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A Novel Approach to Detect Face Mask using CNN

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***Abstract*—Face detection and recognition will be considered as one of the most intriguing modalities for biometric models. Those researches are mainly required for ensuring security in a most sensitive area. This research paper has proposed a very fast image pre-processing with the mask in the center over the faces. For this system, features extraction and Convolutional Neural Network are used for classification and detection of a masked person. This research work will be carried out in three levels: preprocessing the images, cropping the images and classification of the images. This helps to detect whether the face is masked or not. A webcam or CCTV camera surveillance will record all the time and it checks whether the person is wearing a mask, if the person doesn't wear a mask then the system gives a security alert.**

Keywords—Transforming CNN, Features extraction, Images classification

I. INTRODUCTION

Recent work on the security system has shown great craft. Due to COVID-19 people are died and every day many peoples are inflected by this virus. 213 countries are affected by coronavirus, including all of the development countries like the USA, UK, Russia, China, Japan, Italy, etc. By the report, in 213 countries around the world total of 20 million inflected have been confirmed more than 737,000 people have died from this virus. The major cause of inflected the virus was the carefulness of the peoples and lack of their consciousness. Everyday people entire the office or other apartments without any mask on their faces [21]. It's very difficult to surveillance all the time and also time-consuming. This research mainly helps to solve this problem and help people to protect themselves. Especially in COVID-19, it's an important thing to save ourselves from other peoples [1]. Now a day's this security system increasing which leads to a remarkable change in our daily life. Therefore, the Security system has a crucial rule to safeguard people. Mask face recognition is one of the research areas among practical applications. It may use in the area of law enforcement for surveillance [22]. Security being used for a particular area with CCTV cameras to assure that the place has more security due to wear the mask to the face, mainly in this situation [2]. It monitors the people who didn't wear the mask to delicate areas and matching their images to pre-stored database images to give the accessibility of the person to the place [19].

Several methods are available for detecting mask faces include different angles [6]. This paper involves building a system for mask face detection using several classifiers available on CNN. For security purposes mask face detection is faster than other security systems since multiple faces can be analyzed or detected at the same time. Work with the CNN gives higher accuracy to detect the mask face in a particular area and it's a little bit sensitive when the face comes into the area of the webcam, so it's faster than others.

II. RELATED WORKS

P. Viola et al. [23] discussed a face detection framework which is capable to detect face rapidly over the high detection frame rate. Their paper done by three contributions are integral image, built an efficient classifier by AdaBoost learning algorithm and lastly combining a classification into the cascade for background region. Viola-Jones locator improved the highlights of Haar, yet neglected to handle this present reality issues and was impacted by different components like face brilliance and face direction. It sole detect the frontal sufficiently bright faces and also failed to work in a dark environment and with a non-bright face image. The specialist said if people wear masks, the spreading of COVID-19 will minimize [3]. X. Liu and S. Zhang[2] described the place of origin and the history of the

coronavirus. They also described the protection of the coronavirus by wearing a mask, but their paper didn't any proposed model and didn't use any algorithm. M. Loey et al. [4] worked with GAN for the detection of coronavirus in chest x-ray images using deep learning. Lack of dataset for detecting coronavirus in the chest-x-ray sector was the main motivation of this paper. M.K.J. Khan et al. [9] worked to remove the microphone object from the face of an image. They used the MRGAN method to solve this problem. Their work is divided into two stages, one is in painter and the other is a refiner. S.A. Hussain et al. [10] worked for detection and recognition of image using haar cascade with the support of Keras, CNN. They had three phases where the first phase was detected human face from the camera, the second phase was analyzed the captured image and the third phase was classified the face with their emotions as happy, sad, neutral, angry, etc. Z. Wang et al. [11] described three types of mask face datasets, those are MFDD, RMFRD, and SMFRD. M. Kawulok et al. [12] described face detection and analysis of face using deep learning. Their aim was facial analysis, deception detection, various physiological disorder prediction, etc. L.Wen et al. [13] their system able to detect fault diagnosis with the help of deep learning. Focused on ImageNet and ResNet-50 provided higher accuracy where they showed their accuracy of 99.99% using TCNN (ResNet-50). P. Gupta et al. [17] proposed a model using CNN which able to detect and recognize a human face at a time. Their work showed 97.05% accuracy with the help of Yale's face detect dataset. L.Wang et al. [19] paper showed facial recognition with the help of LBPH for surveillance and anti-theft security purposes. In their work they also used drone technology systems to give an extra boost to their surveillance. Z. Abidin et al. [20] discussed facial expression recognition using fisherface, where the accuracy achieved 89.20%. P. Pattanasethanon et al. [21] proposed a system which recognize a face with the help of eigenface. They also focused on special regions of the face as nostril areas and oral areas, although they had a little amount of dataset, they achieved 100% accuracy for their work. T. Schenke et al. [22] described a facial recognition system with the help of raspberry pi using CNN, KNN with eigenface, and SVM, where the SVM algorithm showed higher accuracy for facial recognition.

Some limitations are detected on the existing models, where some works have limited dataset or they will not give security alert and does not work properly work on mask face, so this work aim to detect mask face in this pandemic situation to prevent coronavirus. Let see some limitation of existing models.

Table 1. Limitation of existing system

Serial Number	References Number	Limitation
01	1	Don't have any methodology, system architecture, and result analysis. They just discuss the use of mask in this covid-19 situation.
02	2	They don't detect mask face. Just focus on how to prevent transmission of COVID-19 wearing mask face.
03	8	Work on detect face base on YOLOv3. No work with mask face.
04	10	No work with mask face detection. They explain real-time face emotion recognition.
05	12	Don't work with mask face recognition. Just work with psychological based facial dynamic recognition.

III. PROPOSED SYSTEM

This system works to detect masked face in this COVID-19 situation to occupy a significant part in order to transform coronavirus from one person to another person. To detect the mask face the CNN algorithm is used in our project which gives higher accuracy. This project able to detect the mask's faces very fast from every possible angle. While a person comes to the surveillance area without wearing a mask then the system provides a security alert to notify the authority.

This paper presents a geminate mask face detector that can able to detect mask face and it regardless of arrangement and train it in a proper neural system to get precise outcomes. It takes an RGB input image from any orientation to obtaining output. The main work of this function is feature extraction and class prediction to the images. In the feature extraction system, the image is sketched and created into a new image where the generated image is more efficient than the previous image. In this part, a large number of images dimensionally reduce to an efficient representation in which an interesting part of the image is a capture.

After doing features extraction in every convolutional layer it gives an output that works better for the image and represents those images a set of labeled images. In our proposed model mask face can be detected from the segmented image or using the webcam. Firstly the size of the input image resize 100*100 and perform feature extraction and prediction. Background noise also reduces and performs filtering to remove high frequency from the input image. After completing the training process it gives us some model data with their accuracy level. In this system three-parts work out to complete the process, the first part is connected with the dataset, the second is created some model with accuracy, and the third part is to detect the mask face.

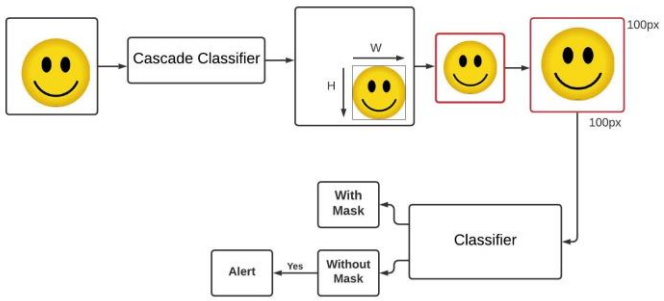

Fig. 1. Proposed system

IV. System Operation

This section will discuss about the working architecture for our proposed model. To detect mask face firstly load the training and testing images into our python IDE. Our model has three-parts which burn into our IDE. While it being the process of the dataset then it will generate 20 models with their accuracy level. Now the algorithm work with the higher accuracy model for better performance.

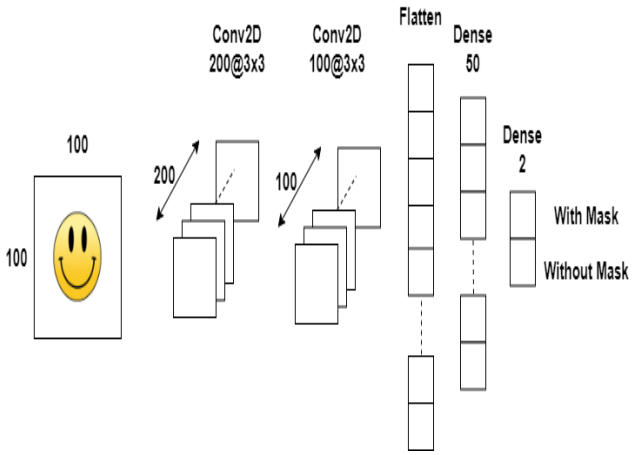

Fig. 2. System architecture of CNN

Firstly some pixels of an input image enter into a first convolutional layer, then those convoluted pixels admin into the second max-polling layer. The output of the max-polling layer ready for entire the second convolutional layer. After computing the second max-polling layer the pixels are prepared for the fully connected layer.

A. Pseudocode

Call Sequential()

Conv2D(200,(3,3),input_shape=data.shape[1:])

Activation('relu')

MaxPooling2D(pool_size=(2,2)

Conv2D(100,(3,3))

Activation('relu')

MaxPooling2D(pool_size=(2,2))

Flatten()

Dropout(0.5)

Dense(50,activation='relu')

final layer which has 2 neurons

Dense(2,activation='softmax')

V. Experimental Analysis

This proposed research work will be carried out in three parts. Due to the limited masked face dataset, it become more complex to learn better features about the masked face detector [6]. For better accuracy and better performance need a much larger dataset but in our dataset had used 690 mask face images and 686 without mask face images. The first layer of our project connects with the dataset and convert the images into grayscale [7][14] with the size of 100*100 also categorize the image into the list. In the second layer, it again loads the dataset which already saved from the previous layer. It burns into the system and generates 20 models with some accuracy level. This model is used to deliver higher accuracy for further processing and sets an alert if the person is not wearing the mask.

A. Transforming the data

This section represents the convolution use of a mathematics equation with an asterisk * sign. Where X representing the input image and f representing the filter, at that point the articulation would be,

$$Z = X * f \text{.....(1)}$$

Here, some images with size 3x3 and a filter of size 2x2.

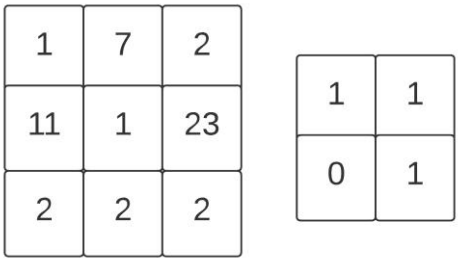

Fig. 3. Filtering 3*3 to 2*2 image

Then multiplication process is performed. Here, the image is segmented into several parts. The filter will consider a small part of image at a time. For example:

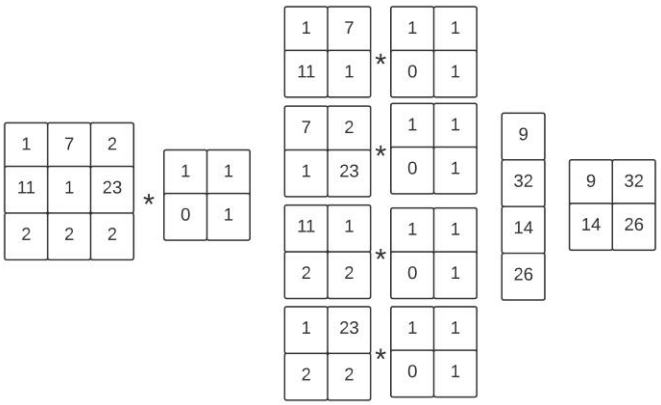

Fig. 4. Segment the images into several part

Look at that closely – it can be noticed that the filter is considering a small portion of the image at a time. It can also be imagined as single image that has been broken down into smaller parts, each of which is convolved with the filter.

The above picture contains 3*3 pixels and also 2*2 filters where the filter runs across the image from top left to right then all the pixels are covered to convolved output.

$$1 \times 1 + 7 \times 1 + 11 \times 0 + 1 \times 1 = 9$$

$$7 \times 1 + 2 \times 1 + 1 \times 0 + 23 \times 1 = 32$$

$$11 \times 1 + 1 \times 1 + 2 \times 0 + 2 \times 1 = 14$$

$$1 \times 1 + 23 \times 1 + 2 \times 0 + 2 \times 1 = 26$$

There is a 3x3 image and a 2x2 filter. It is easy to convert 2x2 output. However, the state of yield can be detected for a more perplexing input image and filter. For this problem,

Measurement of picture = (n, n)
Measurement of filter = (f, f)
Therefore, the measurement of final output will be ((n-f+1), (n-f+1))

So, the convolutional layer extracted valuable features from input data. Then the feature sent it to a fully connected layer for the final result. The fully connected layer of CNN is the traditional neural network. The yield of the convolution layer is a 2D array [17]. However, a completely associated layer can just work with a 1D array. For this, the output from the convolution layer first converts into a 1D array.

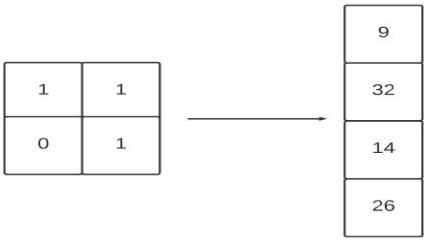

Fig. 5. Convert 1D array

Then converted 1D array send to the completely associated layer. The entirety of value considers as a different feature that speaks for the image. The completely associated layer performs two transformations, one is linear and another is non-linear.

Firstly apply the direct change (linear transformation) on this information, the equation stands for

$$Z = W^T * X + b \quad \ldots\ldots\ldots(2)$$

Here, X means input, W means weight, and b stands for a constant value. The graphical representation is given below,

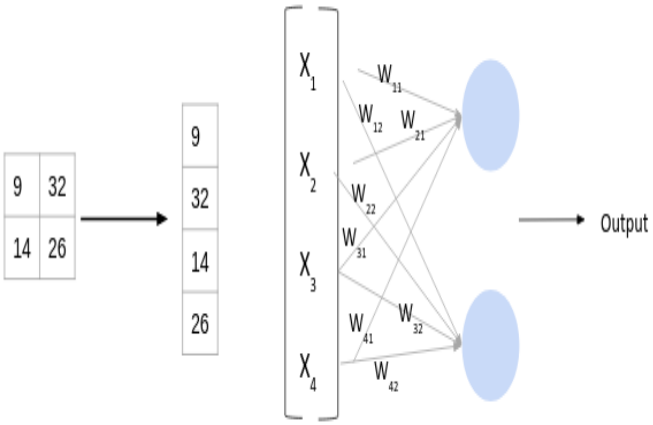

Fig. 6. Fully connected layer

The Non-linear Transformation cannot work alone. The Non-linear Transformation needs an additional function called the activation function. The activation function depends on the type of problem. Here ReLU is used. The equation is,

$$f(X) = \max(0, X) \quad \ldots\ldots\ldots(3)$$

f(X) misleads zero when X is under zero and f(X) is equivalent to X when X is greater or equivalent to zero.

At the end of all work our system able to detect mask face and also detect without a mask with a security alert into a live cam. Here only one output sample is shown below.

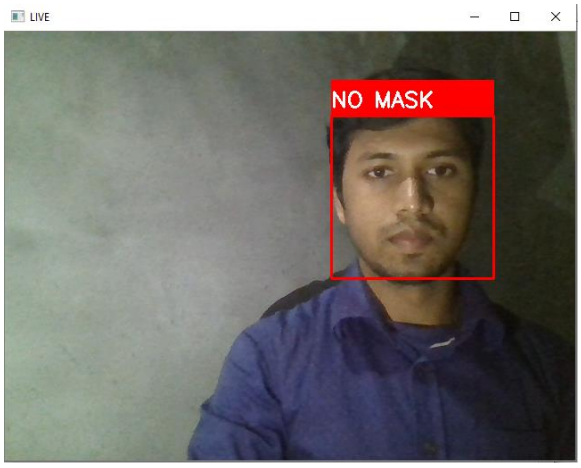

Fig. 7. Detected no mask face

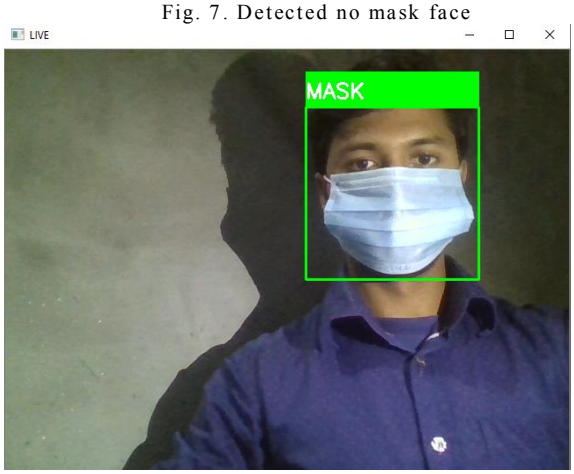

Fig. 8. Detected mask face

VI. RESULT ANALYSIS

In the field of face recognition CNN adopted the main method where the convolutional layers are combined into a single layer. For its combined convolutional neural network gives higher accuracy than the rest of other algorithms, also it quite fast compares with other algorithms. Detection of a masked face showed a higher accuracy rate and capable of faster detecting the mask face and without mask face of a person, which helps systematically detection of a person over the visual detection.

During this COVID-19 period many research trying to work about face mask detection and wearing masks [1]. Many of them are come out with good accuracy and validation except giving automatic alert. Our experiment has been performed about 1,376 images (available on GitHub) with mask and without mask face. Out of those images, 90% of images were used for the training dataset and 10% dataset was used for testing purposes.

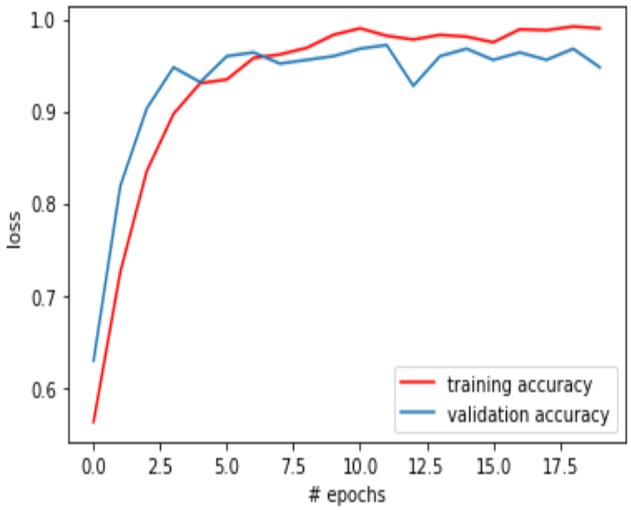

Fig. 9. Training and validation accuracy

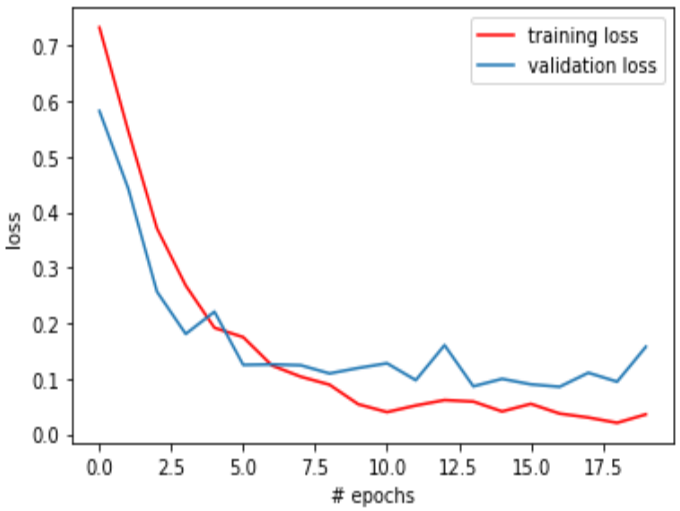

Fig. 10. Training and validation loss

After the post-processing of our model, it generates some models with frequent number of accuracy which used further processing with generated higher accuracy which was 0.98 whereas validation lost 0.0855 and validation accuracy 0.9637.

Some accuracy of other research papers and their used algorithms.

Table 2. Accuracy with other algorithms

No.	Ref.	CNN	DNN	Eigen face	Fisher Face	LBPH	1-NN	Accuracy
1	17		√					97.5%
2	18						√	100%
3	19					√		91%
4	20				√			86.85%
5	22			√				83.10%

VII. COMPARATIVE STUDY

Table. 3. Comparative Study

SL No.	Proposed System	Existing Systems
01	In this proposed system, CNN is used to detect mask faces.	Other authors used CNN with filter operation (2D-Gabor filter), Haar-Cascade, etc, to detect mask face.
02	Our algorithm has less complexity.	On the other side existing systems have a little more complexity.
03	This system Provides a security alert when a person doesn't wear a mask.	Previous systems did not give security alerts.
04	Proper explanation of each methodology.	Fewer dislikes have been seen.
05	Detecting time very fast.	Take more time than ours.

VIII. ADVANTAGE

During this pandemic, situation peoples are trying to stave the COVID-19 all over the world. Some advantages of wearing mask on the face are

i. Detect mask face with in 0.5s.

ii. Provide security alert whereas mask face not found.

iii. Can give protection of spreading coronavirus.

iv. Take awareness of COVID-19 using security alert.

IX. FUTURE WORKS

As our project can't ensure to detect face from every angle so in the future, it can be developed to detect and work fluently from every angle. In this pandemic situation, people are more involved in crime by wearing a face mask. The proposed model can detect and recognize the person irrespective of their masked face [6] [11], it may help to reduce crime all over the country [22].

X. CONCLUSION

This paper works along with CNN to detect masked face in a secured way and for establishing a better surveillance, a security alert is deployed -for this and ensures the surveillance of the place [19]. For this work, some dataset are available and it quite small but gives away a better accuracy. The system shows up some models with higher accuracy and based on this model, the proposed project layer has worked and ensured the outcome.

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