

# Face Mask Detection Using TensorFlow and OpenCV

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**Abstract**—During pandemic COVID-19, WHO has made wearing masks compulsory to protect against this deadly virus. In this tutorial we will develop a machine learning project – Realtime Face Mask Detector with Python. We will build a real-time system to detect whether the person on the webcam is wearing a mask or not. We will train the face mask detector model using Keras and OpenCV. We are going to build this project in two parts. In the first part, we will write a python script using Keras to train face mask detector model. In the second part, we test the results in a real-time webcam using OpenCV.

**Keywords**—Coronavirus, Covid-19, Machine Learning, Face Mask Detection, Convolutional Neural Network, TensorFlow

## I. INTRODUCTION

With the reopening of countries from COVID-19 lock-down, Government and Public health agencies are recommending face masks as essential measures to keep us safe when we venturing into public to curtail the spread of Coronavirus and thereby contributing to public healthcare. Regardless of discourse on medical resources and diversities in masks, all countries are mandating coverings over the nose and mouth in public. To mandate the use of facemask, it becomes essential to devise some techniques that enforce individuals to apply a mask before exposure to public places. This application can be very useful in public areas such as airports, railway stations, crowded markets, malls, etc. The proposed method used here is carried out in two steps. The first step is to train the face mask detector using transfer learning.

The second step is to use this trained face mask detector on images or videos of people to identify if they are wearing a mask. For building this model, I will be using the face mask dataset provided by Prajna Bhandary. It consists of about 1,376 images with 690 images containing people with face masks and 686 images containing people without face masks. I am going to use these images to build a CNN model using Tensor-Flow to detect if you are wearing a face mask by using the webcam of your PC. Additionally, you can also use your phone's camera to do the same!

## LITERATURE SURVEY

All governments around the world are struggling against COVID-19, which causes serious health crises. Therefore, the use of face masks regulatory can slow down the high spread of this virus. Our project deals with face mask detection. In which we have use visual studio in background for coding. We have used python as a programming language for coding purpose. For database purpose we have used Prajna Bhandary dataset. In that dataset , there is approx. 700+ image file of peoples who wear mask and some of them not wearing mask. The proposed method used here is carried out in two steps. The first step is to train the face mask detector using transfer learning.

The second step is to use this trained face mask detector on images or videos of people to identify if they are wearing a mask. Different performance metrics (accuracy, F1-score, precision, and recall) are used to judge the performance of the proposed model.

## II. RELATED WORK

In face detection method, a face is detected from an image that has several attributes in it. According to [21], research into face detection requires expression recognition, face tracking, and pose estimation. Given a solitary image, the challenge is to identify the face from the picture. Face detection is a difficult errand because the faces change in size, shape, color, etc and they are not immutable. It becomes a laborious job for opaque image impeded by some other thing not confronting camera, and so forth. Authors in [22] think occlusive face detection comes with two major challenges: 1) unavailability of sizably voluminous

datasets containing both masked and unmasked faces, and 2) exclusion of facial expression in the covered area. Utilizing the locally linear embedding (LLE) algorithm and the dictionaries trained on an immensely colossal pool of masked faces, synthesized mundane faces, several mislaid expressions can be recuperated and the ascendancy of facial cues can be mitigated to great extent. According to the work reported in [11], convolutional neural network (CNNs) in computer vision comes with a strict constraint regarding the size of the input image. The prevalent practice reconfigures the images before fitting them into the network to surmount the inhibition.

Here the main challenge of the task is to detect the face from the image correctly and then identify if it has a mask on it or not. In order to perform surveillance tasks, the proposed method should also detect a face along with a mask in motion.

### III. DATASET

Two datasets have been used for experimenting the current method. Dataset 1 [16] consists of 1376 images in which 690 images with people wearing face masks and the rest 686 images with people who do not wear face masks. Fig. 1 mostly contains front face pose with single face in the frame and with same type of mask having white color only.



Fig. 1. Samples from Dataset 1 including faces without masks and with masks

Dataset 2 from Kaggle [17] consists of 853 images and its countenances are clarified either with a mask or without a mask. In fig. 2 some face collections are head turn, tilt and slant with multiple faces in the frame and different types of masks having different colors as well.

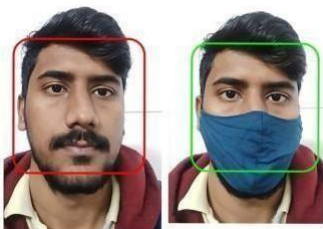


Fig. 2. Samples from Dataset 2 including faces without masks and with masks

## IV. INCORPORATED PACKAGES

### A. TensorFlow

TensorFlow, an interface for expressing machine learning algorithms, is utilized for implementing ML systems into fabrication over a bunch of areas of computer science, including sentiment analysis, voice recognition, geographic information extraction, computer vision, text summarization, information retrieval, computational drug discovery and flaw detection to pursue research [18]. In the proposed model, the whole Sequential CNN architecture (consists of several layers) uses TensorFlow at backend. It is also used to reshape the data (image) in the data processing.

### B. Keras

Keras gives fundamental reflections and building units for creation and transportation of ML arrangements with high iteration velocity. It takes full advantage of the scalability and cross-platform capabilities of TensorFlow. The core data structures of Keras are layers and models [19]. All the layers used in the CNN model are implemented using Keras. Along with the conversion of the class vector to the binary class matrix in data processing, it helps to compile the overall model.

### C. OpenCV

OpenCV (Open Source Computer Vision Library), an open-source computer vision and ML software library, is utilized to differentiate and recognize faces, recognize objects, group movements in recordings, trace progressive modules, follow eye gesture, track camera actions, expel red eyes from pictures taken utilizing flash, find comparative pictures from an image database, perceive landscape and set up markers to overlay it with increased reality and so forth [20]. The proposed method makes use of these features of OpenCV in resizing and color conversion of data images.

## V. THE PROPOSED METHOD

The proposed method consists of a cascade classifier and a pre-trained CNN which contains two 2D convolution layers connected to layers of dense neurons. The algorithm for face mask detection is as follows:

Algorithm 1: Face Mask Detection	
<b>Input:</b> Dataset including faces with and without masks	
<b>Output:</b> Categorized image depicting the presence of face mask	
1	<b>for each image in the dataset do</b>
2	Visualize the image in two categories and label them
3	Convert the RGB image to Gray-scale image
4	Resize the gray-scale image into 100 × 100
5	Normalize the image and convert it into 4 dimensional array
6	<b>end</b>
7	<b>for building the CNN model do</b>
8	Add a Convolution layer of 200 filters
9	Add the second Convolution layer of 100 filters
10	Insert a Flatten layer to the network classifier
11	Add a Dense layer of 64 neurons
12	Add the final Dense layer with 2 outputs for 2 categories
13	<b>end</b>
14	Split the data and train the model

### A. Data Processing

Data preprocessing involves conversion of data from a given format to much more user friendly, desired and meaningful format. It can be in any form like tables, images, videos, graphs, etc. These organized information fit in with an information model or composition and captures relationship between different entities [6]. The proposed method deals with image and video data using Numpy and OpenCV.

a) *Data Visualization*: Data visualization is the process of transforming abstract data to meaningful representations using knowledge communication and insight discovery through encodings. It is helpful to study a particular pattern in the dataset [7].

The total number of images in the dataset is visualized in both categories – ‘with mask’ and ‘without mask’.

The statement `categories=os.listdir(data_path)` categorizes the list of directories in the specified data path. The variable `categories` now looks like: ['with mask', 'without mask']

Then to find the number of labels, we need to distinguish those categories using `labels=[i for i in range(len(categories))]`. It sets the labels as: [0, 1]

Now, each category is mapped to its respective label using `label_dict=dict(zip(categories,labels))` which at first returns an iterator of tuples in the form of zip object where the items in each passed iterator is paired together consequently. The mapped variable `label_dict` looks like: {'with mask': 0, 'without mask': 1}

b) *Conversion of RGB image to Gray image*: Modern descriptor-based image recognition systems regularly work on grayscale images, without elaborating the method used to convert from color-to-grayscale. This is because the color-to-grayscale method is of little consequence when using robust descriptors. Introducing nonessential information could increase the size of training data required to achieve good performance. As grayscale rationalizes the algorithm and diminishes the computational requisites, it is utilized for extracting descriptors instead of working on color images instantaneously [8].

We use the function `cv2.cvtColor(input_image, flag)` for changing the color space. Here flag determines the type of conversion [9]. In this case, the flag `cv2.COLOR_BGR2GRAY` is used for gray conversion.

Deep CNNs require a fixed-size input image. Therefore we need a fixed common size for all the images in the dataset. Using `cv2.resize()` the gray scale image is resized into 100 x 100.

c) *Image Reshaping*: The input during relegation of an image is a three-dimensional tensor, where each channel has a prominent unique pixel. All the images must have identically tantamount size corresponding to 3D feature tensor. However, neither images are customarily coextensive nor their corresponding feature tensors [10]. Most CNNs can only accept fine-tuned images. This engenders several problems throughout data collection and implementation of model. However, reconfiguring the input images before augmenting them into the network can help to surmount this constraint. [11].

The images are normalized to converge the pixel range between 0 and 1. Then they are converted to 4 dimensional arrays using `data=np.reshape(data,(data.shape[0],img_size,img_size,1))` where 1 indicates the Grayscale image. As, the final layer of the neural network has 2 outputs – with mask and without mask i.e. it has categorical representation, the data is converted to categorical labels.

### B. Training of Model

a) *Building the model using CNN architecture*: CNN has become ascendant in miscellaneous computer vision tasks [12]. The current method makes use of Sequential CNN.

The First Convolution layer is followed by Rectified Linear Unit (ReLU) and MaxPooling layers. The Convolution layer learns from 200 filters. Kernel size is set to 3 x 3 which specifies the height and width of the 2D convolution window. As the model should be aware of the shape of the input expected, the first layer in the model needs to be provided with information about input shape. Following layers can perform instinctive shape reckoning [13]. In this case, `input_shape` is specified as `data.shape[1:]` which returns the dimensions of the data array from index 1. Default padding is “valid” where the spatial dimensions are sanctioned to truncate and the input volume is non-zero padded. The activation parameter to the Conv2D class is set as “relu”. It represents an approximately linear function that possesses all the assets of linear models that can easily be optimized with gradient-descent methods. Considering the performance and generalization in deep learning, it is better compared to other activation functions [14]. Max Pooling is used to reduce the spatial dimensions of the output volume. Pool\_size is set to 3 x 3 and the resulting output has a shape (number of rows or columns) of: `shape_of_output = (input_shape - pool_size + 1) / strides`, where strides has default value (1,1) [15].

As shown in fig. 4, the second Convolution layer has 100 filters and Kernel size is set to 3 x 3. It is followed by ReLU and MaxPooling layers. To insert the data into CNN, the long vector of input is passed through a Flatten layer which transforms matrix of features into a vector that can be fed into a fully connected neural network classifier. To reduce

overfitting a Dropout layer with a 50% chance of setting inputs to zero is added to the model. Then a Dense layer of 64 neurons with a ReLu activation function is added. The final layer (Dense) with two outputs for two categories uses the Softmax activation function.

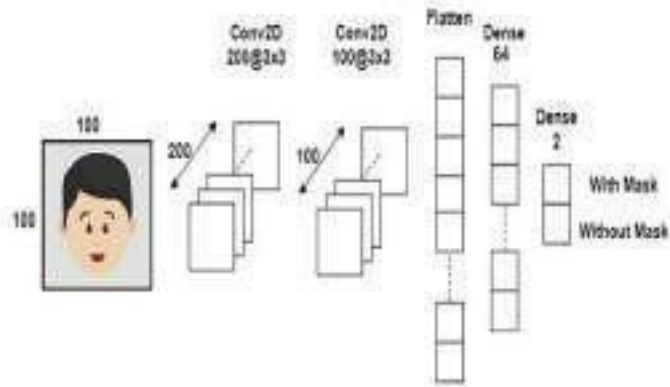


Fig. 4. Convolutional Neural Network architecture

The learning process needs to be configured first with the compile method [13]. Here “adam” optimizer is used. *categorical\_crossentropy* which is also known as multiclass log loss is used as a loss function (the objective that the model tries to minimize). As the problem is a classification problem, metrics is set to “accuracy”.

b) *Splitting the data and training the CNN model:*

After setting the blueprint to analyze the data, the model needs to be trained using a specific dataset and then to be tested against a different dataset. A proper model and optimized *train test split* help to produce accurate results while making a prediction. The test size is set to 0.1 i.e. 90% data of the dataset undergoes training and the rest 10% goes for testing purposes. The validation loss is monitored using *ModelCheckpoint*. Next, the images in the training set and the test set are fitted to the Sequential model. Here, 20% of the training data is used as validation data. The model is trained for 20 epochs (iterations) which maintains a trade-off between accuracy and chances of overfitting. Fig. 5 depicts visual representation of the proposed model.

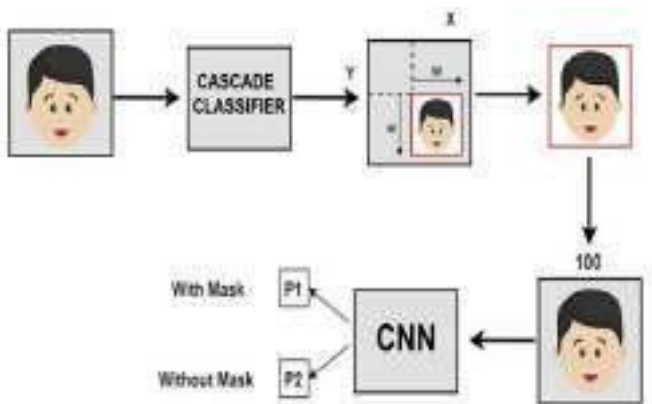


Fig. 5. Overview of the Model

## VI. RESULT AND ANALYSIS

The model is trained, validated and tested upon two datasets. Corresponding to dataset 1, the method attains accuracy up to 95.77% (shown in fig. 7). Fig. 6 depicts how this optimized accuracy mitigates the cost of error. Dataset 2 is more versatile than dataset 1 as it has multiple faces in the frame and different types of masks having different colors as well. Therefore, the model attains an accuracy of 94.58% on dataset 2 as shown in Fig. 9. Fig. 8 depicts the contrast between training and validation loss corresponding to dataset 2. One of the main reasons behind achieving this accuracy lies in *MaxPooling*. It provides rudimentary translation invariance to the internal representation along with the reduction in the number of parameters the model has to learn. This sample-based discretization process down-samples the input representation consisting of image, by reducing its dimensionality. Number of neurons has the optimized value of 64 which is not too high. A much higher number of neurons and filters can lead to worse performance. The optimized filter values and pool size help to filter out the main portion (face) of the image to detect the existence of mask correctly without causing over-fitting.

The system can efficiently detect partially occluded faces either with a mask or hair or hand. It considers the occlusion degree of four regions – nose, mouth, chin and eye to differentiate between annotated mask or face covered by hand. Therefore, a mask covering the face fully including nose and chin will only be treated as “with mask” by the model.

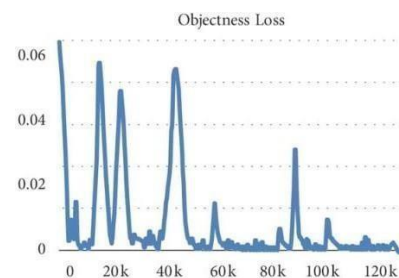
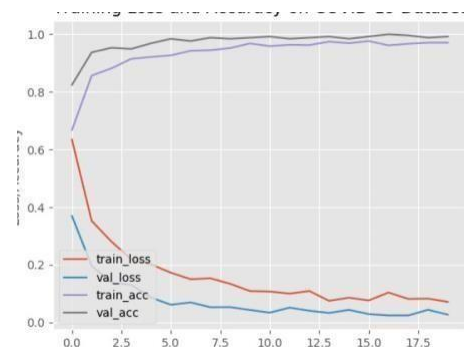


Fig. 8. # epochs vs loss corresponding to dataset 2

Fig. 9. # epochs vs accuracy corresponding to dataset 2



The main challenges faced by the method mainly comprise of varying angles and lack of clarity. Indistinct moving faces in the video stream make it more difficult. However, following the trajectories of several frames of the video helps to create a better decision – “with mask” or “without mask”.

## VII. CONCLUSIONS

In this paper, we briefly explained the motivation of the work at first. Then, we illustrated the learning and performance task of the model. Using basic ML tools and simplified techniques the method has achieved reasonably high accuracy. It can be used for a variety of applications. Wearing a mask may be obligatory in the near future, considering the Covid-19 crisis. Many public service providers will ask the customers to wear masks correctly to avail of their services. The deployed model will contribute immensely to the public health care system. In future it can be extended to detect if a person is wearing the mask properly or not. The model can be further improved to detect if the mask is virus prone or not i.e. the type of the mask is surgical, N95 or not.

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