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Real-Time Face Mask Detection in Mass Gatherings to Reduce COVID-19 Spread

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Abstract:
The Covid 19 (coronavirus) pandemic has become one of the most lethal health crises worldwide. This virus gets transmitted from a person by respiratory droplets when they sneeze or when they speak. According to leading and well-known scientists, wearing face masks and maintaining six feet of social distance are the most substantial protections to limit the virus's spread. In the proposed model we have used the Convolutional Neural Network (CNN) algorithm of Deep Learning (DL) to ensure efficient real-time mask detection. We have divided the system into two parts—1. Train Face Mask Detector 2. Apply Face Mask Detector—for better understanding. This is a real-time application that is used to discover or detect the person who is wearing a mask at the proper position or not, with the help of camera detection. The system has achieved an accuracy of 99% after being trained with the dataset, which contains around 1376 images of width and height 224×224 and also gives the alarm beep message after the detection of no mask or improper mask usage in a public place.

Keywords: *Covid, Machine learning, Face mask detection, Deep Learning.*

1. Introduction

Covid (coronavirus disease) was first identified in Wuhan, a city in central China, in December 2019, and its first case in India was reported in Kerala on 27th January 2020. Around 152 million people are affected [20] by this pandemic. By 2022 it had become a part of our lifestyle as a normal cold and cough. Covid is a contagious disease that gets transmitted when an infected person comes in contact with another person, particularly when individuals sneeze or otherwise release droplets into the air. The spread of this coronavirus rises from person to person [1]. According to researchers the only way to protect from, or to prevent a coronavirus transmission is by using sanitizer of at least 70% alcohol, using a face mask, and maintaining social distance. These steps are the only way by which we can at least stop the spread of this virus. No medicine can completely eradicate this problem, but vaccines exist (although they are not 100% effective). Prevention is better than cure, so following the guidelines provided by the government is a necessary step towards improvement in transmission rates.

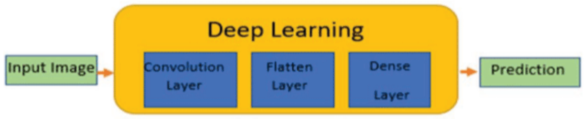


Figure 1. Deep learning structure

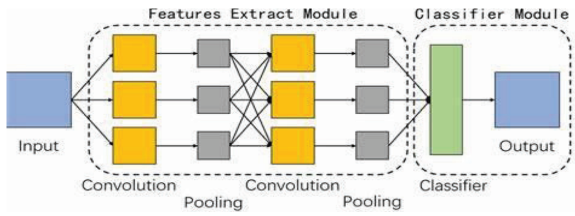


Figure 2. The classic structure of CNN

In this application, we are trying to build a real-time system application (face mask detector) that will detect whether a person is wearing a mask or not; it also checks if the mask is in the right position (properly covering the nose and mouth). Manual monitoring can be done, but technology can help in preventing infection. Deep Learning (DL) (Fig. 1), part of Machine Learning, is used efficiently in many projects for detection, recognition, recommendations, and so on. It allows us to analyze massive data in an efficient way (fast and accurate). We had decided to use the same proposed learning in our face mask detection model. This real-time face mask detection model can be integrated with surveillance cameras [8] and can detect in real time without the need of any website [17]. This type of model can be implemented in public gatherings like railway station gates, airport entrance checking gates, mall entrances, and so on. It can be further implemented in college and school auditoriums with the addition of a database and can be made better. We used a dataset from Kaggle (prajna Bhandari). This model will use many libraries, such as opencv, keras, tensorflow. It uses Convolution neural network (CNN) Figure 2, mobilenetv2, VGG16. These libraries and algorithms have their importance and can provide an efficient model.

2. Literature Review

Militante & Dionisio et al. [5] have presented their research paper on "Face Mask Detection" and a dataset

Table 1. Comparison of different Covid models

Papers/Attribute	Accuracy	Face count	Voice Recommendation	Algorithm
Mohammad Marufur Rahman et al. [2]	98.7%	No	No	CNN
Nieto-Rodríguez et al. [6]	95%	No	No	CNN
Das, Ansari & Basak et al. [4]	95.77%	No	No	CNN
Militante & Dionisio et al. [5]	96%	No	No	ANN
Wadii Boulila et al. [7]	93.4%	No	No	R-CNN, YOLO
S. V. Kogilavani [21]	97.68%	No	No	VGG16

of around 25,000 images is being used, with a pixel resolution of 224×224 with an accuracy of 96%. To replicate the stimulation of the human brain Artificial Neural Network (ANN) is used. In this work, Raspberry pi detects the proper mask-wearing in public areas, and if someone is entering without a mask, sets off an alarm to create awareness. Das, Ansari & Basak et al. [4] have presented their research paper on mask detection as well. In their research work, the 2 datasets have been compared on the basis of accuracy and loss results in the dataset. OpenCV, TensorFlow, and Keras libraries were used to get the favorable result. Das et al. have defined their own datasets for detection: datasets contain a total of 1376 images, 690 with masks and 686 without masks. A 2nd dataset was taken from Kaggle, which has a total of 853 images and has been separated into two classes (with mask and without a mask). They have trained their model with 20 epochs and with a test split of 90% training and 10% validation data. Based on the mentioned dataset, the conclusion is an accuracy rate of 95.77%, and 94.58% for dataset1 and dataset2, respectively. Wadi et al. [7] have presented their research on real-time facemask detection based on deep learning concepts. The proposed model works on an offline as well as online approach. Offline approach works on Deep Learning (DL). With the help of DL, it will be easier to detect the face mask and whether it is properly worn or not. The next approach is an online approach which deals with deploying the Deep Learning model (DL) so that it can detect masking in real time. Mobile Net V2 technology is used for the research results. The authors made the comparison between several technologies—namely, ResNet50, DenseNet, and VGG16—but the best result was assured by MobileNetV2 in terms of training time and accuracy. This proposed system detects a face mask with 99% accuracy. Mohammad Marufur Rahman et al. [2] created their research on Automated Systems. They have used the technology named Deep Learning (DL). The researchers have made use of a deep learning algorithm in order to detect masks on the face. The facial images which the researchers have used are of two types (with mask and without a mask). The research done by the authors has an accuracy rate of 98.7%. Nieto-Rodríguez et al. [3] have presented their research paper, "System for Medical Mask Detection in the Operating Room through Facial Attributes." They have designed a method to detect surgical masks in an operating room. The researchers have used the combination of two detectors, one for faces and another for medical masks, which leads to enhancement of the model's performance, thus achieving 95% rate of accuracy in detecting faces with surgical masks. Its limitation is that the narrow method would not work in cases with faces more than a distance of 5 m away from the camera. Manoj et al.'s [19] Deep Learning-based paper emphasizes images, especially chest X Rays and CT scan. Input is taken as pictures and work on pattern and cluster structures confirms the actual status of the virus in the human body. The author shows how graphic design will give better and clearer results in understanding the problem. This image learning based model gives us a reliable result to diagnose the virus's actual position in the body. S. V. Kogilavani et al. [21] published a paper on how SARS-CoV-2 virus affects the Covid-19 and the cause of pandemic. In this paper the authors focus on how radiological techniques can support the system when lack of RT_PCR kits were not properly available. Due to the city scan concept and applying a Deep Learning algorithm (CNN architecture VGG, Desenet121) on datasets, they found 97.68 and 97.53 respective accuracy.

3. Methodology

3.1. Phase 1: Training

Dataset

In the dataset there are 1376 overall images: 690 with mask and 686 without mask [24]. The images in the dataset are collected from Kaggle, in which the overall proportion of mask and no mask images are the same, which makes the dataset balanced. To avoid Overfitting, we did Splitting the dataset into three different parts. The three parts are the Training dataset, test dataset, and validation dataset. In the training dataset, we train the model, in which the model observes and learns from the given dataset. In the Validation dataset, the hyper parameters, such as learning, and other parameters are selected. If a model has a greater number of hyper parameters, then we need large numbers in the validation dataset; a model with a lesser number of hyper parameters requires a smaller amount of validation dataset. This makes them easy to update and tune. In our dataset we have taken 60% of the dataset as Training dataset, 20% of the dataset as validation dataset, and remaining 20% as test dataset.

When our model is performing well in the validation dataset, then the learning can be stopped by the training dataset mentioned in Figures 3 and 4.

Figure 3. Without mask

Figure 4. With mask

Image processing

Now in this part, before moving ahead, we need to capture an image by the computer or pc's webcam and it requires pre-processing. For resizing and normalizing the images we have to do pre-processing of images to maintain the uniformity of the input images. After that we have to normalize the image, and then try to set the pixel range between 0 to 1. This normalization process helps the learning algorithm, by which learning is faster and captures necessary features from the images.

Training the model

Training the model is the most important step, as we used about 4095 images as a dataset, which is further divided into masked and no mask images. This will be used for training the model. We used keras TensorFlow as a basic building block for the model and Convolutional neural network (CNN) algorithm was also used.

3.2. Phase 2: Deployment

In the Deployment process, the first step of the procedure is to provide the training on the face mask detector and then the second step is to load the face mask detector, followed by performing face detection, and then the last step is to classify the face with mask and without a mask. Figure 5 clearly defines the steps to understand the process.

3.3. Approach

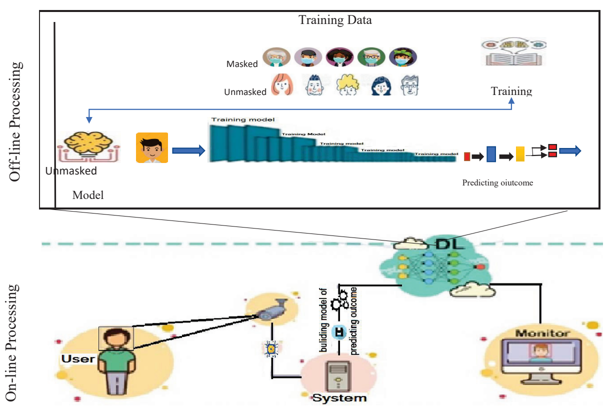


Figure 5. Predictive approach model

Flow Chart

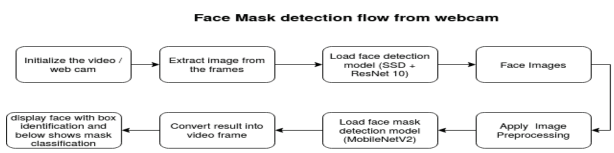
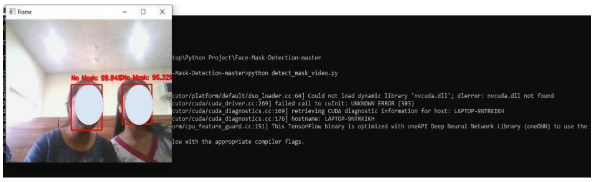


Figure 6. Face mask detection flow diagram

4. Inferences

We implemented our model on various live images mentioned in the figures below, which contained faces with and without masks. Some of the screenshots of the implementation are shown below:

Figure 7. Interface of face mask detection



In our proposed system we used Deep Learning algorithm (convolutional neural network, CNN) with an accuracy of 99.99%. This also had a sound alert system and face counting feature.

In our proposed system we had introduced an alert system: that is, if a person with no mask was detected then a beep alert will sound as a warning, otherwise a voice message you are allowed to go in will be there.

In our proposed system we had one more feature: the number of faces will be counted. As a person comes in the range of the camera they will be added to a count of faces.

Mathematical Model

This mathematical representation of the problem space detection will comprise the layer filter that needs to be put over the point-to-point representation with (1*1) layer on which new features will be evaluated. A method to represent the actual "depthwise separation" convolution block placed in the logic to form depthwise and pointwise convolution. The result produced by our method is somehow identical to the earlier mapped approach defined in convolution. With the modification in the speed our earlier concept. Mobile Net architecture is included in the proposed building block architecture in initial phase there are standard 33 convolutions in first access layer point to be nested by 13 iterations of this building blocks. These blocks have different category so their access dimension are based on number of levels of pooling between layers. While demonstrating the task of space representation we opt to select a feasible mode of approach to avoid compression stride of 2 layers is introduced. It's impacted the output channel with associated pointwise management by the factor of 2. In this manner the output response with 7x – 7x 1024 extract map in response to a 224 x 224 x 3

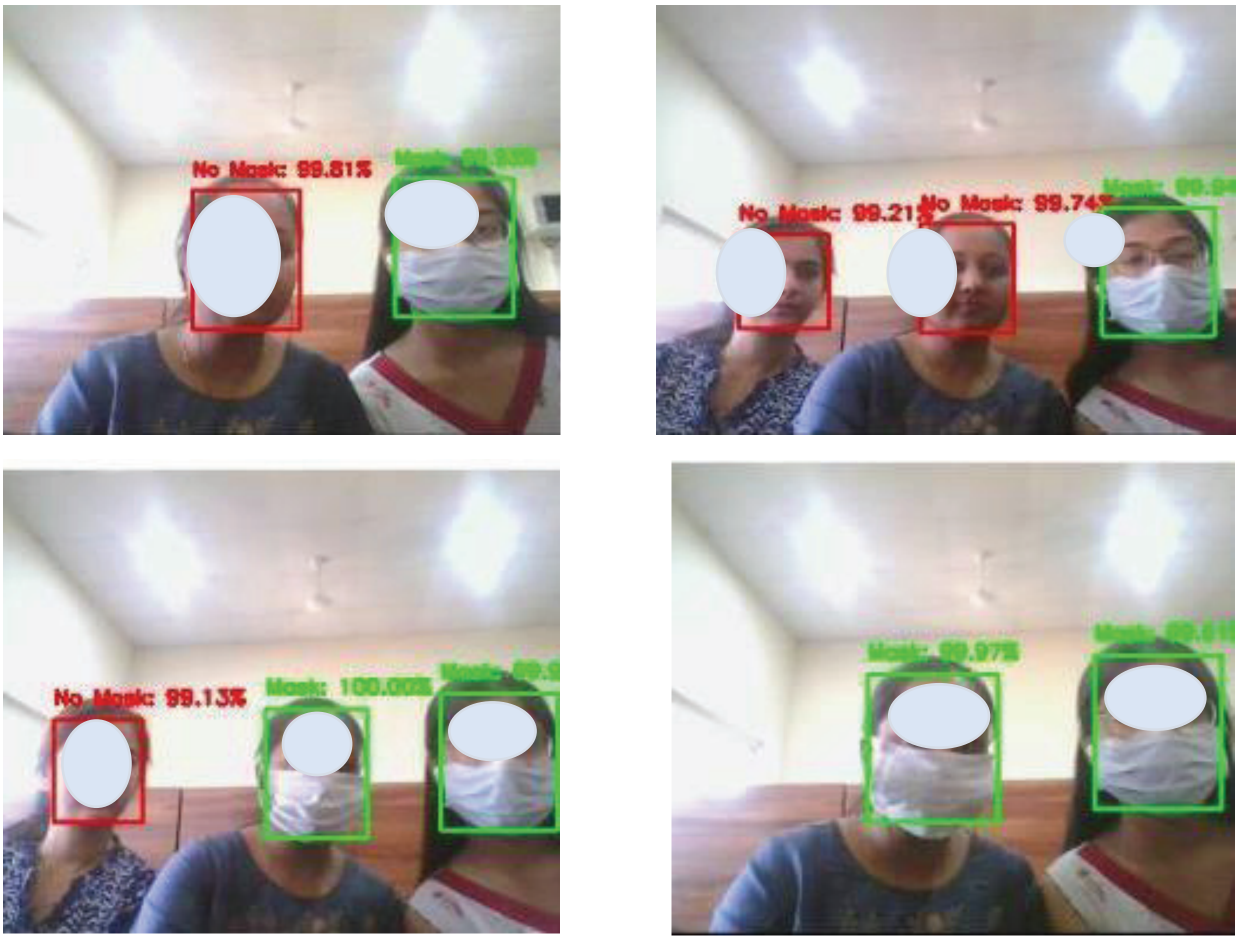


Figure 8. Final output of proposed work

```
# sound

label = "Mask" if mask > withoutMask else "No Mask"
if label == "Mask":
    color = (0, 255, 0)
    playsound("1.mp3", True)
    break
elif label == "No Mask" :
    color=(0, 0, 255)
    playsound("beep.wav", False)
    break
```

Figure 9. Code for sound alert

```
# only make a predictions if at least one face was detected
lenafter=len(faces)
if len(faces) > 0:
    # for faster inference we'll make batch predictions on *all*
    # faces at the same time rather than one-by-one predictions
    # in the above `for` loop
    faces = np.array(faces, dtype="float32")
    preds = maskNet.predict(faces)
    if(lenbefore != lenafter):
        numberOfFaces = len(faces)
        #print(numberOfFaces)
        foundstr='Found ' + str(numberOfFaces) + (' faces' if numberOfFaces > 1 else ' face')
        import win32com.client as wincl
        speak = wincl.Dispatch("SAPI.SpVoice")
        speak.Speak(foundstr)
lenbefore=lenafter
```

Figure 10. Code for face count

input values in image. The convolution layer will be optimized by batch normalization which comes into force for activation with ReLU6 mobile Net. Identical to the ReLu and have protected against large activation mapping against the safeguard approach of doing the things.

$$y = min(max(0, x)6)$$

While comparing the existing ReLU we found it's advantageous under low precision calculations.

MobileNet V2's building block will be defined under the separable convolutions. In in-depth convolution, the input space matrix is got multiplied by the convolution operand by unit time, producing a feature space as the output. Against features map at Xout layer, the sum of the input feature space map represented and accessed via Input X_{in} in the corresponding layered model these are standard denotes for input and output in convolution network with Xin (as input) and Xout (as Output) with specific weight at convolution stages

$$\mathrm{W_{std}} = \mathrm{C_{in}} * \mathrm{K_w} * \mathrm{K_H} * \mathrm{C_{out}}$$
$$\mathrm{W_{gtstd}} = \mathrm{X_{in}} * \mathrm{K_w} * \mathrm{K_H} * \mathrm{X_{out}} \qquad (1)$$

- Measurements of the kernel's height and width, respectively, are written as Kw *KH.
- The computational burden of producing result feature maps of dimension fw* fH is:

In depth features, input is expressed by unit convolution over the feature space before the output will be placed to produce

$$\mathrm{W_{gtdws}} = \mathrm{K_w} * \mathrm{K_H} * \mathrm{X_{out}} \qquad (2)$$

Depthwise convolution layer will produce computation result in the form of layers which is as follows:

$$CCost_{dws} = K_w * K_H * X_{in} * f_w * f_H + X_{in} * X_{out} * f_w * f_H \qquad (3)$$

This process will decrease the weighting and calculations over wide ranges in Input layers for Xin range.

DWS can be used as standard method for convolution in the computation for decreasing cost by some factors. Under varying computing points over the depth and space access point in category. All input measured with single filtering while expression describes convolution depth.

$$\mathrm{F(a,b,i)} = \sum_{v=1}^{m}\sum_{v=1}^{m} M \quad \mathrm{(v,v,i)} * \mathrm{N(a+v-1, v-1, i)} \qquad (4)$$

where m denotes convolutional kernels of dimension m x m x cin in-depth and cin form x m x cin convolutional kernels in size. By applying the nth filter from M to the nth input channel of N, the nth channel of the filtered result feature vector F is generated. The result of the depth-wise convolution is clustered linearly, and this is used to generate new features in the point-wise convolution. Equation expresses a convolution at a single location.

$$\text{P(a,b,j)} = \sum_{i=1}^{cin} \text{M(v,v,i)} * \text{Q(i,j)} \tag{5}$$

An expression for computation of DWS may be as follows:

$$C_{dws} = m^2 * c_{in} * h.w + x_{in} * x_{out} * h * w \tag{6}$$

This second Specification for the MobileNet V2 under neural network will allow using small screens. The image classifier will be enhanced with other classifiers to detect and improve results in tandem.

Evaluation Metric

The confusion matrix will be calculated for input in the Learning/representation of the task using the following table

	Predicted No (0)	Predicted Yes (1)
Actual No(0)	TN	FP
Actual Yes(1)	FN	TP

So here TN means True Negative, FN means False Negative, FP means False Positive, TP means True Positive

Accuracy:

The overall performance for the system will be described with all representational classes of the input to the output need to be mapped in overall improvement based on classes that derive the fruitful and needed results. It should be a notation of classes that needed actual performance to be represented over time

$$Accuracy = (TP + TN)/(TP + TN + FP + FN)$$

Precision:

Input and the level of decision with positive intervals that are specified over positive criteria to the tagged values in leveling. The level of accuracy recognized in a positive sample can be evaluated by the point placed for looking at its precision.

$$Precision = TP/(TP + FP)$$

Recall:

To calculate recall, the process includes dividing the total number of positive samples by the number of positive samples that were correctly identified as positive. Defined by the percentage of positive samples that were correctly identified. The recall statistic will tell how well a model can recognize positive data and provides an evaluation of this ability. The higher the recall, the higher the number of genuine positives that are found.

$$Recall = TP/(TP + FP)$$

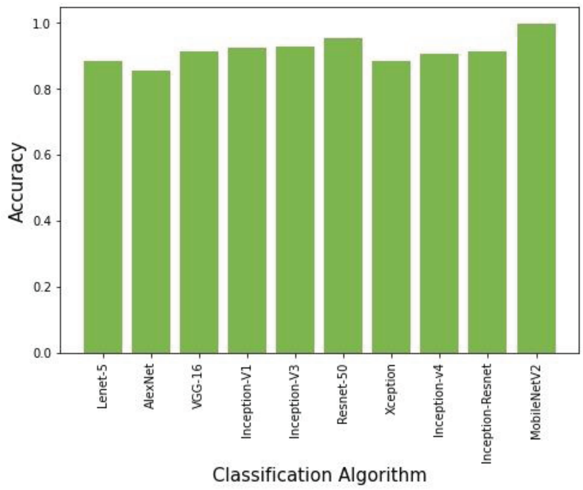


Figure 11. Comparison of algorithms with accuracy

Table 2. Results (comparison of different algorithms)

Algorithm	Accuracy	Precision	Recall	F1-score
Lenet-5	0.886	0.89	0.96	0.93
AlexNet	0.85	0.85	0.90	0.87
VGG-16	0.91	0.88	0.90	0.88
Inception-V1	0.92	0.94	0.90	0.92
Inception-V3	0.94	0.92	0.90	0.90
Resnet-50	0.95	0.94	0.96	0.94
Xception	0.93	0.95	0.93	0.93
Inception-v4	0.91	0.92	0.96	0.93
Inception-Resnet	0.97	0.94	0.96	0.94
MobileNetV2 (Proposed Work)	**0.99**	**0.98**	**0.99**	**0.98**

F1 Score:

The F-score is a statistic define to evaluate the overall performance of the computation model. It is the representation of values taking the harmonic mean of the model's precision and recall.

$$F1\ Score = 2 * (Precision * Recall)/(Precision + Recall)$$

Table represent the comparison of different algorithm with comparisons. Here the results show how our work's accuracy is give better results with other algorithms.

5. Conclusion

In this paper, we have developed a real-time face mask detection application by working on an efficient CNN i.e. convolutional neural network model based on MobileNetV2. A dataset of about 1376 images has been used i.e. from Kaggle and other sources. Our proposed system will predict whether a person is wearing a face mask or not and if a person with no mask is detected then an alert sound will be there, Moreover, it will keep the count of people that will be present in the video stream. This real-time application after being trained and tested has achieved an accuracy of about **99.99%.** The model finds its use in public gatherings like airports, schools, offices, etc.

6. Future Scope

We are aware that how quickly the Deep Learning area is evolving and how intensively major organizations are conducting research. Researchers in the field of machine learning, especially deep learning researchers, are attempting to do groundbreaking research. As a result, more variants in this model may appear in the future, which can improve its efficiency in terms of implementation and performance. Real-Time Face Mask Detection in Mass has an immensely boundless scope in the future due to the technology used in it. It can be modified as and when required, as it is versatile in terms of extension and open to updating according to the latest technology. Some aspects can be further modified such as face-recognizing distance can be extended, a Graphics processing unit (GPU) can be used for a large amount of the database and quick processing, data storage can be made server-based and can be integrated with multiple cameras at the same time.

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