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## A review of face recognition methods using deep learning network

Arun Kumar Dubey & Vanita Jain

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## **A review of face recognition methods using deep learning network**

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### **Abstract**

Face recognition could be a technology capable of distinguishing or confirming an individual from a digital image or a video frame from a video supply. Face recognition technology is employed in wide selection of applications like authentication, access management, and police investigation. It is finding applications in all industries ranging from retail, advertising to banking etc. It is to this extent that Large retailers are using facial recognition to recognize customers and present offers, they also use it to catch shoplifters. Deep learning Network is influencing every aspect of computer vision technology and research. In this paper, we are depicting the role and achievements of different deep models for face recognition in images and videos, we have also compared recent algorithms for face recognition.

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**Keywords:** *Deep Neural Network, 2D Face, 3D-Face, Data sets, Face Recognition*

### **1. Introduction**

Face recognition has been active research area over 50 years and Deep model is enhancing and supporting this area to achieve better result. Deep learning is a machine learning method that has made

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extraordinary progress in fields like picture acknowledgment, discourse acknowledgment, gender recognition [1] and so on. There are four kinds of deep learning models which are mostly used in face recognition.

- Stacked Auto encoder [2]: This model is generally built by stacking a few auto encoders. It consists of two phases encoding and decoding stage. An auto encoder figures out how to pack information from the info layer into a short code, and after that uncompressed that code into something that intently coordinates the first information.
- Deep Belief network (DBN) [3] : DBN is a generative graphical model, or on the other hand a class of profound neural system, made out of numerous layers of inert factors, with associations between the layers and not between units inside each layer. At the point when prepared on an arrangement of cases without supervision, a DBN can figure out how to probabilistically remake its sources of information. After this learning step, a DBN can be additionally prepared with supervision to perform arrangement. It is stacked with numerous confined Boltzman machines that utilizations Gibbs inspecting to prepare the illustrations.
- Convolutional neural network : This is the most commonly utilized deep learning for large scale picture characterization. This model consist of an input and an output layer along with many hidden layers. The hidden layer of CNN model mainly consists of convolutional layer, pooling layer, and fully connected layer. Convolutional layer[4] applies a convolution task to the information and after that passes the outcome to the following layer. Pooling layer joins the yield of neuron group at one layer into another single neuron in the resulting layer. Fully connected layer[5] interface each neuron in one layer to each neuron in another layer.
- Recurrent Neural network [6] : It is another type of deep learning[7] model where associations between units shape a coordinated diagram along an arrangement. It is learned to highlight the arrangement of information by memory of past data sources that are put away in the inner condition of neural systems. Faster Recurrent Neural network[8](FRCNN) concatenate the feature of image and work better as per ROC curve.

Deep learning has been used in all the aspect of research work and significantly used in computer vision. The limitation for Deep learning-

based face recognitions are facial expression, illumination, ageing, pose changes, occlusion etc.

The most difficult task in automatic face recognition is that it involves detection of faces from a littered background, facial expression and face identification. This review paper has been discussed on these issues and we have divided it in two section. In the first section, we have discussed Introduction of Deep Neural Network for Face recognition and second section describe Face Recognition deep Models. Face recognition Deep Model is further divided in to five subsections Face recognition methods in Image, LBP comparison with other algorithms, Frequently used Methods for Deep Model, Popular Dataset available in public forum and Face Recognition methods for videos.

## 2. Face Recognition Deep Models

### 2.1 Face recognition method in Image

Face Recognition [9] on static 2D images uses two types of features namely geometric and appearance-based features. Geometric features as those features which help to recognize the shape of the face along with various other components including mouth, eyes, eye brows etc. Geometric features are calculated using Normalized Central Moments (NCM).It computes spatial moments ( $m_{ji}$ ) of images by following equation:

$$m_{ji} = \sum_{x,y} (I(x,y) \cdot x^j \cdot y^i)$$

where

$I(x,y)$  is the binary image with the face local shape represented with 1 and background with 0.

Normalized central moment ( $nu_{ji}$ ) is given as:

$$nu_{ji} = \text{central moment} / m_{00}^{(i+j)/2+1}$$

Appearance based features considers texture of face affected by the facial expression. These are calculated using Local Binary Pattern (LBP) using local regions over holistic approach. When the regions are of varied shapes and sizes, basic LBP is used. Once an image is labelled with LBP operator, a histogram of the labeled image  $f_i(x,y)$  can be defined as:

$$H_i = \sum_{x,y} I(f_i(x,y) = i) ,$$

$$i = 0, 1, 2, 3, \dots, n-1$$

Where n is number of different labels produced by LBP operator

$$I(A) = \begin{cases} 1, & A \text{ is true} \\ 2, & A \text{ is false} \end{cases}$$

Feature extracted from LBP and NCM help Support Vector Machine (SVM) for getting better face recognition using local region specific feature [10]. It uses following steps

1. **Landmark position estimation** is done using DLIB machine learning toolkit.
2. **Selection of regions** is done by dividing face into 29 local regions. As human face is symmetric, hence only a subset of these regions is required. Finally paper [10] describes that only 13 regions out of 29 regions were selected to avoid any redundant information being considered and hence reducing the time complexity for computation.
3. **Feature extraction** is done using LBP and NCM
4. Lastly, **SVM** is used for classification purpose.

## 2.2 LBP comparison with other Face recognition algorithm in Image

We have shown the comparison of LBP with other recent face recognition algorithms on FERET face images that consist of 14051 gray scale images. This database contains facial expression, pose angle, lighting etc. in this experiment front faces are considered.

X : contain front image of 1195 people.

Y : Person is asked for alternative facial expression

Test1 and subTest2 respectively considered for picture was take in other time and subset of Test1, containing those image that were take at least a year before.

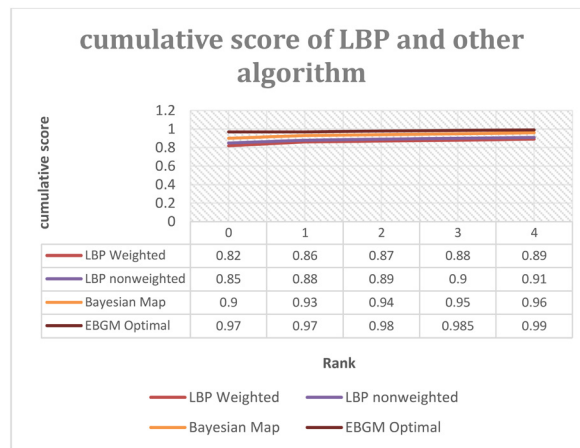
Table 1 shows the comparison of LBP[11][12] weighted, LBP non-weighted, Bayesian MAP[13] and Elastic Bunch Graph matching-EBGM[14] optimal algorithm. Mean accuracy of LBP weighted is higher than others. Rank and Cumulative score comparison is shown in figure 1. Rank is the comparison of classes, group of test2 data, with Test1 data. Rank curve shows that LBP has higher face recognition[15][16] rate than another algorithm.

## 2.3 Frequently used Methods for Deep Model

The direct correlation method and eigenface method both performed best for face recognition when used within intensity normalization

**Table 1**  
**LBP comparison with other Face recognition algorithm**

Method	X	Y	Test1	Test2	Mean accuracy
LBP Weighted	.96	.78	0.67	.65	.81
LBP No weighted	.92	.52	.62	.51	.75
Bayesian MAP	.82	.37	.52	.32	.72
EBGM Optimal	.89	.41	.45	.23	.65



**Figure 1**  
**Rank vs Cumulative Score**

achieving an equal error rate of 18.0% and 20.4% respectively. The fisher face method achieves the lower equal error rate of 17.8% when used within the slb pre-processing technique. Only a slight improvement is seen in fisherface method from 20.1% to 17.8% equal error rate whereas direct correlation method has much more significant equal error rate improvement from 25.1% down to 18.0%. Table 2 summarizes the most frequently used techniques for face recognition in image.

#### 2.4 Popular Data Set available in Public for face recognition

Searching dataset for face recognition is a big task, we are listing some popular dataset that is available in public forum in Table 3. It shows name of dataset, number of faces available in dataset and number of distinct identities exist in dataset.

**Table 2**  
**Frequently used face recognition Model**

Methods/Approach	Test database	Result/conclusion on technique
Direct correlation method[17]	AR Face database	18.0% Equal Error Rate
Eigenface method[18]	AR Face database	20.4% Equal Error Rate
Laplacianface, eigenface and fisherface[19]	Yale face database-A	Laplacianface algorithm has more confidence score than eigenface algorithm and accuracy on increase of samples
discriminant face descriptors (DFD) [20]	LFW	DFD enhances the heterogeneous face recognition performance of LBP by over 25 percent.
Multi-Keypoint Descriptors (MKDs) [21]	LFW, FRGCv2.0	Superior in recognizing both holistic and partial faces without required alignment.
DeepId3[22]	LFW	Better than Deep Id,DeepId2.Good for face verification and identification task

**Table 3**  
**Popular Dataset for face recognition**

Dataset	Number of faces in Dataset	Number of distinct identities
LFW[23]	13233	5749
CelebA[24]	202,599	10177
YTF[25]	3425 videos	1595
CFP[26]	7000	500
UMDFaces[27]	367888	8277
VGGFace[28]	2600000	2622
MegaFace[29]	4700000	672000
PaSC[30]	2802 videos	293
IJBA[31]	25809	500
UMD Face Video[32]	22075 videos	3107

**Table 4**  
Face recognition model for Video

approach	Feature used	Mathematical term used for	Test database	Result/conclusion on technique
Gabor Filter [38]	Skin Texture	Calculation of edge detection and rotation value. Then frequency and simulation are used to extract features.	pubfig+10 dataset, Movie trailer face dataset	Feature Vector is extracted.
HOG Filter [39]	Skin Texture	The magnitude and orientation gradient of the localized region is calculated.	pubfig+10 dataset, Movie trailer face dataset	Feature Vector is extracted.
Principal Component Analysis-PCA [40]	Extracted feature vector from hog, Gabor.	Removal of redundant feature vectors with the help of eigenvectors of the covariance matrix.	pubfig+10 dataset, Movie trailer face dataset	Removal of redundant feature vectors.
SRC-Sparse Representation based Classification [41]	Feature vectors optimized by PCA.	Calculating residuals using minimum coefficient vectors and to create prediction classes.	pubfig+10 dataset, Movie trailer face dataset	Predicting classes using residuals
RSRC	Feature vectors optimized by PCA.	Used to calculate sparsity index fro single coefficient vector for a single frame to get an improved average precision.	pubfig+10 dataset, Movie trailer face dataset	Predicting classes using residual with much more precision than SRC



## 2.5 Face Recognition Methods in Video

The application of Facial Recognition [33] has made its way into the advancement of security needs and law enforcement. Facial Recognition [34] is done by extracting relative position and size of facial features like nose, jaw, eyes and is searched in the corresponding database to find a match. Broadly speaking Facial Recognition can be classified into 3 categories:-

1. Key Frame Based [35]:- A model is trained over static image database thus the model learns key faces from the selected key-frame via clustering.
2. Temporal Model-Based [36] :- A Hidden Markov Model is used to make the model learn temporal/facial dynamics of the face throughout the video.
3. Image-set Matching Based[37]:- Modelling of a face track as an image set such that each face track is modeled in its own subspace.

There are so many method and optimized method in face detection in video. We have shown some important of them in Table 4.

Face recognition in image and video is always a tough task but Deep neural network has made this task easy. It has reduced the human intervention as well as increased the accuracy of the system. 3D face recognition is also a burning research area, Point Distribution input Model [42] has done it very well. Hydride and localization method [43] help in this recognition. Application of face recognition [44] and human posture recognition [45] with neural network have made major role in the research but Deep neural network has given new paradigm for it.

## Conclusion

Deep Models are also integrating many algorithms for face recognition in image and video dataset. We have depicted latest techniques in research along with its mathematical importance. A significant comparison has been depicted for face recognition in image that shows LBP weighted has higher mean accuracy in compare to Bayesian MAP and EBGM optimal. List of popular data set ,image and video, available in public forum is also discussed in this review paper.

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