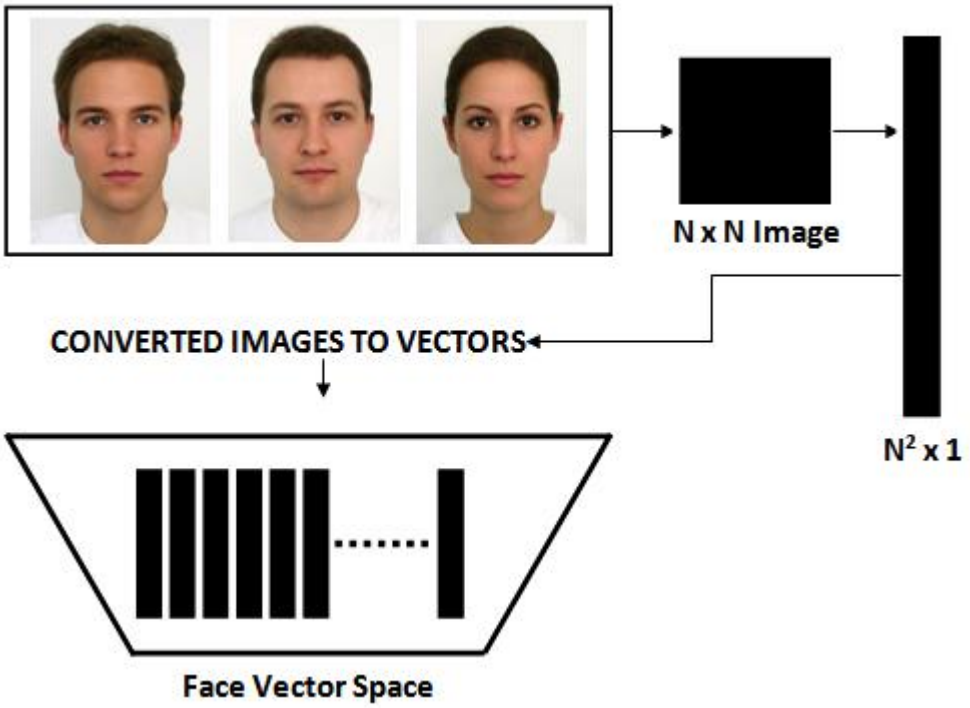


Fig. Images Converted to Face Vectors

The Steps of PCA Algorithm

1. Find out the difference between mean and each value of the column matrix.
2. Calculate the Covariance Matrix.
   Variance is measure of the variability or spread in a set of data. It is also the average squared deviation from the score of mean. And Covariance is a measure of the extent to which corresponding elements from two sets of ordered data move in the same direction.

( ) ____ ∑ ( ) ( )…….(3.1)

Where
n is the number of score in each set of data.
is the mean of the n scores in the first dataset.
is the th deviation score in the first set of score.
is the mean of the n scores in the second dataset.
is the th deviation score in the second set of score.

$$Cov(x,y) = \begin{bmatrix} Cov(x,x) & Cov(x,y) \\ Cov(y,x) & Cov(y,y) \end{bmatrix} \quad \text{.....(3.2)}$$

Table: Example of Covariance Matrix

X	Y	X-X^	Y-Y^	(X-X^)* (X-X^)	(X-X^)*(Y-Y^)	(Y-Y^)*(X-X^)	(Y-Y^)*(Y-Y^)
4	2	-0.1	-0.08	0.01	0.008	0.008	0.0064
4.2	2.1	0.1	0.02	0.01	0.002	0.002	0.0004
3.9	2	-0.2	-0.08	0.04	0.016	0.016	0.0064
4.3	2.1	0.2	0.02	0.04	0.004	0.004	0.0004
4.1	2.2	0	0.12	0	0.	0	0.0144
X^	Y^			SUM (X-X^) (X-X^) / n-1	SUM (X-X^) (Y-Y^) / n-1	SUM (X-X^) (X-X^) / n-1	SUM (Y-Y^) (Y-Y^) / n-1
4.1	2.08			0.025	0.0045	0.0075	0.007

$$Cov(x,y) = \begin{bmatrix} 0.025 & 0.0075 \\ 0.0075 & 0.007 \end{bmatrix} \quad \text{.....(3.3)}$$

3. Evaluate Eigen Values and Eiginvestors from Step 2.
   A is an N x N matrix. The λ is an eigen value os A is there is a non-zero vector V such that,
   AV= λV.....(3.4)
   Here, V is Vector called as as Eigen Vector of A corresponding to λ. So, Condition will be,
   AV= λV

   (A - λ) V = 0.....(3.5)

   The determinant is A - λ will be = 0.
   f (λ) = det (A - λ) .....(3.6)

4. Select the Feature Vector now.
5. Then after selecting the Features the vector will be multiplied with the transposed feature vectors by the transposed adjusted data.

Characteristics

- Relatively Simple
- Fast
- Robust
- Working efficiently with high Dimensions

Drawbacks

- **Illumination Problem**

It means that when same image with same condition appears the clarification or illumination problem will occur. In this method it restricts the person to keep fixed distance, exact expression of face, same point of view and the same lighting condition. It can appear far different in diverse lighting conditions (8).

- **Pose Problem**

Different facial poses results problem in Face recognition. The recognition rate will be reduces if the face pose rotated by big changes in face appearance. The dissimilar results will be shown if the person tries to compare the exact face image with the different facial poses (8).

4.2 Distribution Based Methods - LDA Algorithm

In 1936 Sir Ronald Aylmer Fisher developed the LDA (Linear Discriminant Analysis) method which classifies the distribution based methods. LDA is called the Fisher's Discriminant Analysis. This method has the dimensionality reduction in earlier processing steps. In pattern classification and for machine learning this method is used. This method is more emphasizing on maximizing the separatilibity among known categories. So LDA is the supervised method and PCA is an unsupervised method. For classification LDA increased in-between-class scatter matrix and decreased within-class scatter matrix which shows its more reliability (25). Sung and Poggio developed this method for the face detection. It deals with how to bifurcate the image pattern from one object class. In this method there were two parts, distribution based model and multilayer classifier. In first stage image is normalized and processed to size of 19 x 19 pixels. Then image is considered as a 361 dimensional vector and then patterns are grouped into individual clusters (82, 84).

Characteristics

- It is faster than Eigenface (In some experiments)
- Error rate is very low.
- The method is proved well in different facial expression and illumination conditions.

Disadvantages

- It can uphold only small databases.
- Input face must be stored in Database.
- It is not working proper with high dimension

4.3 Distribution Based Methods – ICA Algorithm

Independent Component Analysis is based on statistical method. It scrutinizing and breaking large and complex database into individual sub-parts. It is data analysis tool which is extracted from source separation signal processing technique. It recovers original signals from known observation which is an unknown or totally different or mixture of original signals. It is mostly used in subspace projection technique that utilizes the data images from high dimensional vector space to low dimensional space. It is also known as the generalization of PCA Algorithm.

3.5 Related Work Done

Recognizing face is demanding, emerging but more interesting dilemma. The Bledsoe's (41) and Kanade's (42) research based on automatically or semi- automatic face recognition strategies and also introduced more helpful thing classification of faces based on their feature point's ratios and distances. That legacy continued and bring in by Yullie et al (43). In last ten years, lots of dissimilar applications and methods have been discovered and implemented in several fields. And PCA emerged as very effective and popular from all these methods in face recognition. But the major disadvantage is PCA cannot work effectively at 90 degree (2). The PCA is the backbone algorithm for the face recognition. Then in 1984 Jeanny Herault and Bernard introduced the Independent Components Analysis (ICA) and it followed and researched by many researchers. This ICA is used to find the primary essentials or components from the multidimensional numerical data and source signals which are independent from each other. (44). The same earlier researcher (45, 18) approached with new combined algorithm to amplify the performance. 18) PCA is used as a baseline algorithm and for face recognition ICA is essential. Once PCA is successful at the initial stage then researcher starts to research on LDA (Linear Discriminant Analysis) to solve the N-class classification problem where PCA is used as an unsupervised method and LDA is used as a supervised method. Input and output is known by the user as supervised method. Only input is known by unsupervised method while output is unpredictable. According to the Hardik Kadiya (1), face recognition is done on ATT and IFD database using different techniques, to compare PCA and ICA there is LDA has a higher accuracy rate. According to B.S.Patil, A.R.Yardi, Dr.Patil.S.B (3), if eigen values are increased, recognition rate will also increase.

In Forensic face recognition have some challenges like facial aging, facial marks, forensic sketch recognition, face recognition in a video and many more.(12) In mobile devices to secure the data using different algorithms nowadays Face verification application is also used. (10). With a frontal view PCA gives a better result. (11). In the current advanced world of technology only password is not enough for database security therefore database template security is also an important issue. To secure the data key is generated from biometric template. There are many different techniques are used for generating the key from the biometric template (21). On ORL database Face recognition was implemented using PCA on 4 different distance classifiers. The outcome of the result denotes that, with Euclidian distance classifier PCA gave better results and the squared Euclidian distance classifier than the City Block distance classifier. The recognition rate using the Euclidian and the Squared Euclidian distance classifier is the same and is higher than the City Block distance classifier (34). PCA algorithm able to give the best result with the help of Euclidian distance classifier and the squared Euclidian distance classifier.(35) "Image Encryption" is used for the image encryption and decryption, existing algorithm. It does Image Encryption of any Grayscale image and generates the key. It encrypts image using Bitwise XOR operation and returns 0 if both input matrix and key matrix are same (40).

According to Md. Abdur Rahim, LBP is divided into three parts like Face representation, feature extraction, and classification. The image is compared with database image in the classification (56). According to Ammad Ali, LBP describes the texture and shape of digital data and calculating the distance between images on Yale database using histogram (57).

There are several methods introduce or developed to detect the face from a single image and there are so many issues like data collection, evolution metrics and benchmarking and many more.

Table 3.2 Review of different methods

Approach	Review
Knowledge based method	Multi-resolution set of rule based method. It is top to down method (62).
Feature invariant method	Facial features - Group of edges (63, 64) Texture – Space gray level dependence metrix (SGLD) of face pattern (65) Skin Colour – Mixture of Ganssian(66, 67) Multiple Features – Integration of skin colour, size and shape(68)
Template matching	Predefines face templates – shape template (69) Deformable template – Active shape model (70)
Appearance based	Eigenface – Eigen vectors decomposition and

method	clustering (71) Distributionbased–multilayesGaussian distribution (72) Neural network – Ensemble of neural networks schemes (73) Support vector machine – SVM with polynomial kernel (74)

Kwok-Wai Wong, Kin-man Lam and Wan-Che Siu (98), proposed effective algorithms for human face detection and features extractions using different conditions. The face is detected by using genetic algorithm and then eigenface algorithm applied for the first location of the face. The genetic algorithm is applied to find out the possible region of the face while eigenface is applied for the strength of the region. A genetic algorithm is limited to the eye region so detecting time of the face is reduced. It also improves the level of detection reliability.

Faizan Ahmad, Aaima Najam and Zeeshan Ahmed (99), proposed image-based face detection and recognition. Face detection is done using the LBP technique, but in a different way. That increase, the result compares to PCA and LDA.

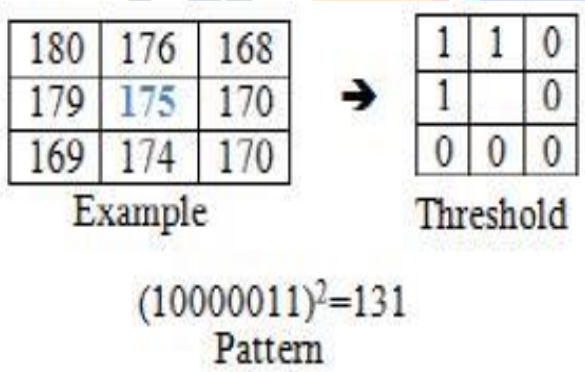


Fig 3.4. LBP Image calculation in a different way(97)

3.6 The IBM Face Recognition System

IBM researchers developed various varieties of projects in various application domains in current and next coming years. The system is fully described even therefore it is easy to understand the basic function of the programme which consists four modules, Face detection, feature extraction, representation and matching modules. For detects the face regardless of scale and locations face detection is useful. And also use for the filtering hierarchy procedure to find the location. Different face classifiers are used to detect the face from image or video. Fisher's linear discriminant and Gaussians methods are mostly used.

The accurate result is possible with Gaussians method though it is a slower method but able to give the accurate result. For detecting faces from a colour image Skin-tone detector is used. There are twenty nine standard features are used by the facial different parts in the next stage of feature extraction. The system extracts the appropriate principal features of the face based on the face detect. The system works in

hierarchical order. It first extracts the large features and then divides the face into subspace like eyes, mouth, chine, eyebrow, etc. They use PCA and LDA methods for feature extractions. For face recognition, Gabor wavelet is also used. The range of 40 Gabor wavelets is used with different scale and orientations. There are 29 vectors compared with input image with database images. That defines the similarity score and on the bases of that score person is identified (44, 45, 46, 47, 50).

3.7 Review of Image Cryptography

According to M. Sukumar Reddy and S. Murali Mohan (86), it is a visual cryptography. Each pixel of the image is in the smaller block, but they are always the same number of the black and white block. Each pixel is divided into two blocks and one is black and the other one is white block in the first step. Both are must divided into same equal parts. In second stage pixel is divided into identical or invert state. Means half is black and half is white like shown in the Fig 3.4.

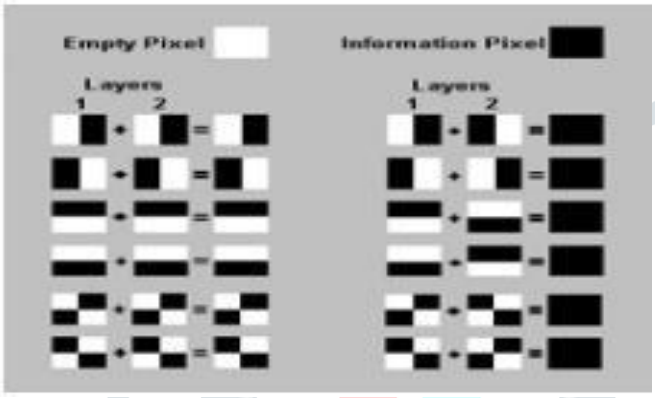


Fig 3.5. Pixel value is divided into four parts (86)

Pankesh Barot (88), Image is encrypted using pixel shuffling. Images are converted into the grayscale and the numbers of column are jumbled randomly. This random number is preserved and use as a secret key between two communication parties sender and receiver. Sagar Kumar (87), securing the image using color visual cryptography and wavelets. In this research paper, image is divided into small parts and then sends to the receiver. Receiver side merges the parts to get the original image. Color visual cryptography is done by using the wavelet technique. Mohammad Ali Bani Younes and Aman (89), image is encrypted using block-based transmission and well-known algorithm of cryptography Blowfish. The original image is divided into the blocks and then rearranged. After the rearranged image is encrypted using the Blowfish algorithm.

Seyed Mohammad Seysdzade, Reza Ebrahimi Atani and Sattar (90), proposed a new approach for encryption based on the SHA- 512 hash function. It consists intwo parts: pre-processing operation for shuffling of the first half of the image. Second half of the image part uses the hash functions, then XOR operations for encryption decryptions. Sesha Pallavi Indrakanti and P.S.Avadhani (95), proposed the novel approach for random pixel permutation with maintaining the quality of the image. There are three phases in the process.

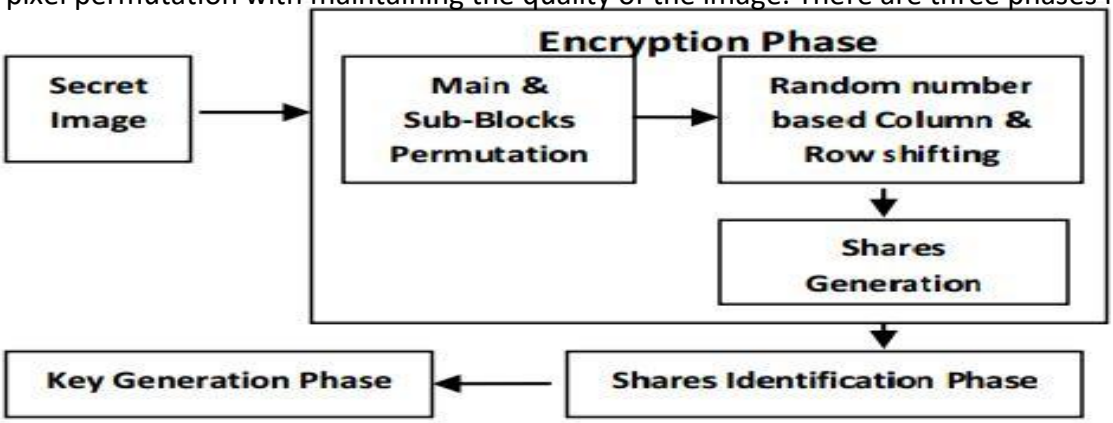
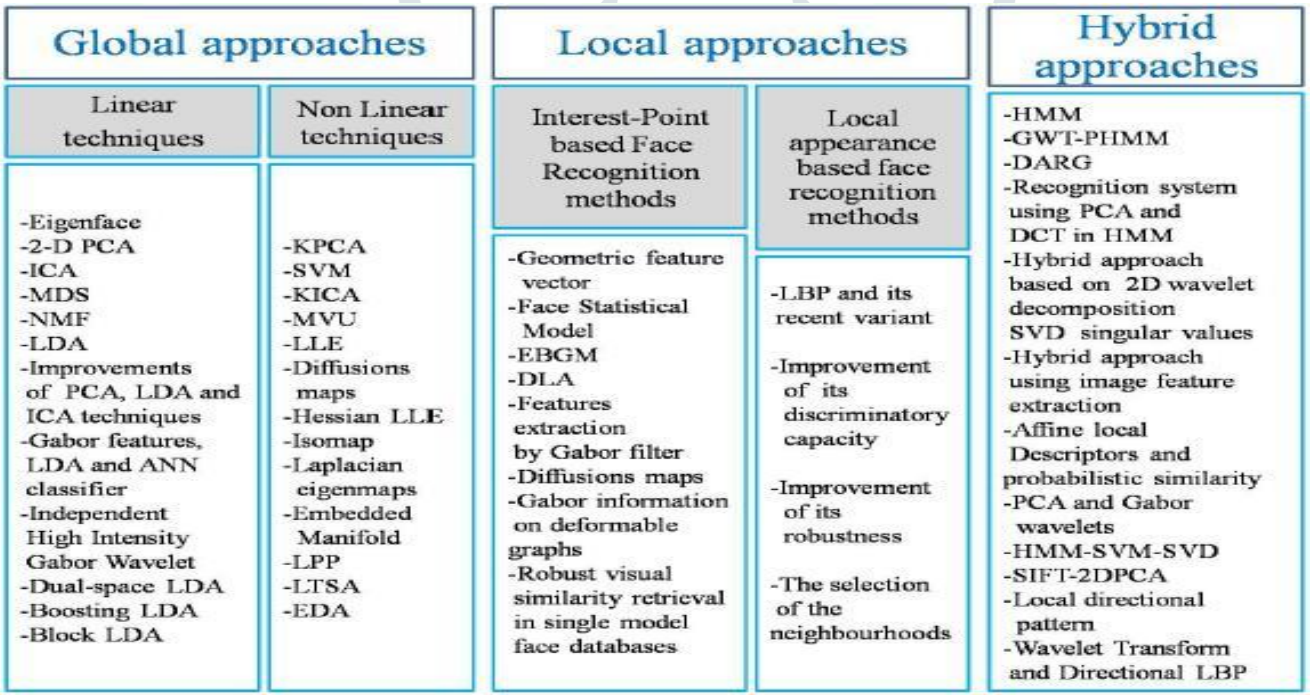


Fig 3.6. Proposed Scheme of Permutation based Image Encryption Technique (95)

3.8 Current Trends in Face Recognition

The human face has dynamic face object with a different appearance that makes difficulties to identify a person. Accuracy and speed are main issues in this field. In this paper it evolutes different methods of face recognition and detection and provide a complete solution with high accuracy rate (100). At present, there are various applications available in different areas like Airport, University, Offices, ATM, and bank and in any location with a security system. There are three parts in this paper. First part describes a common method for feature extraction. The second part describes feature applications with examples and the third part with future research direction (101). Face Recognition includes two-dimensional 2D and three-dimensional 3D systems and also explain three-dimensional systems with different phases like Detection, Alignment, Measurement, Representation, Matching, and verification or Identification. (102).

According to the literature review of 2016, face recognition applications' demands increase in different areas like criminal Justice, Image database investigation, surveillance, smart card application, video indexing, civilian applications, human-computer interaction, Multimedia environment and much more. Appearance-base method and model-based methods are most popular (109).In this research paper whole face is not considered as an input data but only some features or area of the face and methods that use global and local face features simultaneously. Different classifications of face recognition are as below (110).



3.7 Current Trends in Face Recognition (110)

Table 3.3 Summery of Literature Review

Method Name	Overview	Characteristics	Drawback
Knowledge-based methods (25)	• Capture our knowledge of faces, and translate them into a set of rules • Ruled-based methods	• Easy to implement	• The features of the image can be corrupted due to noise, illumination. It uses different edge methods. •easy to guess some simple rules •difficulty in building an appropriate set of rules •false positives if the rules were too general •false negatives if the rules were too detailed • hierarchical knowledge-based methods used for this but it detect face based on textures or the color of human skin
Feature-invariant methods (25,32)	• Distinctive features of the face like Mouth, Nose, Eye, Cheekbones, Chin, Lips, Forehead, Ears	• find invariant features of a face anyway of it's angle or position	• Facial expression
Template matching methods (25)	• Compare input images with stored patterns of faces or features • Different features can be defined independently for example; a face can be divided into eyes, face contour, nose and mouth. Also a face model can be built by edges	• simple to implement	• Limited to faces that are frontal. • Pattern of the face is manually predefined. • A face can also be represented as a shape. • Other templates use the relation between face regions in terms of brightness and darkness. • This approach is simple to implement, but it's insufficient for face detection. • It cannot achieve good results with variations in pose, scale and shape

Appearance-based methods Eigenface-(3,8,20,25) Distribution (25,82,84)	**Eigenface-** • Based on Principal Component Analysis (PCA reduces the dimension of the data) • PCA is best dimensionality reduction data tool which help to reduce large dataset to smaller one	• Relatively simple • Fast • Robust • Work well with high dimension	• Different head pose • Different alignment • Different facial expression • All face images must be in exact same size or same dimensions
	Distribution • Based on Fisher's Linear Discriminant Analysis (LDA maximizes the between-class scatter LDA minimizes the within-class scatter) • Fisherface Uses 'within-class' information to maximise class separation	• Faster than eigenfaces, in some cases • Has lower error rates • Works well even if different illumination • Works well even if different facial express	• Small databases • The face to classify must be in the DB • Can't work well with high dimension

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