IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 2, July 2022
Impact Factor: 6.252

Automatic Face Mask Detection using PCA

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Abstract: *The corona virus COVID-19 pandemic is causing a global health crisis so the effectiveprotection methods is wearing a face mask in public areas according to the World Health Organization (WHO). The COVID-19 pandemic forced governments across the world to impose lockdowns to prevent virus transmissions. Reports indicate that wearing facemasks while at work clearly reduces the risk of transmission. An efficient and economic approach of using AI to create a safe environment in a manufacturing setup. This paper represents an implementation of Principal Component Analysis (PCA) on masked and no masked face recognition. Security is an essential term in our today's life. In various Biometric technology, face recognition is widely used to secure any system because it is better than any other traditional techniques like PIN, password, fingerprint etc. and most reliable to identify or verify a person efficiently. In recent years, face recognition is a very challenging task because of different occlusion or masks like the existence of sunglasses, scarves, hats and different types of make-up or disguise ingredients. The accuracy rate of face recognition is influenced by these types of masks. Many algorithms have been developed recently for non-masked face recognition which are widely used and give better performance. Still in the field of masked face recognition, few contributions has been done. Therefore, in this work a statistical procedure has been selected which is applied in non-masked face recognition and also apply in the masked face recognition technique. PCA is more effective and successful statistical technique and widely used. For this reason in this work, PCA algorithm has been chosen. Finally, a comparative study also done here for a better understanding.*

Keywords: Machine learning, PCA Algorithm, Eigen Face, Eigen Value. Face MaskDetection

I. INTRODUCTION

The input face mask identification system is a video obtained and the final result an identification or detection of the mask of detected video database. From these issues, mitosis detection is significant feature in detecting the level of face progression. The process of identifying the variations in faces and train count is very tough for pathologists because of two reasons, the size and shape of the mitotic nuclei are same as like non-mitotic nuclei, and pathologist would develop a huge amount of histopathological images. Automated mitotic cell detection and segmentation methods are proposed for multispectral histopathological images

Face recognition is one of the most promising field of computer vision. Recognize a face and verifying a person automatically from images, known as face recognition system [1]. Face recognition plays an important role in our regular life. In a passport checking, ATM, credit card, voter verification, smart door, criminal or terrorist investigation and many other purposes face recognition is widely used to authenticate a person automatically and accurately. For those reasons, face recognition is the most popular than any other Biometric techniques.

In all automated personal identification system, face recognition has gained much attention as a unique Biometric recognition technique. For protecting the assets of many industries in the world are now trying to implement this authentication technique in their organizations. Throughout the world, many of the governments also interested to secure the public places such as railway stations, airports and bus stations etc. by using face recognition system. Recently many algorithms have been developed for reliable face recognition. Different techniques depend on different methods and they have different recognition accuracy. All of these algorithms, Principal Component Analysis (PCA) gives a better accuracy rate in normal or non-masked face recognition.

In present days masked face recognition is more important. Mainly terrorists and criminals covered their face with mask for disguise. Besides this, sunglass, hat, color festoon etc. also act like mask. Using different types of masks or occlusions the key features to identify a person is decreasing. Lower numbers of face features in the masked face cause difficulties than other normal face recognition technique

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Fig 1: Various People using mask.

II. LITERATURE SURVEY

An Automated System to Limit COVID-19 Using Facial Mask Detection in Smart City Network (Base Paper)[1]:
COVID-19 pandemic caused by novel coronavirus is continuously spreading until now all over the world. The impact of COVID-19 has been fallen on almost all sectors of development. The healthcare system is going through a crisis. Many precautionary measures have been taken to reduce the spread of this disease where wearing a mask is one of them. In this paper, we propose a system that restrict the growth of COVID-19 by finding out people who are not wearing any facial mask in a smart city network where all the public places are monitored with Closed-Circuit Television (CCTV) cameras. While a person without a mask is detected, the orresponding authority is informed through the city network. A deep learning architecture is trained on a dataset that consists of images of people with and without masks collected from various sources. The trained architecture achieved 98.7% accuracy on distinguishing people with and without a facial mask for previously unseen test data. It is hoped that our study would be a useful tool to reduce the spread of this communicable disease for many countries in the world.

Case cade framework for masked face detection[3]:
Accurately and efficiently detecting masked faces is increasingly meaningful, since it can be applied on tracking and identifying criminals or terrorists. As a unique face detection task, masked face detection is much more difficult because of extreme occlusions which leads to the loss of face details. Besides, there is almost no existing large-scale accurately labeled masked face dataset, which increase the difficulty of masked face detection. The CNN-based deep learning algorithms has made great breakthroughs in many computer vision areas including face detection. In this paper, we propose a new CNN-based cascade framework, which consists of three carefully designed convolutional neural networks to detect masked faces. Besides, because of the shortage of masked face training samples, we propose a new dataset called "MASKED FACE dataset" to fine-tune our CNN models. We evaluate our proposed masked face detection algorithm on the MASKED FACE testing set, and it achieves satisfactory performance.

Study of the Performance of Machine Learning Algorithms for Face Mask Detection[2]:
Nowadays, the situation of the Covid-19 virus still intensifying throughout the world. The number of populations of each country is severely infected and deaths. One solution to preventis to wearing a masked face. Many businesses and organization need to adapt and protect an infected person by detecting whoever does not wear masked face; however, the number of users or customers are more than staffs result in difficult checking. This paper studies the performance of the three algorithms: KNN, SVM and Mobile Net to find the best algorithm which is suitable for checking who wearing masked face in a real-time situation. The results show that Mobile Net is the best accuracy both from input images and input video from a camera (real-time).

Masked Face Recognition Using Convolutional Neural Network[4]:
Recognition from faces is a popular and significant technology in recent years
Face alterations and the presence of different masks make it too much challenging. In the real-world,when a person is uncooperative with the systems such as in video surveillance then masking is further common scenarios. For these masks, current face recognition performance degrades.An abundant number of researches work has been performed for

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recognizing faces under different conditions like changing pose or illumination, degraded images, etc. Still, difficulties created by masks are usually disregarded. The primary concern to this work is about facial masks, and especially to enhance the recognition accuracy of different masked faces. A feasible approach has been proposed that consists of first detecting the facial regions. The occluded face detection problem has been approached using Multi-Task Cascaded Convolutional Neural Network (MTCNN). Then facial features extraction is performed using the Google Face Net embedding model. And finally, the classification task has been performed by Support Vector Machine (SVM). Experiments signify that this mentioned approach gives a remarkable performance on masked face recognition. Besides, its performance has been also evaluated within excessive facial masks and found attractive outcomes. Finally, a correlative study also made here for a better understanding.

Control The COVID-19 Pandemic:

Face Mask Detection Using Transfer Learning Currently, in the face of the health crisis caused by the Coronavirus COVID-19 which has spread throughout the worldwide. The fight against this pandemic has become an unavoidable reality for many countries. It is now a matter involving many areas of research in the use of new information technologies, particularly those related to artificial intelligence. In this paper, we present a novel contribution to help in the fight against this pandemic. It concerns the detection of people wearing masks because they cannot work or move around as usual without protection against COVID-19. However, there areonly a few research studies about face mask detection. In this work, we investigated using different deep Convolutional Neural Networks (CNN) to extract deep features from images of faces. The extracted features are further processed using various machine learning classifiers such as Support Vector Machine (SVM) and K-Nearest Neighbors (K-NN). Were used and examined all different metrics such as accuracy and precision, to compare all model performances. The best classification rate was getting is 97.1%, which was achieved by combining SVM and the MobileNetV2 model

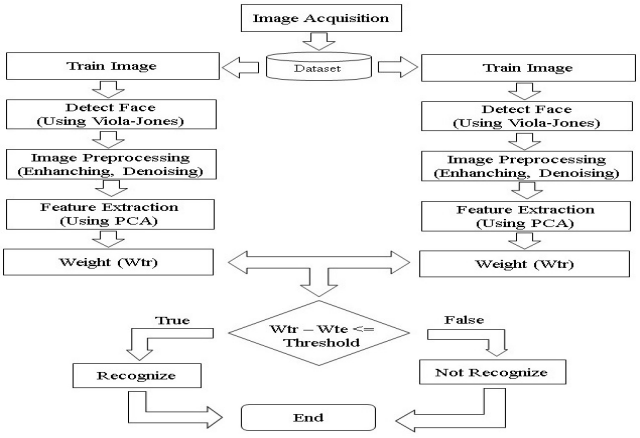
III. PROPOSED METHOD

From a digital image or video sources identify or verify aperson automatically by comparing facial features is called face recognition. Using various algorithms, features are extracted and then perform comparison between trainingimage and test image for recognize a face.

3.1 Facial Image Acquisition

Image acquisition is the first stage of face recognition system. After obtaining the images, different methods of processing can be applied on the image. If the image has not been acquired correctly then the desired tasks are difficult to achieve. In this work we use faces from a database named ORL Database and some of our own captured images. We mix up our own masked and non-masked images to the database to enlarge the dataset so that our work is more reliable and efficient.

3.2 Detecting Face and Preprocessing



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After acquiring the images, the first work is to segment out the face for further processing. We choose Viola-Jones face detection algorithm for detecting face region. Then implemented it in the MATLAB library to automatically segment the face region. Some of our face images quality arenot much better as we needed. Up to expectation this face detector fails to detect face region in image. Faces which areheavily disguised or most of the important facial features arecovered are subjects to fail detect face region. Every face image is normalized and apply image enhancement methods,so to achieve better results. This set of enhanced face imagesare therefore used to perform further experiments and evaluations.

3.3 Facial Feature Extraction using PCA

Principal Component Analysis (PCA) is an important statistical procedure and also defined as an orthogonal linear transformation. This algorithm emphasizes variation and brings out strong patterns in a dataset. It is used to minimize abig dataset to a small dataset still contains almost all the information as large dataset. PCA finds the data mean and principal components. It is popular as dimension reduction procedure. The technique is usually used for maximizing variance and seizing strong patterns of features in a dataset [8].It was introduced by Karl Pearson in 1901. PCA is an effectivestatistical method.

For correlated data, Principal Component Analysis (PCA) works well. An image is also a highly correlated data. Hence extracting features from images, PCA performs better. Performing different operations on image matrix, it is transformed to a lower dimensional Eigen subspace. There after find out the covariance matrix from the lower dimension matrix. Relative variance between pixels in an image are represented by covariance matrix. Afterward Eigen vectors are

Calculated from this covariance matrix. Eigen vectors with the highest Eigen values are considered as the principal components

Steps of Principal Component Analysis algorithm arementioned below-

Step 1: Input data
Step 2: Calculate mean value of data
Step 3: Subtract the mean value from each input data
Step 4: Calculate Covariance matrix
Step 5: Calculate Eigen vectors and Eigen values
Step 6: Finding the greatest eigenvalue(s)
Step 7: Calculate Weight

3.4 Eigenvalue and Eigenvector

Eigenvalue and eigenvector comes from German word “Eigen” that means “Characteristic”. In a square matrix eigenvalue is a scalar that represent by λ, which is a Greek letter. Eigenvector is represented by small letter x and it is anon-zero vector [9]. Here is an equation which is satisfied by all eigenvector and eigenvalue. Here, S is a given square matrix.

$$Sx = \lambda x (1)$$

3.5 Eigen Face

Basically a set of eigenvector is called Eigen face which isused for face recognition of human. Eigen face extract the main feature from image and major Eigen face is selected forface recognition. In face recognition, Eigen face is used for represent the face image efficiently by principal component analysis. Images can be reconstructed as like as original image from a few number of weights and pictures [10]. Eigen face ina face recognition system must be less or equal to the total size of dataset. In figure 3 shows some of Eigen faces.

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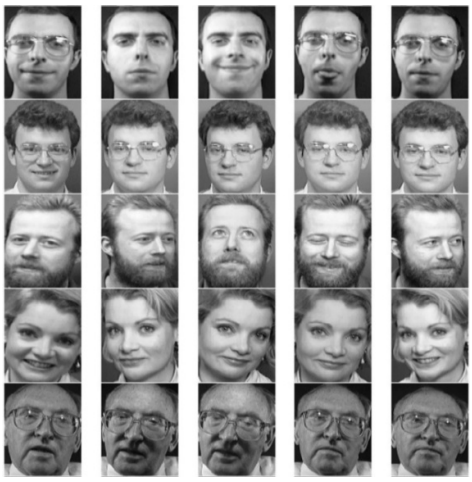

Fig. 3. Some Eigen faces.

IV. MATHEMATICAL ANALYSIS

For face recognition we need to train a dataset and then apply Principal Component Analysis on train dataset step bystep. At first, we have to convert train dataset into face vector.Each 2D (p by q) train image is converted into 1D ($p \times q$ by 1)face vector. After converting all images, they are loaded which is called dataset. In this research work, total images K= 12 (face of our dataset). Here K depends on the number of trainimages and I is a variable which loads all images.

$$I = \{\Gamma_1, \Gamma_2, \Gamma_3, \cdots\cdots\cdots, \Gamma_K\} \quad (2)$$

After load the dataset next procedure is to calculateaverage or mean face

Then, subtract the mean face from each image of the dataset which is called normalization. Here ϕ_n is a variable which stores the result of normalization. Then new matrix $D$is generated,

$$\phi_n = \Gamma_n - \bar{X}$$

$$D = \{\phi_1, \phi_2, \phi_3, \cdots\cdots\cdots, \phi_K\} \quad (4)$$

After normalizing, we get a normalized face vector. Thenwe calculate covariance matrix of normalized vector.

$$C = DD^T\text{s}$$

Covariance matrix C is a large square matrix. For efficientand accurate calculation eigenvalue and eigenvector is calculated for reducing a huge face space vector. For recognition, we need to calculate weight which is compared with test image weight

$$\omega_K = {}^T(\Gamma_n - \bar{X})$$

V. EXPERIMENTAL RESULT

Proposed methodology is applied on our dataset images and found the resultant images. First step of face recognitionis created a training dataset which contains pre-processed input images. After creating training set, average face is calculated for normalized training set. For normalize thedataset, subtracting an average face from each original face. Figure 5 shows the normalized faces of original face image. Then calculate the Eigen face which are shown in figure 6. Finally test some images for recognition. Here create some masked face images and also test them if it can be recognized the person properly

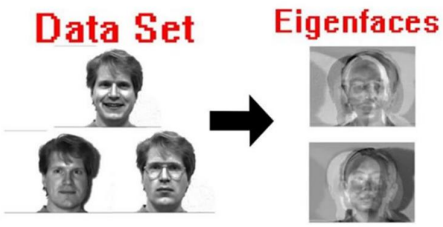

Fig. 4. Some Eigen faces

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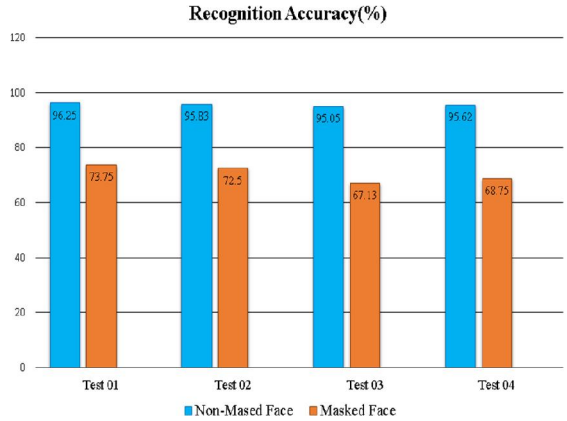
Fig. 5. Testing (a) Masked face and (b) Non-Masked face

A statistical comparison between masked face recognitionand non-masked face recognition using PCA algorithm shownin table-I. This table shows the recognition accuracy of both masked and non-masked face images. A graphical representation also shown in figure 8 for a better data visualization.

Test no.	Total trainimage	Total testimage	Image types	Accuracy(%)
Test 01	300	80	Non-masked	96.25
	300	80	Masked	73.75
Test 02	300	120	Non-masked	95.83
	300	120	Masked	72.50
Test 03	300	160	Non-masked	95.05
	300	160	Masked	67.13
Test 04	300	200	Non-masked	95.62
	300	200	Masked	68.75

Table I: Masked and Non-Masked Face Recognition Accuracy

Fig. 8. Graphical representation of both masked and non-masked facerecognition accuracy



From the above table, accuracy of masked face image recognition is on average 72% where non-masked face is on average 95%. So PCA gives poor recognition rate for maskedface images rather than non-masked faces.

VI. CONCLUSION

This paper analyzed non-masked face recognition andmasked face recognition accuracy using Principal Component Analysis (PCA) to recognize a person. It is proved that, a face without mask gives better recognition ratein PCA based face recognition system. But when a person iswearing mask, facial recognition gives poor recognition rate.It is found that extracting feature from a masked face is less than non-masked face. Because of missing features for wearing mask which decrease the recognition rate. Finally, we conclude that traditional statistical algorithm Principal Component Analysis (PCA) is better for normal face recognition but not for masked face recognition. So in the future, our concern to improve the accuracy of masked face recognition using other sophisticated machine learning methods

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