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# Face Recognition Challenges and Solutions using Machine Learning

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***Abstract:*** Face Recognition (FR) is an interesting real-time field of Computer Vision. After many efforts, the research is still in the development stage. Although recent developments in face recognition have been done but challenging also. Particularly, challenges come with: different positions of faces, illumination levels varied, blurred faces, and post-surgery faces. With the help of Face detection and face recognition, one can identify the right person from the captured face with a camera/video. The objective of the research is to consider the existing research in the area of face detection & face recognition & finding their limitation such as accuracy and performance. This paper presents the issues that come with the uncontrolled environment such as aging, illumination, occlusion, facial expressions, low resolution, etc. Moreover, this paper also analyses existing techniques and possible expected solutions to reduce issues and enhance the performance of the FR system.

***Keywords:*** *Face Recognition, Computer Vision, Face Detection, Uncontrolled Environment*

## 1. Introduction

In current society, the human face plays an important function in human verification. Biometric face recognition technology uses the face as a security key. Face Recognition has a wide range of applications in both law and non-law enforcement. This is a computer framework that analyzes and evaluates patterns to verify a face from a digital image/ video. This is accomplished by choosing face elements of an image and matching them against an existing facial database. For matching of picture of a person's face with preserved one from a group of faces, a photograph marked with personal identification is reported. A correctly labeled facial area is critical to the overall efficiency and accountability of a face awareness application. Face recognition has several possible uses in education, government sectors, private companies, and banks like automated entrance administration procedures in form of biometrics.

The appearance of a photo varies depending on the version, occlusion, snapshot orientation, lighting environment, and face elements. Face recognition also functions as a crime deterrent because captured and archived face photos can be used to identify a person. Face awareness offers some advantages over other biometrics technologies that involve fingerprint/palm print and iris. Like it is possible to record photographs of a person's face from a considerable distance without having to touch them, and it is not necessary to engage with the man or woman. It entails the coordination of multiple domains, such as corporate, scientific, or military systems, and is used for access control in safety, video surveillance in high-security or religious locations, and other extremely sensitive regions, such as airports. Face print-based

facial consciousness methods quickly identify target members in suitable settings [1-6]. The program is less trustworthy if the face location is partially veiled, facing in any other direction, or if the light is insufficient.

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## 2. Face recognition

It uses the human face as an individual identifier to find out right person. Face Recognition systems capture photographs of a person's face as they enter a defined region, rather than requiring them to lay their palm on a reader or precisely capture their eye in front of a scanner. It's incredible to be able to recognize and understand people's feelings just by looking at their faces. Working out the feelings of the people around us is a method to connect with the outer world. The aspects are measured using a face print, which is a numerical code that represents the face in the database. The human face has a lot of unique features, especially when it comes to emotional expression. Face expression recognition systems have a lot of attention in human communication. Even we can confirm an individual emotional state more quickly by facial expressions rather than using words. A digicam is used to input the attributes of a person's facial graphics. It determines the whole structure of the face, as well as the distances between the borders of the eyes, nose, mouth, and jaw [7,8].

### 2.1. Face recognition Process

The face recognition model first captures an image/video as input and then detects a face from the image. After that main important step is pre-processing in which resizing, compression and normalization are applied to the image and extracting features like eyes, nose, and lips from the face and doing classification of an image with test database image features to match whether that image is authenticated or not. Therefore, three steps of the Face Recognition process are:

Face Detection- faces are detected from the image or video. Apply preprocessing to know the exact location/coordinates of the face and extract that face for further processing then

Feature Extraction-by crop the face from the image and extracting features from it.

Face Recognition- compare faces for embeddings of every face in the data saved in a file and classify whether the face of a person is matched or not [9-11].

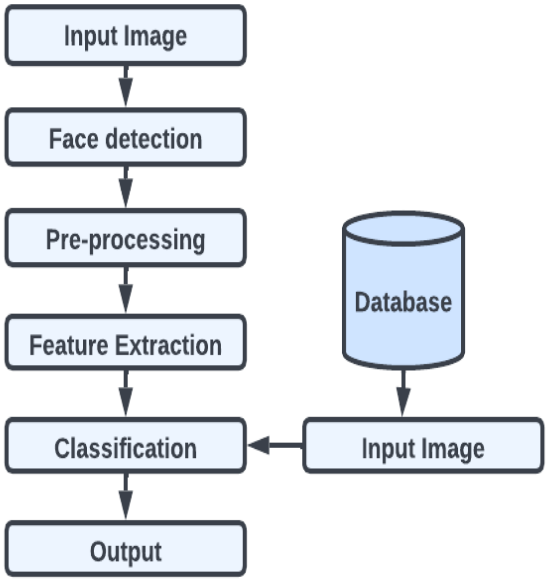


**Fig. 1.** Face Recognition Process Model

### 2.2. Face recognition measures

Biometrics is often regarded as an excellent approach for detecting threats. Face elements are made up of multiple, distinct landmarks, unique peaks, and valleys. There are around eighty nodal aspects to each human face. Things that can be measured with the use of facial recognition are eyes span a wide range of distances, nostril area, shape of cheekbones, and jaw dimensions. The measurements are entered into a database and compared afterward [12].

**Fig. 2.** Face Recognition dimension measures

## 3. Methodology

Face recognition objectives are to identify people in images or videos using pattern recognition techniques. The method locates the person's face and compares it to a face database. It is possible to transfer the verification and try it again. The technique usually takes less than five seconds to reach a decision. The methodology used is that the Picture is captured from the digicam and applied to pre-process and got a cropped face and extract features then compare and classify whether a person is matched or not. If matched then the face is recognized.

## 4. Related work

The research layout certain difficulties faced in the face recognition area and facial features. The performance might vary on different datasets. The study shows the gap for researchers. For the development of the face recognition technique; datasets were used and have provided the essence of scholars' papers including methods, performance, and limitations. A CNN system for recognition & identification of expression of a student's face was presented. Some research work considered deeply learned classifiers in the case of age and gender prediction. The network has 4 levels in which 2 layers were fully connected and 2 were max-pooling layers. Finally, a model has been created for facial emotion recognition that identifies the emotions and facial expressions of students from faces [1-7]. The model has three methods: Haar Cascade detector to detect faces, normalization, and emotion recognition in Convolution network with FER dataset. To identify faces seven different expressions were considered and finally achieve a 70% rate of accuracy at 106 epochs. The proposed system is helpful in education that helps teachers to recognize the interest of students by their expressions during their studies. Then the probability of face embeddings (PFE'S) also has done.

In addition, a comprehensive overview and extended detection and recognition approaches were used for the accuracy of faces. The research observed most of the difficulties to identify faces with properties like the texture of facial skin, shape, color, etc., and environmental effects on faces like head pose, expressions on faces, light effects, etc. Further performance analysis of a system with higher accuracy using linear binary histogram pattern rather than Eigenfaces and Fisherfaces. Then three phases were categorized: detection of face, recognition of the face, and classification of the face. For the CV approach, OpenCV and python were proposed. The expressions were represented in 7 states which express distinct situations/modes of faces of people. Viola-Jones detector on Kdef database and VGG-16 on dlib with CNN framework were applied and achieved 88% of accuracy. Hence the designed system performs better than existing ones and is helpful to analyze the emotions of students' E-learning techniques.

Moreover, end-to-end CNN architecture was introduced. CNN model was trained for supervised face bounding boxes and personal identities using Wider_FACE and CasiaWeb_FACE databases and tested with face detector and fddb and lfw data sets. A spatial transformer network (STN) was used without any face alignment stage for the feature map. The results come with 89% accuracy in the detection phase and 98% in the recognition phase. Therefore, it is better to conclude that rather than two models, combining them as a single one has better performance [8-13]. After that, a system was used that might detect a person directly from a group of persons. For this, they used a deep convolution network that trained the model and gave good results by applying a filter to detect the face of a person from multiple gestures and facial emotions. In this way, prominent performance has been obtained, and the model performed with 99.7% accuracy on the Labeledwild_Faces and 94% on YTF databases [14-19].

## 5. Challenges and possible solutions

In general, face recognition in digital imaging must struggle with variable lighting conditions, substantial pose variations, partial occlusions, facial expressions, facial hair changes, face makeup,

and aging while remembering that the human face is not a single rigid entity. Similarly, videos are frequently taken in uncontrolled conditions or from moving cameras in scenarios such as visual surveillance. In essence, there are many obstacles as well as key factors that can have a substantial impact on face recognition ability as well as matching scores. Therefore, they are facing several challenges and trying to find out possible solutions respectively. The look of the face is influenced by several aspects. Variations in facial appearance can be caused by a variety of factors that can be categorized as:

### 5.1. Poses

When the viewpoint of the observer's head position changes, so does the facial expression. These shifts in body position create significant difficulties in identifying the input picture. A Face Recognition System can handle minor rotations without issue, but as the angle of rotation rises, problems arise since the database picture may only be a frontal view of the face, which may be posed differently from the input image [3]. The research observed most of the difficulties in identifying faces with properties like the texture of facial skin, shape, color, etc., and environmental effects on faces like head pose, expressions on faces, light effects, etc. Further performance analysis of a system with higher accuracy using linear binary histogram pattern rather than Eigenfaces and Fisherfaces.

The research focused on facial expressions algorithms of face detection that were proposed and abbreviated such as PCA, LBP, OF, Gabor filters, and many more for a better understanding [4]. CK+ databases were used to detect difficulty with correctness during cognition of facial expressions with the environment and when poses were changed then system accuracy was also suffered. For classification and regression methods used CNN, SVM, KNN, Naive Bays, Hidden Markov Model (HMM), Decision Tree (DT), and many more.

**Fig.3.** Pose variations on the same individual face

### 5.2. Aging

The human face is a varying object. With the passing of time, everything changes, including a person's appearance, which has an impact on the facial recognition system. To improve the chances of recognizing a person with aging effects by using a large dataset for face images, which included images of the same person; taken at various times throughout his/ her life.

A convolution neural network method has been proposed to predict the group of age & gender of images. Images of faces are not filtered. Here used a two-layer model. The first layer is used to extract features & second layer used classification to find out the right age and gender of a person. The convolution network was already trained with the IMDB-wiki dataset and was on Morph_II images and at last with the OUI-adience dataset. When classify with the OUI dataset then analyze that architecture achieved a good performance in a group of age and gender. The model results were better with 16.6 classifications of age and achieve 3.0% more accuracy for the classification of gender [5].

Other techniques include such as Eigenfaces, SVM, and FaceNet neural networks on Facial Embedding. The facial embeddings have been set up by passing through a Pre-trained Network. Viola-Jones algorithm was used for face detection. The maximum accuracy obtained to classify aging is 97% and KNN has a better result over Decision Trees, Logistic Regression, SVM, and Naïve-Bayes [6].

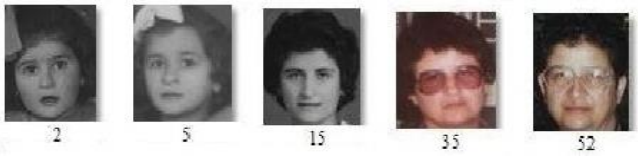


**Fig.4.** Aging variations on the same individual face

### 5.3. Low Resolution

A low-resolution issue occurs in a face recognition system when the facial picture resolution is less than 16x16. This is a concern in many forms of surveillance, from small-scale stand-alone cameras in retail and banking to ubiquitous CCTV in public spaces. In cases when there is not enough resolution in security camera photos to accurately identify a human face. Due to the distance between the camera and the subject's face, the face area will be less than 16x16. Low-resolution facial images don't carry much recognition information because of the lack of detail. A deep convolution neural network model with a lasting algorithm will be considered. The Challenging conditions come with a resolution, lightning effects, and deep makeup on the OUI_images dataset. So, we can investigate the apparent age estimation approach. The model results were better with 16.6 classifications of age and achieved 3.0% more accuracy for the classification of gender [5].

There are some other system problems such as issues caused by facial recognition system flaws such as camera distortion, background noise, poor storage, the identification between similar faces, and incorrect procedures among others.

**Fig. 5.** Low resolution on the same individual face

### 5.4. Occlusion

A person's face might be partially hidden by other factors. In many cases, just a piece of a person's face will be seen if they are in a group with other people whose features are partially obscured by others. It's a challenging part of facial recognition.

Facial landmark detection is a difficult task. Facial features may be obscured, making identification impossible even if the face is located. That makes features difficult to recognize. In real-world applications [12], it's not uncommon to see people chatting on phone, or covering their faces with a mask, dupatta, or with their hands for various reasons. Such an issue can have a significant impact on the recognition system's categorization process. Such an issue can have a significant impact on the recognition system's categorization process.

Therefore, suggested a 5-dimensional multi-color fusion model with SRC for face detection against occlusion. They employed merged color information to identify faces even when they were partially obscured. The findings were applied to four different data

sets to boost recognition rates. They improved the recognition rate by up to 24.5% on the AR database, 3.8% on the Curtin database, 25% on the FRGC database, and 2.86 percent on the Bosphorus database. A two-dimensional multi-color fusion method was used to improve face identification in the presence of occlusion [16].

**Fig.6.** Occlusion variations on the same individual face

### 5.5. Facial expressions

The face is one of the essential human biometrics and it has an important part in transmitting the identity of humans and emotion through its distinctive traits. The human mood varies as a result of various emotions, resulting in a variety of facial expressions. The facial expression changes as a result of the make-up & hairstyle. Due to these variations, it becomes more challenging to match a face with the existing dataset.

The optimization was performed for seven expressions on the faces of persons. To recognize/identify emotions convolution neural network, an approach with Keras and theano libraries was implemented for facial expressions. The Viola-Jones method was utilized for emotion recognition on the FER2013 dataset. The accuracy was observed with public and private test data and detected at 69% with public data and 59% with private test data. The rate of accuracy was also evaluated with a group of seven face emotions and the highest accuracy of 88% was achieved with happiness in images and the lowest accuracy with sadness was 57% detected [13].

The researcher noted that SRC has small databases. The errors occurred during the recognition of gestures and, the expression of the face was still a challenge. Therefore, Face recognition might be further rectified with the merging of CNN locality and SRC linearity to enhance variants. In the future may also investigate overcoming errors in gestures and expressions of face [21].

**Fig.7.** Face expression variations on the same individual face

### 5.6. Illumination

Light variations are referred to as illumination. Changes that come in illumination can affect the overall intensity of reflected light, and even the shading and shadow pattern as shown in a picture. Indeed, changing the illumination can produce larger visual differences than changing a face's identification or viewpoint.

With changes in lighting conditions [23], the same person captured with the same camera and seen with precisely the same facial expression and pose might appear significantly different. Face identification in changing lighting conditions is widely acknowledged as a difficult task for people and algorithms alike. As a result, the problem provided by changing lighting conditions continues to be a substantial challenge for face recognition systems. The distinction between two photos of the same human captured under distinct illumination was found to be a bigger difference than the variation between two images of distinct persons taken under the same illumination [24]. The appearance of the face is greatly altered by variations in lighting.

**Fig.8.** Illumination variations on the same individual face

### 5.7. Plastic Surgery

Face recognition techniques have been seen to fail to recognize individuals' faces in case of post-plastic surgery. These are the circumstances in which an individual's face is completely altered, transforming them into a completely different person. The process of plastic surgery on the human face changes; the skin texture between photographs of the same person, makes facial identification harder. Rhytidectomy is a common example of plastic surgery which can alter the appearance of the face to a large extent [23].

This is a process in which the entire appearance of the face is altered. This can speed up the transition from an older to a younger skin texture, resulting in a change in texture. Eye lifts, nose reshaping, and jaw enlargement are important modifications to the face that lead to changes in facial look. These algorithms have been designed to be resistant to the effects of plastic surgery.

**Fig. 9.** Plastic surgery variations on individual face

## 6. Face Recognition Techniques

Various machine learning algorithms discussed here are Support Vector Machine classification (SVM), K-Nearest Neighbour classification (KNN), Decision Tree classification (DT), and LBPH, CNN. Different techniques such as KNN, SVM, LBP, LBPH CNN, and many more try to reduce these challenges and some better solutions can be tried in the future, described below in table 1 to increase the performance of face recognition in varying conditions.

**Table 1.** Challenges and Solutions techniques

| *Citation* | *Techniques used* | *Challenges* | *Solutions* |
|---|---|---|---|
| [1] | SVM, LBP | The system face problem with the evaluation of age effects. | The system can be implemented with newborn child's faces. |
| [3] | Eigenfaces, Fisherfaces, and LBPH | Several faces were identified with a single data when using the LBPH database. | In the future, can elaborate with ambient analysis and implementation for the recognition of faces with distinct angles and poses. |
| [5] | two-level CNN layer | Challenging conditions with resolution, lightning effects, and deep makeup on the OUI_images dataset. | A deep convolution neural network model with a lasting algorithm will be considered. We can investigate the apparent age estimation approach. |
| [10] | KNN, Facet | The system got confused in fear and sad faces so with feared expression results were comparatively poor. | In the future, can try to apply the CNN framework with 3D face images of students with facial expressions and try to find out the involvement of students' emotions comes on their faces. |
| [15] | FCN faster R-CNN, Mask R-CNN, G-Mask model | The model suffered from overfitting when detected in between 70 and 80 passes and then the model seems to overtrain. | This model can be extended to identify a person's mood swings due to situations that come in an environment that was the reason for varying behavior and expressions. |
| [18] | Deep learning framework with CNN, ResNet. | The difficulty in impact measure of low-quality facial images. | CNN may use to work in measuring the effect of face and gender bias to detect and express individuality signs. |
| [20] | CNN classifier and Csv image format were used. | The problem comes with many faces while the model detected them. This restriction shows poor results. | Try to make an adequate system that overcomes the limit of detection of faces. |
| [22] | SRC, CNN's | Errors occurred during recognition of gestures and, expression of face was still a challenge. | Face recognition might be further rectified with the merging of CNN locality and SRC linearity to enhance variants. May also investigate to overcome errors from gestures and expressions of the face. |

## 7. Conclusion and Future Work

In today's time, Face recognition is a very promising field, despite its difficulties. This paper concludes possible solutions for issues come during the recognition of a face with different techniques and datasets. Also, analyze that there is no single method that solves all challenges. Therefore, design an algorithm that reduces the respective issue. It has been concluded that several kinds of research provide better accuracy after compression. Compression of image result is the low resolution of images. These images are less space-consuming. Therefore, in the future, a model can be designed that will be more effective to solve the real scenario challenges in facial recognition. The proposed research work is supposed to provide better accuracy and performance during face recognition.

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