iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VI **Month of publication:** June 2019

DOI: http://doi.org/10.22214/ijraset.2019.6271

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, June 2019- Available at www.ijraset.com

Deep Learning Techniques for Face Recognition: A Review

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Abstract: Biometric applications are increasing day by day. Face is one of the active research topic in the area of biometrics. It is a technology capable of identifying and verifying an individual from images and videos. Face recognition systems are more secure than any other traditional security methods such as username, password etc. It has wide variety of applications like crime investigation, access control etc. The challenge of face recognition task is to extract the features accurately. Deep learning techniques are becoming popular as it is able to handle large datasets. This paper provides an overview of deep learning techniques and its usage for face recognition.
Keywords: Face Recognition, Face Detection, Face Normalization, Deep learning, Feature extraction.

I. INTRODUCTION

Biometrics determines the identity of an individual. Face recognition is one of the most popular biometric authentication systems[1]. Face Recognition refers to identifying and verifying an individual from images and videos. It is more secure than other security mechanisms such as username and password. The main advantage of face recognition is it is easy to use and its non intrusive nature. Face recognition has some applications such as access control, social media, crime investigation etc. Some of challenges affecting the face recognition system include occlusion, aging, facial expressions etc. Traditional face recognition systems rely on handcrafted features. These techniques are not able to address all the challenges in unconstrained environment.

Recently deep learning techniques are popular in the face recognition research. The main advantage of deep learning technique is that it is able to handle large datasets and learn the features. Many researchers have been focusing on face recognition, but still have some issues to solve [2].

In this paper, Section II describes the basics of face recognition. Section III describes the basics of deep learning approaches and Section III discusses the deep learning techniques used for face recognition and conclusion is presented in section IV.

II. FACE RECOGNITION

The face is one of the most acceptable biometrics, and it has been the most common method of recognition that human use in their visual interactions. the problem with authentication systems based on fingerprint, voice, iris and the most recent gene structure (DNA fingerprint) has been the problem of data acquisition. for example, for fingerprint the concerned person should keep his/her finger in proper position and orientation and in case of speaker recognition the microphone should be kept in proper position and distance from the speaker. But, the method of acquiring face images is nonintrusive and thus face can be used as a biometric trait for covert (where user is unaware that he is being subjected) system. Face is a universal feature of human beings .Facial recognition is a type of biometric technology that measures and analyses the unique mix of a person's identifiable biometric facial characteristics.

The face recognition problem can be divided into two main stages: face verification (or authentication), and face identification (or recognition). Detection stage is the first stage. Recognition stage is the second.

Face recognition is often described as a process that first involves four steps; they are: face detection, face alignment, feature extraction, and finally face recognition.

1) *Face Detection:* Initial step is to locate one or more faces in the image and mark with a bounding box.
2) *Face Alignment:* Normalize the face to be consistent with the database, such as geometry and photometrics.
3) *Feature Extraction:* At the feature extraction stage , extract features from the face that can be used for the recognition task. Feature descriptors are used in this phase.
4) *Face Recognition:* At the face recognition stage, perform matching of the face against one or more known faces in a prepared database.

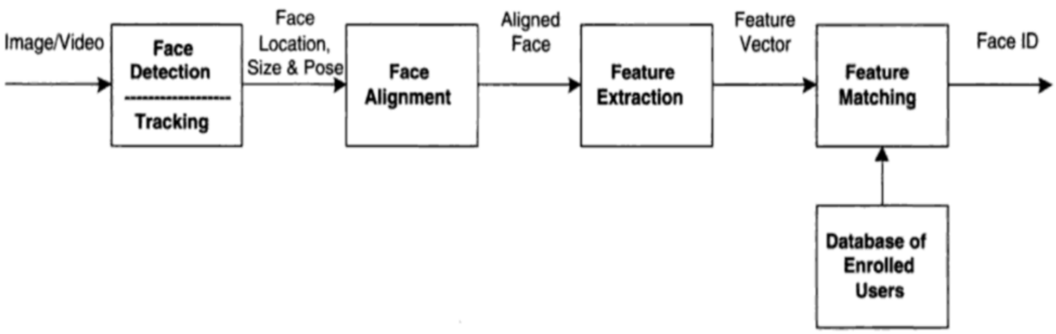

Fig 1. General Block Diagram of face recognition systems [4]

Although it has advantages,there are some challenges in face recognition. Images of human faces undergo many changes due to acquisition conditions and natural aging. Acquisition conditions refer to the pose of the face with respect to the camera, illumination conditions, facial expressions and the number of pixels in the face region. Additional variations may be caused by disguises, occlusions (due to sun glasses, baseball hats, etc) and gain/loss of weight and facial hair. As part of aging one may undergo weight gain or loss, thus adding another dimension to the variations in human faces. Although the person is the same, the range of faces images can be very large. The challenge of face recognition task is to be able to recognize a person in the presence of all these variations.

III.DEEP LEARNING

Deep learning is a part of machine learning method based on neural networks. Deep learning is a solution for variety of computer vision problems, such as object detection, motion tracking , action recognition , human pose estimation , and semantic segmentation. Deep learning consist of wide variety of methods, encompassing neural networks, hierarchical probabilistic models, and a variety of unsupervised and supervised feature learning algorithms[3].

A. Convolution Neural Networks

A Convolutional Neural Network (CNN) is consisting of one or more convolutional layers (often with a subsampling step) and then followed by one or more fully connected layers as in a standard multilayer neural network. The architecture of a CNN is designed in such a way that it takes privilege of the 2D structure of an input image or any 2D input. This is achieved with local connections and tied weights followed by some form of pooling which results in translation invariant features.

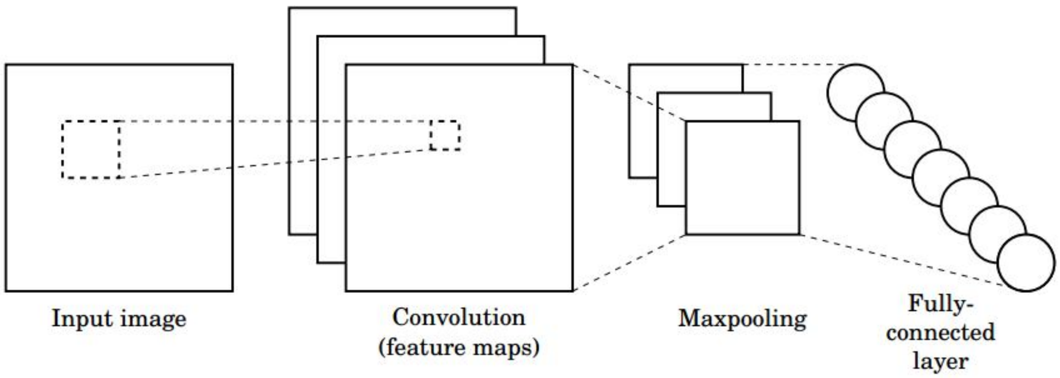

Fig 2. General Diagram of convolution networks[5]

B. Deep Belief Networks

Deep Belief Networks are one of the successful models of Deep learning. It consists of many layers of hidden units with a unsupervised learning algorithm. Deep Belief Networks[7] is a class of deep neural network which comprises of multiple layer of graphical model having both directed and undirected edges. It is composed of multiple layers of hidden units, where each layers are connected with each other but units are not. Deep belief networks uses Boltzmann machine as a learning module which is shown in Fig 3.

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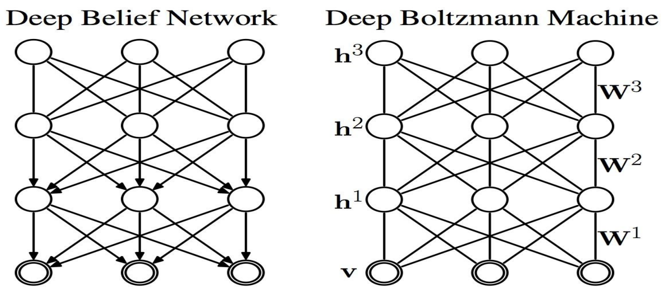

Fig 3. Deep Belief Network[6]

C. Stacked Autoencoders

A stacked autoencoder is a neural network consist several layers of sparse autoencoders where output of each hidden layer is connected to the input of the successive hidden layer. Autoencoder is a kind of unsupervised learning structure that owns three layers: input layer, hidden layer, and output layer. As shown in in Fig 6. An auto encoder training process consists of two parts: encoder and decoder. Encoder is used for mapping the input data into hidden representation, and decoder is referred to reconstructing input data from the hidden representation. It is possible to stack denoising autoencoders in order to form a deep network by feeding the latent representation (output code) of the denoising autoencoder of the layer below as input to the current layer. The unsupervised pretraining of such an architecture is done one layer at a time. Each layer is trained as a denoising autoencoder by minimizing the error in reconstructing its input (which is the output code of the previous layer). When the first k layers are trained, we can train the (k+1)th layer since it will then be possible compute the latent representation from the layer underneath.

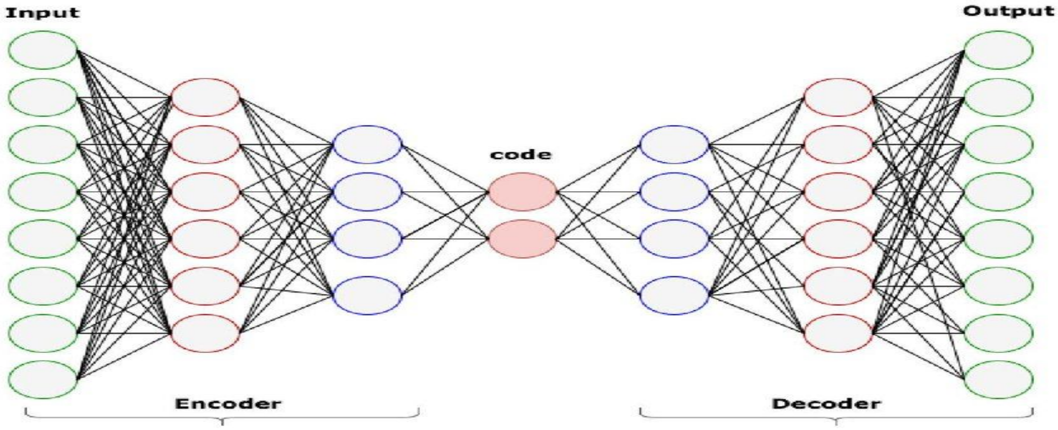

Fig 4. Structure of Stacked Autoencoder [6].

IV. DEEP LEARNING TECHNIQUES FOR FACE RECOGNITION

Several recent works mainly focus on utilizing the better loss functions to improve the performance of face recognition.

Taigman et.al [7] proposed a framework which is CNN based method to extract deep features of the faces that are aligned to frontal through a general 3D shape model and performs better than many traditional face recognition methods. This was the first method which uses a nine-layer CNN with several locally connected layers and it uses a 3D model for pose normalization. In pose normalization process ,all the poses are rotated to the frontal pose. In Deep face an 8-layer CNN is trained using four million pose-normalized images.

The performance of face recognition is further improved by Deep ID2, Deep ID2+[26],Deep ID2 combine the softmax loss and the contrastive loss to learn discriminative face representation. Sun et.al [9] presented a DEEP ID3 method. The method consists of two deep network architectures based on stacked convolution and inception layers to make them suitable to face recognition. DeepFace uses Joint identification-verification supervisory signals to the last fully connected layer as well as a few fully connected layers branches out from pooling layer. This method is also used in DeepID3 to make the architecture suitable for feature extraction . In addition, the DeepID3 network is significant deeper compared to DeepID2+ by using ten to fifteen non-linear feature extraction layers. As a result, DeepID3 achieved greater accuracy.

Shroff et.al [8] proposed a framework called FaceNet in which face images are mapped to Euclidean distance where distances correspond to a measure of face similarity. This approach is learning from the images. Tasks such as face recognition, verification and can be easily implemented using standard techniques with FaceNet embeddings as feature vectors. This method uses a deep convolution network trained to directly optimize the embedding itself. For training roughly aligned matching/ non-matching face patches generated using a novel online triplet mining method was used. The advantage of this approach is greater computational efficiency.

Liu et.al proposed a system called SphereFace[10] in which large margin softmax is used. They introduced the important idea of angular margin , their loss function needed a series of approximations in order to be computed, which resulted in an unstable training of the network. In order to stabilise training, they proposed a hybrid loss function which includes the standard softmax loss.For feature selection, softmax function is achieved by imposing multiplicating angular constraints to each true class. Sphere Face applies L-softmax to face recognition using weight normalization. The benefit of this approach to extract the features accurately.

V. CONCLUSION

Face recognition has received great deal of attention over the last few years as it has large applications in multiple domains This paper provides an overview of face recognition and deep learning techniques which is becoming popular in the area of computer vision and machine learning. A suitable feature descriptor can improve the accuracy of face recognition systems. Recently deep learning performs well in a promising way than any other traditional methods. However, there can be many advances in this direction because there are vast scopes of improvement and development. This study will hopefully motivate future researchers to come up with smarter and more robust face recognition system using deep learning .

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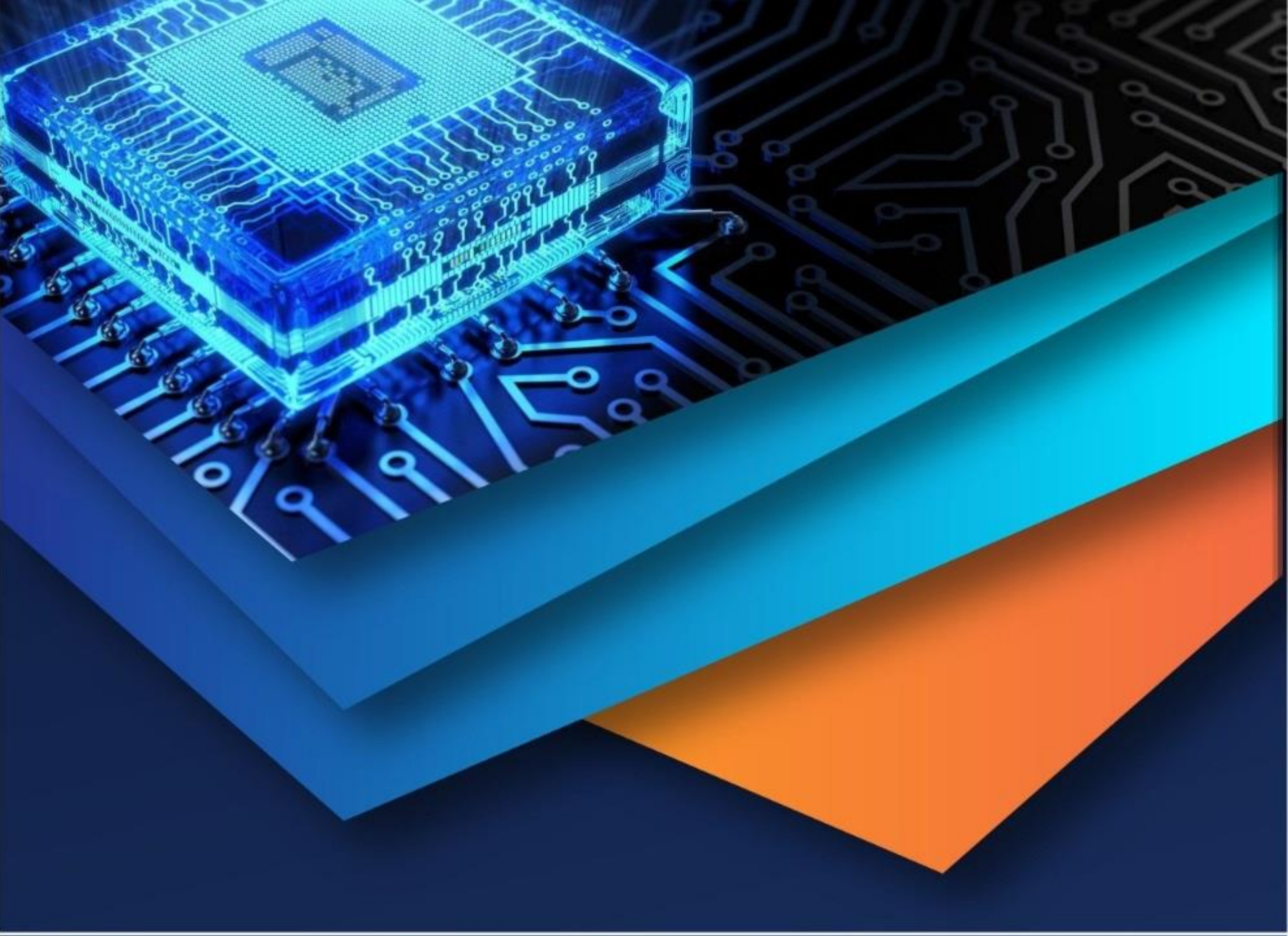

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