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FACE RECOGNITION TECHNIQUES: A REVIEW

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Abstract: With a huge abundance of data and information, there is a need for high security. Face Recognition is a fast-growing and interesting area in the present scenario due to its wide variety of uses in different fields. In the last decades, a large number of algorithms have been developed for facial recognition such as SVM, Neural Network, Naive Bayes Classifiers, Sparse Network of Winnows, and Hidden Markov Model. In this paper, an attempt is made to review a wide range of methods used for facial recognition comprehensively.

IndexTerms **- Neural Network, Facial Recognition, Humans, Algorithms, Machine Learning.**

I. INTRODUCTION

The objective of developing biometric applications has become important for smart cities. Many scientists and engineers throughout the world have focused on establishing accurate methods and efficient algorithms to protect our personal data through face recognition techniques. This biometric methodology for security has the main advantage as the presence of a person in front of sensors is sufficient hence, there is no more need to remember passwords to get access[1].Face recognition includes face detection, face position, identify recognition, image processing, etc. related technologies for building a face recognition system[2]. This system identifies people based on their biological and behavioral characteristics which makes it more attractive and easier to use. This biometric authentication system gives its potential in many fields such as in security it is used for surveillance, border control, and tracing of suspects. In schools, colleges, or companies it is widely used for attendance marking. In smartphones, it is used for unlocking.

II. LITERATURE REVIEW

Facial recognition has been one of the powerful applications as it has progressed the structure and amalgamation of efficient machine learning algorithms to recognize and verify faces. This finds applications in multiple interfaces such as multi-factor authentication parameters[3], human recognition and verification, authorization, etc. The feature extraction scenarios are mainly used in the tracking of features for other applications, recognizing the emotional state of humans, etc.[4] An example is presented by [3], who has experimented with three-factor authentication wherein the single sign-on token is issued after ensuring password, pin and facial recognition systems match against the user. Following the same example, [5]have also implemented fingerprint, iris, and pin verification for the smartphone user as a method of handling authentication mechanism. The ease of access is in regard to not requiring any special mechanisms to verify the user as the camera will easily capture an image which is further processed for features and verified against the valid match. Another significant application for facial recognition is highlighted by [6], where they have tracked the human emotions to interact with the robot using the Lanade-Lucas-Tomasi algorithm. Advances in facial recognition technology have garnered more interest from social sites to understand their customers better, Deep face[7] was constructed on Facebook's internal dataset to understand and train over its own profile image dataset using deep learning methods. The objectives of performing facial recognition is different for each use case, it consists of various ends that can be created in ambiguous models. [8]predicted hire ability of professional male candidates with potential features including features for classification.

III. BASIC OF FACE RECOGNITION

Face recognition uses ML and algorithms to find faces in an image. Detecting a face in an image is usually complicated because of variables incorporate factors such as buildings, trees, landscapes, objects, lighting, pose, skin color, image resolution, facial hair, etc[9].The basic steps in a typical face recognition system can be shown with a block diagram. The face detection and face extraction process are carried out simultaneously. The complete process of the face recognition system is shown in the figure.

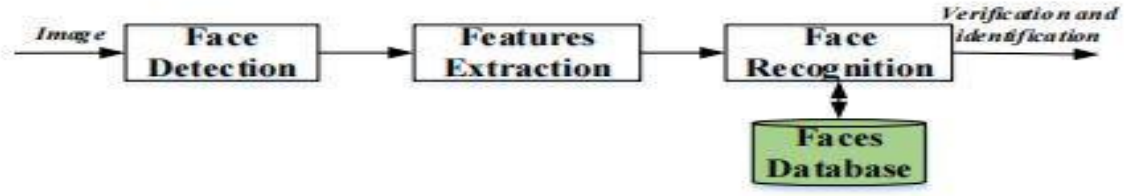

Fig. 3. 1. Face recognition structure [1]

The first process is face detection which is used to analyze the presence of a face in an image or not. It usually starts by searching for human eyes which is an easy feature to detect. Further algorithm detects the eyebrows, iris, mouth, nose and nostrils. Once the algorithm confirms that it has founded a facial region it applies additional test to confirm it a face. In feature extraction alignment and normalization of the face is done for better exactitude. Next, the input image also called as the probe is compared with a database (called a gallery) where images are stored to match with the input image. Once a match report is successfully sent then, the classification is done to identify the sub-population of a new observation belonging[10]. To ensure the accuracy of algorithms, to confirm the presence of face in image it needs to be trained with large datasets with lakhs of positive and negative images. Basically, there are three approaches for face recognition:

3.1 Feature Base Approach:

In this approach local features like nose, mouth and eyes are located, and then features extracted are fed as input data to the structural classifier in face detection for making the task of face recognition easier[11].

3.2. Holistic Approach:

In this approach whole human face is fed as raw data for input in face detection to perform face recognition. This approach has the disadvantage of handling very small size images[11].

3.3 Hybrid Approach:

This approach is a combination of feature-based and holistic approaches[10]. It takes local features as well as the whole face as input for face detection in the face recognition system.

IV. Factors Affecting the Face Recognition

There are various factors that affect the process of face detection and face recognition to perform. A lot of research works are done to achieve 100% precision, but a satisfactory benchmark has not been met due to the factors classified into two categories: intrinsic and extrinsic factors. The intrinsic component includes the physical state of human appearance like aging, plastic surgery, facial expression ,and so on[12]. The extrinsic component includes the changes in the appearance of the human face like low resolution, occlusion, noise, pose variation, illumination etc.

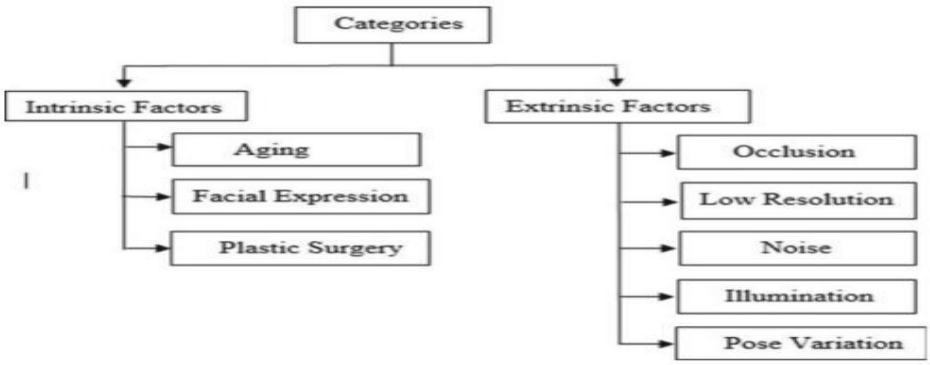

Fig. 4.1 Categories of factors affecting face recognition accuracy[9]

4.1 Occlusion

Occlusion is caused due to the visibility of a partial part of the face. It is caused by the person wearing sunglasses (hides eyes), wearing a mask (hides mouth), scarf or mustaches in boys(hides half of the face), and so on. These factors affect the performance of the system[9].

Fig. 4.2 Partial occlusion in the face[9]

4.2 Low Resolution

The pictures taken from video surveillance is a low-resolution image which results in a challenging task to compare the low-resolution image as input with the high-resolution database image[9].

Fig. 4.3. Frame from surveillance video. a-video, b-captured face[9]

4.3 Noise

Due to various factor affecting in creation of digital image noise is inclined to that particular image. This noise leads to poor detection of face and the accuracy of face recognition[9].

Fig. 4.4. Noise in face image[9]

4.4 Illumination:

The illumination degrades the performance of face recognition. This illumination is caused due to various factors such as shadow, background light etc.[9]

Fig. 4.5. Effect of illumination in face images[9]

4.5 Pose Variation

A frontal face is required to match the profile face with the database face. Thus, due to pose variations, it causes faulty results which degrade the performance of the system drastically[9].

Fig. 4.6. Pose variations[9]

4.6 Facial Expression

When the emotions are expressed by a person, the facial expression changes. Contraction of facial muscles while changing expression changes the geometry of facial features like eyebrows, nose, and mouth. Changes in the geometry of the face create vagueness for face recognition[9].

Fig. 4.7. Different facial expressions[9]

4.7 Aging

Aging is a natural change in humans as time continues. The face is made up of skin tissues, facial muscles, and bones. With, the passage of time these muscles contract hence face highlights are twisted resulting in the facial appearance of a person[9].

Fig. 4.8. Aging variations [9]

4.8 Plastic Surgery

It is a major factor in face recognition. Due to some factors such as accidents, many people change their facial appearance through plastic surgery. Many people especially criminals change their facial appearance to hide their identity. So, a system is needed that should be capable of identifying faces even after plastic surgery[9].

Fig. 4.9. Pose variations[9]

V.DIFFERENT TECHNIQUES FOR FACE RECOGNITION

5.1 Principal Component Analysis (PCA)

It is the most famous algorithm in face recognition. In machine learning, PCA an unsupervised algorithm is used for dimensionality reduction. With the use of mathematical functions, different parameters are excised called principal components[13]. It has the ability to reduce image dimensions. In 1901, PCA was invented by Karl Pearson which was used to identify a set of uncorrelated data from a larger dataset of correlated features through an orthogonal transformation. These datasets of uncorrelated features are called eigenfaces. These eigenfaces value is always less than or equal to the number of original face images. This transformation is done in such a way that the first principal component(PC1) shows the most dominant features of the dataset. The second principal component(PC2) shows the next most possible dominant features under the constraint that it should be uncorrelated with the previous components and continues[1]

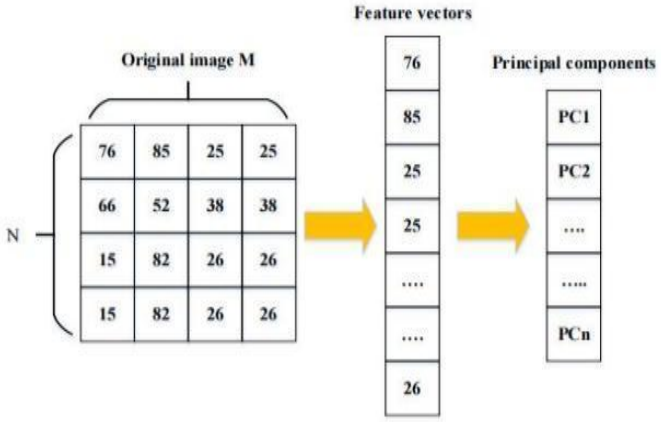

Fig. 5.1. Example of dimensional reduction when applying principal component analysis (PCA)[1]

Since principal components show more precise directions of data than preceding components which contain noise, Only a few first components are selected which depict the most important features that make up the dataset, and the remaining components are discarded. Therefore, each selected component in the original dataset is represented in terms of 'K' principal components as a linear combination of eigenfaces.

Each component is weighted as a contribution to the training dataset. In this way representation of the dataset in terms of principal components reduces the number of variables needed in face recognition. This makes recognition faster and error-free caused due to noise. The main advantage of using this algorithm is of reducing data for identifying to $1/1000^{th}$ of the data represented[14]. But its disadvantage is the recognition rate which decreases with varying posing and illumination.

Applications of PCA are image compression, image processing, movie recommendation system, computer vision, medical data correlation, neuroscience, etc.

5.2 Support Vector Machine (SVM)

SVM stands for Support Vector Machine. It is one of the most famous supervised learning algorithms which is used in regression & classification problems. The primary use of SVM is for classification in machine learning.

SVM was invented by Vladmir N Vapnik and Alexeya Chervonewkis in1963. It was suggested to create a nonlinear classifier by applying kernel tick algorithms[15]. Kernel tick algorithm is a technique through which the given data is transformed and then it finds an optimal boundary between possible output on the basis of transformation.

SVM is used to minimize generalization errors and prevents overfitting problems. To overcome all these factors or process some newly proposed algorithms are used like PCA, LDA, and ANN which is discussed in the paper.SVM is a classified machine learning algorithm based on hinge function in eq— (1)

$$h_j = max(0,1 - z_j(w.I_j - b)) \qquad (5.1)$$

where z is a label from 0 to 1, w.I-b is the output, w and b are coefficients of linear classification, and I is an input vector.The loss function to be minimized can be implemented in Eq-(2)

$$loss = \frac{1}{n}\sum_{i=1}^{n} \quad max(0, h_i) \qquad (5.2)$$

5.3 Artificial Neural Network (ANN)

ANN stands for Artificial Neural Network which was studied firstly by Warren McCulloch and Walter Pitts in 1943. The study was based on a computational model for the neural network. ANN is one of the uttermost algorithms based on neural networks. As we are familiar with the concept of ANN, if someone wants to understand the concept of ANN, they must have the ideology of working of neural network in the human brain. As it is known, the living being's brain consists of billions of neuron cell that takes the input information in the form of the electric signal. Stimuli are received through dendrites of the neurons after which it is converted as output and passed through the axon to the next neurons. In general, it can be said that it is the sigmoid relationship between the activation rate of the hidden words in output words and input signals[16].As it is known that ANN algorithms uses the processing of the brain as a basis to develop the algorithms on which any pattern and prediction exist. A similar process runs between different neurons that help to choose either to accept it or to reject it depending on the basis of the strength of the signal. So, in the same way, the computer also creates an artificial network with inputs for data insertion and then provides output. Further, a data processing hidden layer is present between the I/P and O/P. So, the neurons in input, processing & output layers will be the same and there can be a feed-forward backpropagation network can occur. In ANN backpropagation algorithms are used to send the signal in the forward direction and errors in reverse backward until errors reduce ANN learn the training data[17].

Some important use or applications of ANN algorithms are recognition of patterns, optimization, face detection, speech, and text translation. It is even used in the medical field largely.

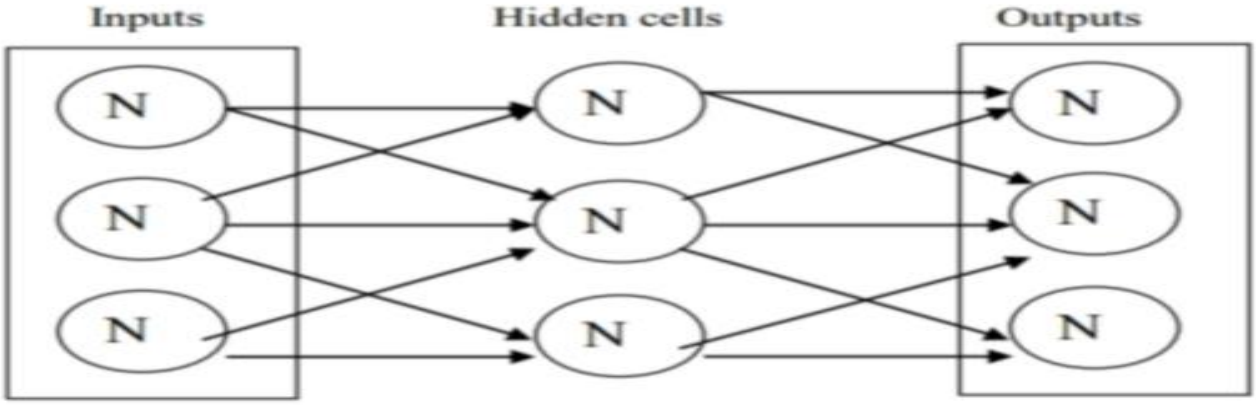

Fig. 12. Artificial Neural Network[17]

5.4 Linear Discriminant Analysis

Feature selection from the face is the central issue in facial recognition. Among various method appearance-based approaches seem to be the most successful. The appearance-based approach directly operates on face or appearances and processes the image in two-dimensional to avoid difficulties in 3D modeling[18]. LDA is a powerful tool that is used for the reduction of data in an appearance-based approach. LDA outperforms PCA due to the most of its focus on discriminant features extraction later simply it achieves object reconstruction. The main motive of LDA is to convert original data into lower-dimensional space. To, achieve this goal there are three steps needed to be performed. In this process, the first step is to calculate the distance between the means of classes also called as a between-class variance. The second step is to calculate the distance between the mean and each sample class called as a within-class variance. The last step is the construction of lower-dimensional space which maximizes minimizes between class as well as within class variance respectively. LDA mainly provides us a small set of data that carries the most relevant information[19].

5.5 Independent Component Analysis (ICA)

Independent Component Analysis (ICA) focuses on converting a set of given vectors into totally independent data points. While using this algorithm, mainly two assumptions need to be made. First, it needs to be made sure that the independent components we are trying to uncover must be a non-Gaussian and second is that they are statistically independent.

Suppose, a and b are two independent components, hereby independent, it is meant that no component gives information about the other i.e. a does not give information about b and vice versa. In mathematical form, it can be represented as

p(a, b)= p(a) p(b)

where p(a, b) represents the joint distribution of and b, p(a) and p(b) represent the distributions of a and b individually. Non-Gaussian assumption means that the distribution is not in the form of the bell curve. One thing that needs to be remembered is there is no use in performing the ICA algorithm when there is only one independent factor of the information that has to be uncovered.

VI. CONCLUSION

In this paper, an attempt is made to review a significant number of papers on the face recognition system, discussed factor that affects it, and some of its famous technique. With the development in fields of science and technology, Face Recognition has played a major part in it. As per the current scenario, face recognition systems with the help of machine learning are becoming emerging technology. Today, all machine learning applications have started to use a face recognition system to perform secure transactions in banking apps, security, and surveillance. Still, there are many factors that need to be addressed that challenges face recognition. The most prominent one is a pose, lighting factor, illumination, and then outdoor imagery. This study shows that there is still in need for advancement in face recognition to overcome these

factors and meet the demands of actual real-life constraints. The list of references is enlisted to provide a detailed understanding of the techniques.

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