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# Real Time Face Mask Detection for Covid-19 Pandemic Using Supervised Learning of Convolutional Neural Network

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A B S T R A C T

Covid-19 pandemic, also known as the coronavirus pandemic, is an ongoing pandemic of coronavirus disease 2019 (COVID-19) causing a serious health crisis. One of the ways to prevent the spread of that virus is by wearing a mask. In this paper, a supervised learning algorithm of the convolutional neural network is used to detect whether the person on the camera entering the particular organization is wearing a mask or not. Face recognition and Image processing had been significant processes in the domain of machine learning. The face mask detection system uses the library such as Keras, Tensor Flow, and OpenCV to detect the face mask and to train the CNN model. The steps for building the system include collecting the raw data which needs to be pre-processed, training the CNN model to label the processed data into two classes, and testing the model to a certain number of epochs to get the high accuracy rate and low loss rate. In the last step, the system can predict and label whether the person on the camera is wearing a mask or not. The experimental results verify the success of the algorithm.

Keywords: Machine Learning, Supervised Learning, Convolutional Neural Network (CNN), Keras, Tensor Flow, open CV

## 1. Introduction

For the past year, with the continuous spreading of coronavirus, humans are suffered a lot. The virus spreads through the air channel when an infected person sneezes or communicates with the other person, the water droplets from their nose are affecting other people from the environment. In the COVID-19 pandemic, face mask detection is a trending methodology all around the world. So that the person wants to wear the mask in public places especially in crowded places. With the help of Machine Learning, Convolutional Neural Network is created. The subfield of Artificial Intelligence is Machine Learning. Machine Learning is defined as understanding the structure of data and fit that data into models that can be utilized by people. Supervised Learning (figure-1) is one of the types of Machine Learning. In Machine Learning, a function maps an input to an output based on input-output pairs. It assumes a function from labeled training data consisting of a set of training examples.

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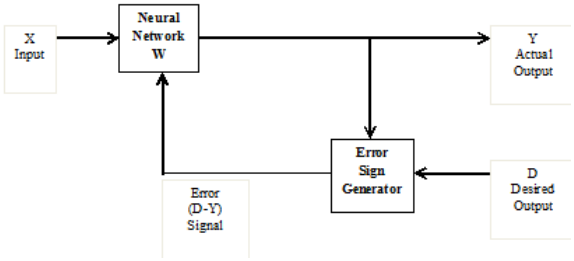


**Figure-1: Supervised Learning**

In the 1980s, Convolutional Neural network also called as ConvNets were introduced by Yann Lecun. Another achievement of CNN includes banking and postal services where they read digits on check and zip codes. The recent achievements of the CNN technique apply to images with low resolution. Face Mask detection problem is naturally try to solve the problems by checking every people and instruct them. In this paper, the Convolutional Neural Network technique [1] is used. CNN can take an image as input, assign attributes (weight, biases) to various nodes in the image. The pre-processing is required in CNN is lower than other algorithms. Keras [2] is a Neural Network API. It is a library written in python. It works with other libraries and packages such as Tensor Flow which is easy for deep learning. Tensor Flow [2] is used for building the machine learning and deep learning model. It is a mathematical computation library. OpenCV (Open Source Computer Vision Library) [2]. It is free for commercial and research. It is based on real-time image processing. Though the Supervised Learning algorithm can find the best way to optimize a solution.

## 2. References

**a.** ***Modular Neural Network(MNN)***

A modular Neural Network is used for face recognition. Genetic optimization of MNN [3] with fuzzy response integration. By using a genetic algorithm, the architecture of MNN and fuzzy systems are created. MNN consist of three modules and each module consists of different information. In the case of human recognition, the modules can be divided based on iris, ear, and face biometric measures. This MNN used the feature of genetic algorithm and fuzzy logic. It can work in a large database.

**b.** ***Artificial Neural Network(ANN)***

Artificial Neural Network has been used in the field of Image processing and pattern recognition [4]. The main element of image processing is an image. An image can be shown as a matrix. Each element in the matrix holds color information in a pixel. The input of the neural network is matrix [5]. The function used in the network is the sigmoid function. The learning rate contains values between 0 and 1{0, 1}. The error suggests being below 0.1.

**c.** ***Retinal Connected of Neural Network (RCNN)***

Retinal Connected of Neural Network (RCNN) is used for retinal face mask detector [6]. This detector was proposed by Minnie, Xinqi, and Hong. The detector is a one-stage object detector. The backbone used in the detector is ResNet and MobileNet. Here, the standard backbone is ResNet [7]. The modules of the detection network are the neck, head, and backbone. In the case of accuracy, the ResNet accuracy is high than the MobileNet.

**d.** ***Principle Component Analysis (PCA) with ANN***

The systematic face detection using a combination of Principal Component Analysis (PCA) and Artificial Neural Network (ANN). For face detection and training, the Multi-Layer Perception (MLP) network is used. The network contains three layers [8], such as the input layer, hidden layer, and output layer with extending transfer function. In the network, the training data set to learn the face patterns and applies the query images for detecting face object. Along with PCA, the Radial Basis Function (RBF) network has been used as the hidden layer for training images [9]. It improves the capability of the concept. The Eigenfaces approach uses a PCA algorithm for image recognition [10]. The equation of Eigenvalues is

| | |
|---|---|
| $(B-\lambda I)Y=0$ | B=identity matrix |
| $\text{Det}\,(B-\lambda I)=0$ | Det=determinant |
| $BYi=\lambda Yi$ where i=1, 2,.. | |

***e.*** ***Fast Neural Network (FNN)***

Fast Neural Network (FNN) is used for face detection. In the network, the equation for cross-correlation [11] in the spatial and frequency domain was determined. The correct formula for cross-correlation is

$G=h\times F$

**f.** ***Convolutional Neural Network(CNN)***

Convolutional Neural Network (CNN) is used for the face recognition method. The network has four distinct layers, such as three convolution layers, two pooling layers, two fully-connected layers, and one softmax layer [12]. For the training and testing process, the Convolution Architecture for Feature Extraction Framework (Caffe) is used. CNN is also used for face detection. It can be categories into two different types, such as (i) two-stage approach and (ii) one stage approach [13]. Region proposed with Convolutional Neural Network (R-CNN) is based on the two-stage approach. The You Only Look Once) is based on a single-stage approach that predicts the class for the images. The Cascade Framework [14] designs the CNN to detect masked faces.

## 3. Comparison Study

On comparing, the several networks [Table-1] such as Modular Neural Network (MNN), Artificial Neural Network (ANN), Retinal Connected Neural Network (RCNN), Principal Component Analysis (PCA) with ANN, Fast Neural Network (FNN), and Convolutional Neural Network (CNN) for the main goal of face mask detection. The Network such as PCA with ANN and CNN moreover has the same recognition rate [figure-2]. So among the several networks, these two are the best Network. In this paper, the system uses Convolutional Neural Network (CNN).

Table-1: Comparing networks for recognition rate

| S.No | Methodology | Recognition rate (%) |
|---|---|---|
| 1 | MNN | 86.4 |
| 2 | ANN | 87.89 |
| 3 | RCNN | 89.6 |
| 4 | PCA with ANN | 95.22 |
| 5 | FNN | 93 |
| 6 | CNN | 95.38 |

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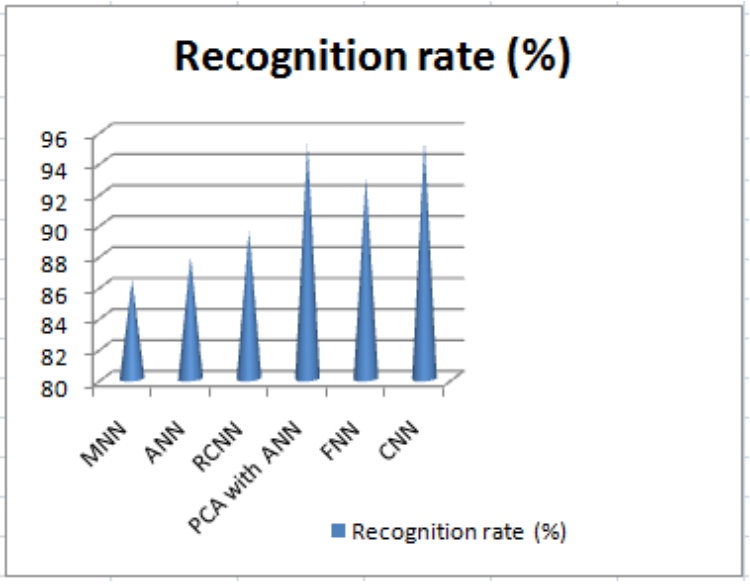
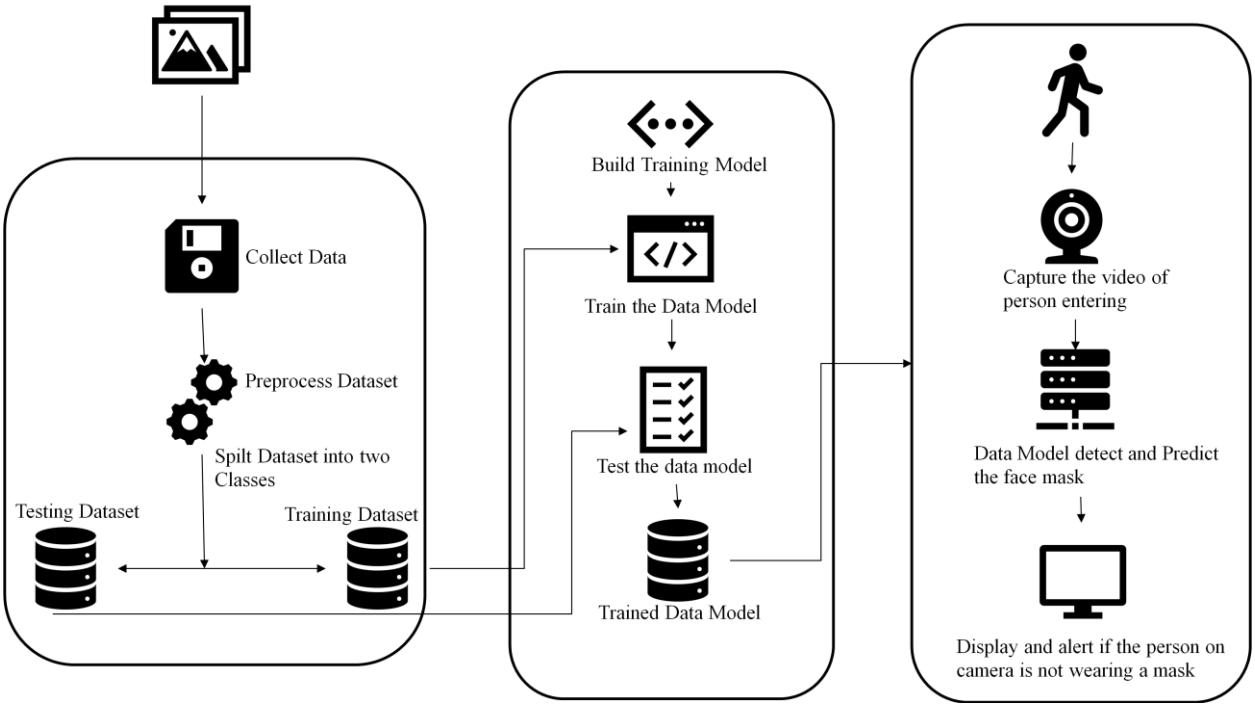



**Figure-2: Graph for indicate recognition rate**

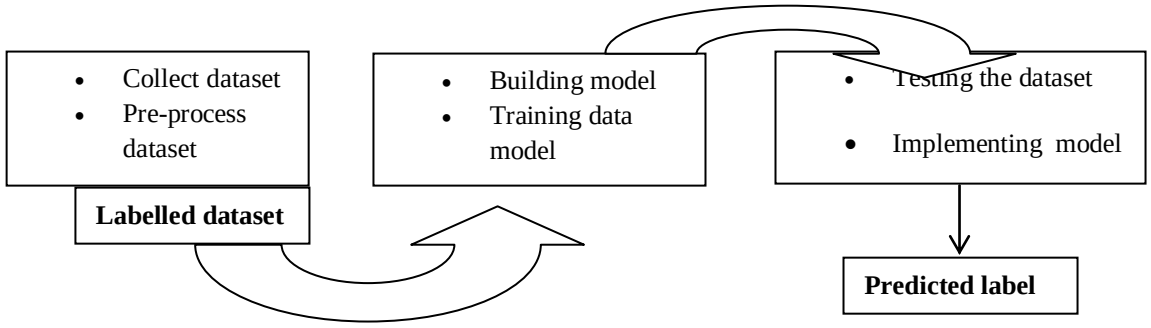
## 4. System Architecture




The architecture of the face mask detection in above diagram. First to prepare a system, want to develop a three model such as labeling the data, training the data, and testing the data. For labeling the data, first want to collect the data and then pre-process (Cleaning, Integration, Transformation, and Reduction) the data set and then split the dataset into two classes first one is training the dataset and the second one is testing the data set and then for training the data, first want to build the model by using the training dataset and then for testing the data, want to build the model for testing dataset. Now, the system is ready for face mask detection. The working principle of face mask detection is when a person enters into an organization, the camera captures the videos [15], and the videos are preprocessing and splitting the videos into an image with two classes are training and testing data set. Then the images are tested using the trained data model and predicts the label as to whether checking a person with a mask or without a mask.

## 5. Module Description

***SUPERVISED LEARNING ALGORITHM AND OPTIMIZATION OF CONVOLUTIONAL NEURAL NETWORK***




**Basic Model of a system**

### *A. Labeled Dataset Model*

The labeled data model is shown in the figure-3. This model has two entities, visualization, and augmentation. Data visualization is the collection of the number of images with a yes or no labeled class. Data augmentation has two categories, such as position augmentation and color augmentation. In this

model, position augmentation is used. It is used to rotate and flip the images in the dataset. After augmentation, the images are spitted into two classes. The data can be split into a training set that contains images that will be trained by CNN and a testing set that contains images in which the given model is tested. After splitting images, 80% of the total images go to the training set, and the remaining 20% of the total images go to the testing set.

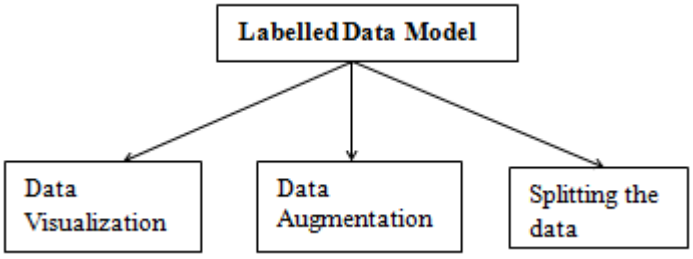



**Figure-3: Labeled data Model**

### *B. Building the Model*

Sequential CNN models have various layers such as Con2D, MaxPooling2D, Flatten, Dropout, and dense. The Softmax function used in the dense layer gives the probability of each of the two classes. For better accuracy, use the MobileNetV2 [2]. The CNN model face mask detection is shown in the figure-4.

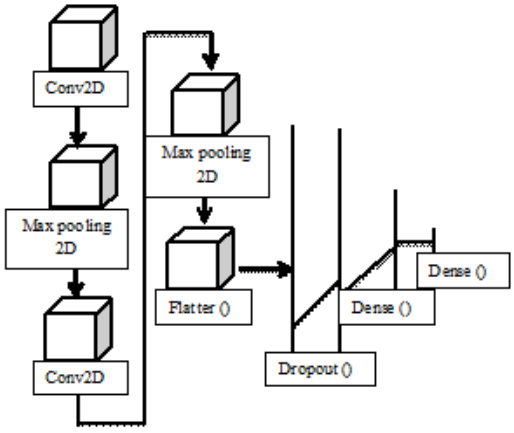



**Figure-4: CNN Model for face mask detection**

### *C. Training Data Model*

After building the model, the images are fit into it. Then there are 60 images in the training set and 80 images in the testing set and trained the model for 10 epochs in figure-5. When train more number epochs mean it obtains a high accuracy rate.

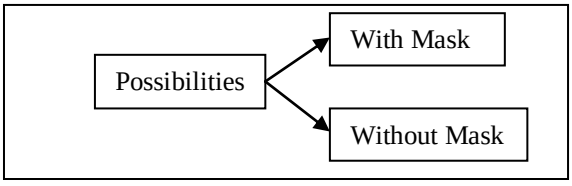
```
Epoch 1/10
 - 126s - loss: 0.4638 - acc: 0.8334
Epoch 2/10
 - 112s - loss: 0.3025 - acc: 0.8916
Epoch 3/10
 - 116s - loss: 0.2645 - acc: 0.9042
Epoch 4/10
 - 111s - loss: 0.2345 - acc: 0.9146
Epoch 5/10
 - 105s - loss: 0.2155 - acc: 0.9214
Epoch 6/10
 - 118s - loss: 0.1923 - acc: 0.9293
Epoch 7/10
 - 112s - loss: 0.1749 - acc: 0.9359
Epoch 8/10
 - 104s - loss: 0.1583 - acc: 0.9425
Epoch 9/10
 - 114s - loss: 0.1455 - acc: 0.9465
Epoch 10/10
 - 140s - loss: 0.1306 - acc: 0.9516
```

**Figure-5 Number of epochs trained**

After 10 epochs, the model has an accuracy of 0.8247 with the training set and an accuracy of 0.8375 with the testing set. In the last epoch, the loss rate is 0.4577, and the accuracy rate is 0.4273. This ensures that is well trained.

### *D. Testing Data Model*

After training the dataset, when new images are given to the system [6] means it will be added to the testing dataset. Then the testing data set is tested for a certain number of epochs to check the loss and accuracy of the training data model. With the help of testing the data model, the system can have two possibilities which are with a mask and without a mask. Then the models will predict the images by the possibility of two classes which are with mask and without a mask. Based on which probability higher, the label will be predicted and displayed on their face with a rectangular box.



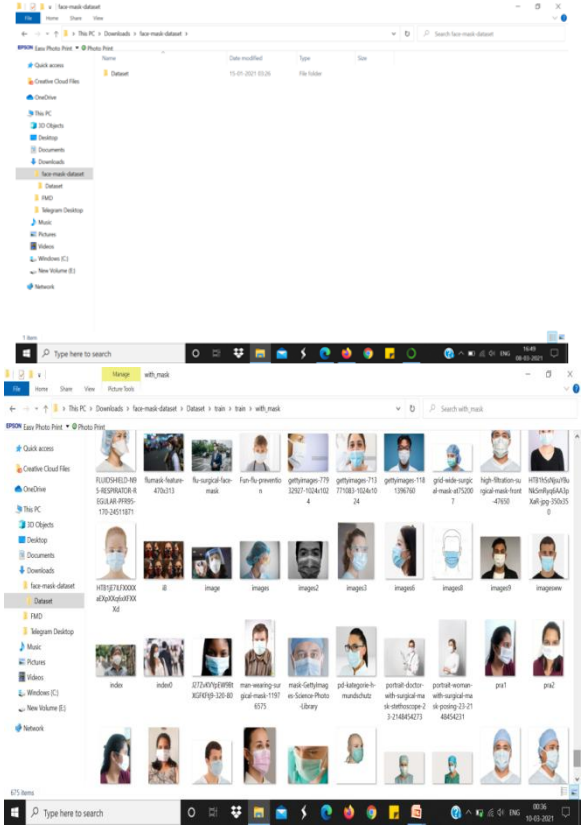

## 6. Experiments and Discussion

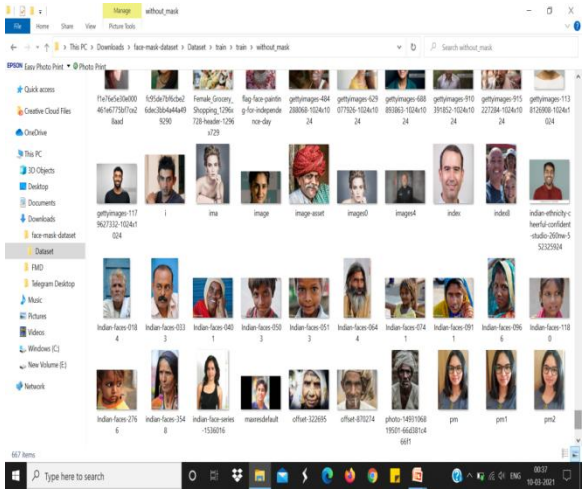
In order to evaluate the performance of the face mask detection system with supervised learning.

### *A. Labeling the dataset*

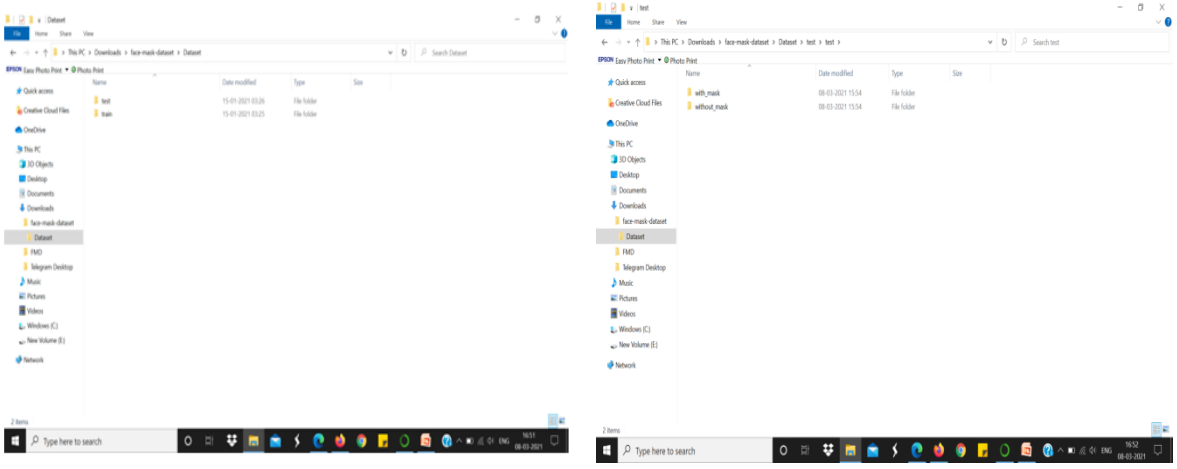
Labeling the dataset model, the system process begins with collecting the data. Then the system has the dataset which includes images of people with and without a mask on their faces.

(I) Collecting raw data

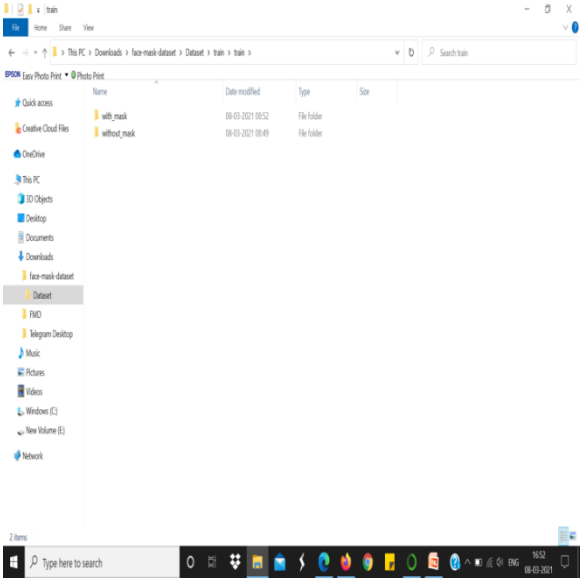




(II). Splitting the data



(III). Labeling the data



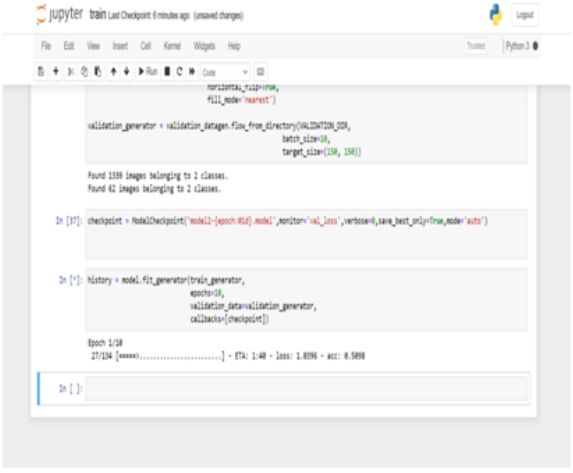
| LABEL | PROBABLITY | COLOUR |
|---|---|---|
| Without mask | 0 | Red |
| With mask | 1 | Green |

### *B. Training the Data Model*

In the training data model, certain numbers of images are fit into the training dataset built by Keras and OpenCV library. Then the model was trained for 10 epochs. When more epochs are trained means can obtain higher accuracy.

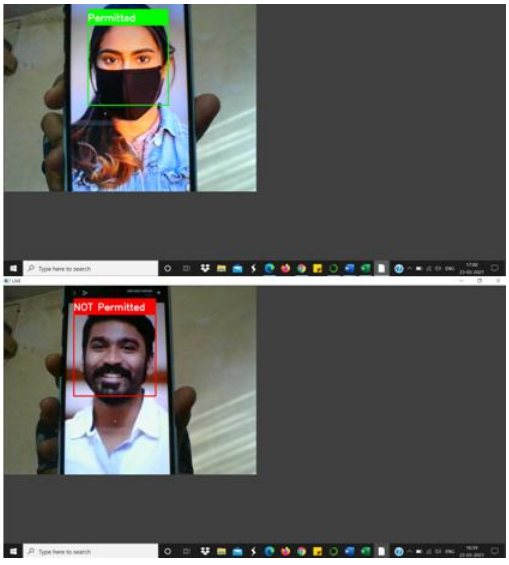
```
Epoch 1/10
 68/134 [==============>.............] - ETA: 1:22 - loss: 0.4577 - acc: 0.8247
```

```
Epoch 1/10
 80/134 [================>.............] - ETA: 55s - loss: 0.4273 - acc: 0.8375
```




### *C. Testing Data Model*

In a testing model, the images are given to the system means they will add to the testing data set. The images are predicted and display with a rectangular box.




## 7. Results

In this paper, we propose a new machine learning algorithm for face mask detection. Our algorithm is based on the cascade framework of Convolutional Neural Network (CNN) and proposed a new data set called "FACE MASKED DATASET" which has 68 images for training and 80 images for testing. The features are extracted from the images used as inputs to the neural network to measure the classification and recognition. To evaluate the face mask detection algorithm on the FACE MASKED testing set, it achieves very satisfactory performance. So thus this challenge would create a scope for new face mask detection algorithm which can have greater accuracies and precisions.

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