

**How to Cite:**

Achyutha, P. N., Hebbale, S., & Vani, V. (2022). Real time COVID-19 facemask detection using deep learning. *International Journal of Health Sciences*, 6(S4), 1446–1462.  
<https://doi.org/10.53730/ijhs.v6nS4.6231>

# Real time COVID-19 facemask detection using deep learning

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**Abstract**--The COVID-19 pandemic is producing a global health pandemic. According to the World Health Organization (WHO), the utmost effective protection is to wear a face mask in crowded regions/areas. During this pandemic, it is compulsory for every person to wear a mask and maintain social distancing. In the field of Image Processing, Convolutional Neural Networks (CNNs) have risen to prominence as the most common type of image realization/recognition model. Our project's purpose is to research and assess Machine Learning (ML) technologies for identification and recognition of people wearing face masks in any pre-recorded videos, photos, or in actual-time (real-time) circumstances. Our project aims to create a real-time Graphics User Interface based Automated Facial Recognition as well as Mask Detection System. The algorithms used in the proposed methodology are Principal Component Analysis (PCA) and the HAAR Cascade Algorithm. Finally, the result is indicated by a "GREEN" color rectangle box, which would be drawn around the section of the face, which indicates that the person on the camera is

wearing a mask, or a “RED” color rectangle box, which indicates that the person on the camera is not wearing a mask. This model achieves 99% accuracy.

**Keywords**---Face Detection, Mask Detection, Convolutional Neural Network (CNN), GUI (Graphics UserInterface), PCA (Principal Component Analysis), Haar Cascade Algorithm.

## **Introduction**

Face Recognition is a method of identifying an individual associated with particular elements of their face by analyzing collected designs from every facial expression from a bunch of people. Face recognition is a straightforward and logical way to discover and verify people's face. People's daily interactions and lifestyles are embedded with face recognition. As a result, automatic face recognition possessing computers and/or gadgets for identity verification all over the clock and even remotely is gaining popularity in today's world. Artificial Intelligence and Machine Learning play a significant role in this. It might be stated as Artificial Intelligence helps reduce manpower and saves time. Face recognition has turned up as one of the computer visions' and image processing's most complex and challenging subject. Through this technology, a person's face could be easily detected using a dataset of comparatively matching appearances. This approach can be used in variety of services, such as the armed forces, defence organizations, primary, secondary as well as higher secondary schools and colleges and universities, airlines, banks, state and central government public service offices, etc. Face masks are becoming more common as part of routine virus prevention measures, particularly in the period of outbreaks like COVID-19. Different companies and institutes as well as organizations must be able to recognize whether or not people are wearing face masks in a specific area and at a specific time. The updating task of the data needsto be done in real time and in an automatic manner. The fundamental variability in faces of human being, such as shape, texture of the skin, coloring, having beard and moustache, wearing different types of spectacles or not, and even wearing masks, is a major issue in face detection. This recommended method is 99% competent and accurate in producing a definite result for the identification of faces wearing mask as well as not wearing a mask and detecting the individuals, as per the experiments done and recorded.

## **Materials and Methods**

This study was done to draw attention to researchers by providing a descriptive review on all the published works related to facemask detection. (Haddad et al., 2020) examined the evolution of object detection algorithms. The performance comparison amongst the algorithms is discussed in reported manner. Finally, this study concludes with a conversation of some of the major problems in the respective study. The model called “Facemasknet” was proposed by (Inamdar et al., 2020) to identify a person wearing a facemask properly or not. The dataset trained to machine contained 35 images including both images of masked faces and un-masked faces. The input data was pre-processed and resized. After pre-

processing, the input image was sent to Facemasknet model, which detected the face. Facemasknet model reported an accuracy of 98.6%. (Shashi Yadav et al., 2020) presented “A system combining Deep Learning and Geometric Learning”, to determine if a someone is keeping a social distance and wearing a mask. The research was done on “Raspberry Pi 4 with RTSP”. Pre-trained SSD framework with “MobileNetV2” was used. 3 criteria were presented. People were identified using “MobileNetV2” which was credited by “OpenCV and TensorFlow”. “Euclidean distances” was measured among detected persons. It was able to identify if people had worn mask. If a person was not wearing mask and/or maintaining social distance then an alarm was turned on to the in-charge people. Here, the performance factor was identifying social distancing. The model accomplished a precision of 91.7%. (Jiang et al., 2021) presented a face detector model called “RetinaFaceMask”. It had a framework of a “backbone network, a neck, and head networks”. The Feature extraction was done in backbone network. The model adopts “ResNet” as preliminary backbone, and “MobileNet” for comparison purpose. Feature Pyramid Network (FPN) was composed and built inside CNN for high-level precision which was called neck. Detection was performed in the head module. In this algorithm, “Transfer Learning (TL)” was used. (Ristea et al., 2020) composed method for facemask detection from speech. “Generative Adversarial Networks (GANs)” was used for training purpose. The initial and transformed accents were converted to spectra that were used as input to ResNet networks with different depths. The start layer was 18, and the end layer was 101. All the outputs of ResNet were mixed in concatenated feature vectors and were considered as input for the SVM, which predicts the final result. The dataset had 36554 samples. 10,895 data were used for training, 14,647 data for developing, and the rest of the data for testing. Huge amount of time was consumed. This was the main drawback of this model. The accuracy of 74.6% was obtained.

### **Existing system**

Due to the obvious distinctive shape of human facial images, established methods for identifying the person's face with and without masks does not respond well. Facial recognition of a human is one of the most recently used biometric methods which are currently being examined. Identification of human faces, on the either hand, is one of the most complex tasks in image processing domain. The main intention of face detection is to find out whether there is a person's face in the captured image/photo as well as to detect the area of that face in an image/photo. Face identification is obviously the first step towards developing an automated system that may include additional face processing techniques. The neural network is formed and trained by collecting a huge amount of training datasets.

#### **Disadvantages of Existing System**

- Cannot detect human faces accurately.
- Cannot detect human faces with and without wearing a mask accurately.
- Doesn't work well because of different facial structures of different people.
- It requires more manpower.
- It is less cost-effective and time-saving.

## Proposed System

Face detection and recognition is accomplished using a simple model that combines CNN and Deep Learning for actual-time detection and identification of human faces as well as the wearing of mask. It is able to recognise human faces in single and multiple face photos in actual-time, both wearing and not wearing the mask. Noise removal and holes filling in colour images are also included in the projected framework's pre-processing phase. Face detection is conducted using CNN architecture after pre- processing. Keras Library in Python is being used to create CNN architectural layers. Faces that have been detected are enhanced to speed up the calculations. The Haar Cascade Algorithm is used to extract features from the augmented images. The military, defence organizations, schools and colleges, institutions, banking, hospitals as well as airlines, can all benefit from this strategy.

### Advantages of Proposed System

- Able to find the person who violates the rule of wearing mask during the pandemic.
- Reduces manpower.
- More cost-effective.
- Easy implementation and low maintenance cost.
- More Accurate in detecting the people who are wearing a mask and also not wearing the mask.

## Algorithms used

### *Principal Component Analysis*

Principal Component Analysis is an effective face recognition approach because it detects variability in human faces that isn't always visible. Principal Component Analysis does not try to categorise faces based on common morphological variations like nose length or jaw line. Instead, PCA is used to examine a group of human faces in order to establish which 'variables' contribute for the variation of the faces. These variables are known as "eigen faces" in face recognition because they have a remarkable similarity to human faces when represented. Although PCA is widely used in statistical data analysis, pattern matching industry has just begun to use it for categorization.

### *Haar Cascade Algorithm*

This is an object detection algorithm that detects faces in images and real-time videos. Viola and Jones proposed edge or line detection features in their research paper "Rapid Object Detection using a Boosted Cascade of Simple Features," published in 2001. For training process, a large number of positive photos with faces and a large number of negative images with no faces are given to the algorithm. Pixels with a value of 1 are the darker regions in the haar feature, while pixels with a value of 0 are the lighter regions. Each of these is in charge of identifying a specific characteristic in the picture.

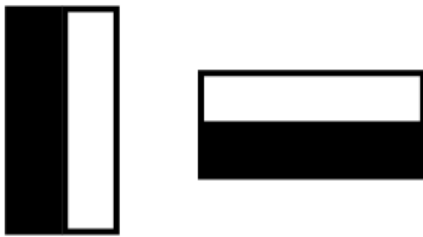


Figure 2(a): Set 1



Figure 2(b): Set 2

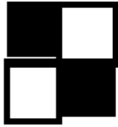


Figure 2(c): Set 3

The first pair of two rectangular features is in charge of determining whether the edges are horizontal or vertical. The second group of three rectangles features is in charge of determining whether a lighter zone is flanked on either end by darker sections or vice versa. The final set of four rectangular characteristics is in charge of determining how intensity values fluctuate across diagonals. Haar Cascade technique is a sophisticated face detection technology that has been around for a long time. Haar Features were employed to recognize faces as well as eyes, lips, vehicle number plates, and other features.

### System Design

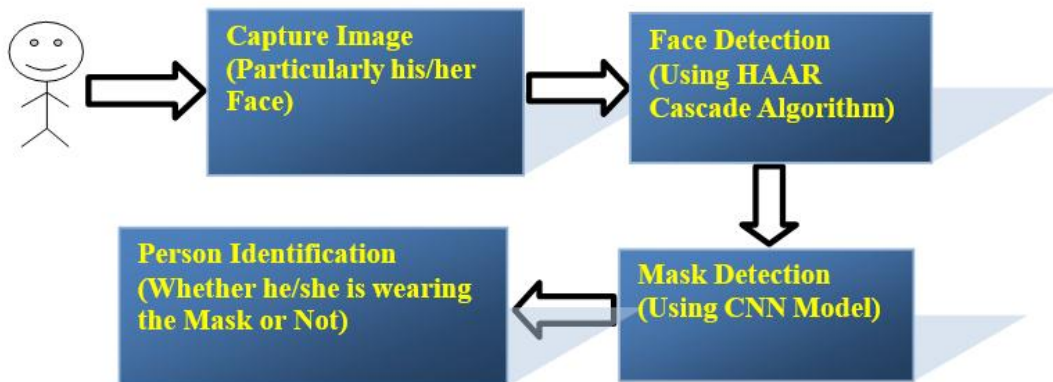


Figure 2(d): System Architecture

#### User

In a real-world setting, a user is a person who stands before a webcam or camera.

#### Capture Images

Images captured either by the webcam or by the camera are then used as a dataset to train the model. The training model's accuracy improves when the

dataset covers human faces in different masks and backgrounds, and also with a large number of human facial images.

#### *Face Detection*

We used the HAAR Cascade algorithm to detect faces. All black pixel in grey-scale photographs are accumulated using this method. The total majority of white squares or boxes are then reduced to the least amount of white boxes. Finally, the result is compared to the specified threshold, and if the requirement is reached, the function considers the result as a success.

#### *Mask Detection*

A sequential Convolutional Neural Network (CNN) model with the open source software Library called Keras in Python is utilised for detecting the mask. Keras is an open-source software library for artificial neural networks that includes a Python interface. Keras serves as a user interface for TensorFlow. Keras includes many variants of standard neural-network basic components like layers, goals, activation functions, optimizers, and plenty of other tools to make working with picture and textual information simpler while also reducing the amount of coding required to write deep neural network code. Keras supports convolutional neural networks as well as recurrent neural networks. Other popular utility layers supported include dropout, batchnormalizing, and pooling. A dataset of human faces with and without masks is used to train the sequential CNN model. Similar to a human mind, the model builds a logic using pre-processed images, and then performs extraction of features and classification methods to identify the person's face and the mask. Further, it proceeds on to the prediction or the identification step/phase after identifying the mask and the person's face.

#### *Person Identification*

According to the training given to the model, it predicts the person's face wearing the mask at this step. Depending on the model's efficiency and the number of images it has been trained on, the prediction happens. Finally, the technology shows the result that whether people are wearing a mask or not wearing a mask.

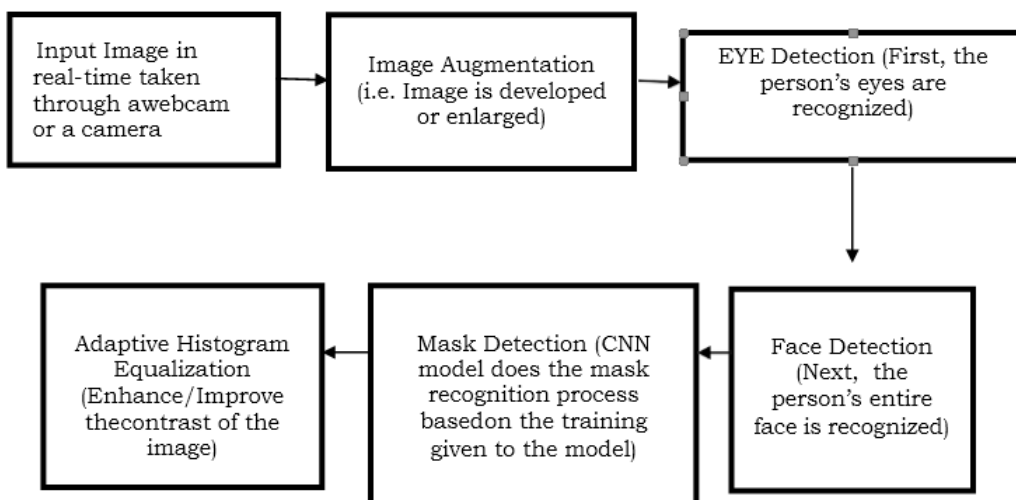


Figure 2(e): Pre-processing

### *Dataset*

The suggested model includes datasets collected from individuals. Faces are divided into two categories. They are wearing masks as well as not wearing masks, furthermore they are maintained in separate folders. Each of the folders contains about 1500 to 2000 photographs of a different persons sitting or standing in different directions/angles. To improve the accuracy of the training model, the each one's facial images must be included collected through various masks and backdrops. In Python, the dataset is combined and mixed deep in the Keras Library. As many data are there, greater accurate is achieved in the training model. As a result, the accuracy of the training model is directly proportional to the dataset images.

### *Data Pre-processing*

Reading images is performed in this step. After reading, the image is enlarged and the noise is also removed. Gaussian blur is the outcome of using a Gaussian function to blur a picture. It is a regular consequence in graphical pictures, and is normally used to reduce noise in the picture. After that, the photos are cleaned up and the intensity values are converted to pixel format. This stage's output is fed into the training model.

### *Segmentation*

Image segmentation is a technique of dividing an image's contents into multiple pixels. By simplifying and/or modifying an image's representation, image categorization aims to make it more informative and easier to study. Image segmentation is used to identify entities in photographs such as edges, curves, size, brightness, and so on. To put it in another way, image segmentation is the process of assigning a label to each pixel in an image because pixels with the same label share similar characteristics. Here, we separate the backdrop from the foreground elements in the image, and strengthen the segmentation with more noise removal. Markers have been used to divide the various things in the image.

### *Edge detection*

The edge detector called Sobel has been used. It works by intervolving the image with a tiny, detachable, also filtered in both the horizontal as well as vertical directions, making it relatively computationally efficient. The Sobel operator finds the two - dimensional absolute gradient in the image. It operates on every pixel of the picture, measuring the gradient magnitude for each pixel. It implements a pair of 3x3 convolutional masks, for both directions. The Sobel edge development filter has advantages like delivering both distinguishing (i.e. the edge response) and smoothing (i.e. the noise reduction) at the same time.

### *Localization*

Face localization is the process of estimating the faces and boundaries of a picture. The primary difference between facial recognition and facial localization is subtle. It tries to recognize the face using a bounding box in face localization. This is known as localized face classification, as well as it also recognizes and classifies numerous faces in an image. The goal here is to locate the object and draw a bounding box around it.

### *Feature Selection*

Feature selection is a features extraction approach extensively used in data mining and knowledge discovery that permits the removal of unimportant/unnecessary features while maintaining the underlying particular data. This means shorter transmission of data as well as more efficient and scalable processing. It also has the potential to improve communication by reducing network congestion, increasing data flow, and increasing storage. Feature selection is a crucial topic in deep learning as well as other related domains since it can remove uninformative or noisy features, improving the quality of the information collected and learning system's performance. One of the most significant benefits of this technique is that it eliminates some needs to take out the features from images by ourselves. During training phase, network is trained to extract the characteristics. PCA examines all of the elements that influence the faces rather than just the geometrical ones. As a result, PCA provides reliable and exact face detection and identification results.

### *CNN Architecture*

The Keras Python package is used to develop the Convolutional Neural Network Architecture layers. Mask detection is achieved by using convolutional layer. It uses Principal Component Analysis (PCA) to extract picture attributes and translates them to a low dimensional picture. It does not lose any qualities of the picture. The convolutional layer's result will be used as the input for the following Batch Normalization layer. For each mini-batch, the Batch Normalization layer provides a standard inputs to a layer. As a result, the learning process is stabilized, and the number of training epochs is drastically reduced. Afterwards, the images of faces are classified. After the photos have been tested, model accuracy calculations and predictions are carried out. If non-test images are acquired, those images are trained first, followed by validation testing. If the model is validating, training operation is performed and the results are kept for future process. If the model is non-validated, then it is subjected to network training, which includes weight loss calculations and adjustments. Finally, the CNN model accurately predicts and predicts the human face hidden behind the mask. The Convolution Neural Networks is a type of deep neural network which is used to analyze visual pictures. Spatially invariant artificial neural networks (SIANN) are built on a weight-sharing structure of convolutional kernels that glides on the input features and provides an equivalent translation response called feature maps. Surprisingly, most convolutional neural networks are only consistent and efficient under translation, rather than invariant. They're utilized in computer vision and pattern recognition, recommendation systems, classification techniques, image classification, medical image classification, natural language processing, brain tumor detection and monetary time - series data and interfaces, etc.

### *Training*

The CNN model receives the pre-processed facial photos for training. A logic is developed in the CNN depending on the datasets to classify the faces based on their attributes. This model has been saved. The trained model can classify human faces depending on whether or not they have masks on them. A

sequence of Convolutional Neural Network model and the HAAR Cascade Algorithm are used to train the model.

### *Prediction*

Whenever a human being stands in front of a webcam or a camera during this phase, the picture is collected as well as forecasted via CNN model using sequential model's logic. Pre-processing is applied to the image. After that, the pre-processed photos as well as the saved CNN model are loaded. According to a trained model, the computer predicts and detects human face based on an algorithm processed by the system.

## **Methodology**

### *The input image*

In this proposed system, real-time input graphics are utilized. Since they have masks on their faces, the faces of people in input picture must be totally or partially hidden. For processing, the computer system (webcam or camera) requires sufficient number of pixels and sufficient degree of visibility. It is expected to operate well both indoors and outdoors, such as in hospitals, hotels, police stations, and schools, based on experimental evidence.

### *The pre-processing stage*

Pre-processing removes noise, improve some relevant features, and for further scrutinization of the trained model, the captured image dataset must be imported as Python data structures. Before performing face detection and masking techniques, the input image must be pre-processed. Removing the noise, eye detection, mask identification, and hole filling procedures are all part of the pre-processing process. Noise reduction and filling the holes help to eliminate incorrect face/face detection. The facial image is now cropped and re-localized after pre-processing. To raise the efficiency of the pre-processed image, histogram normalization is used.

### *The face detection stage*

The HAAR Cascade algorithm is used to find faces. The value from all black pixels in greyscale images was gathered in this system. Then subtraction of the total number of white boxes from the total number of black boxes is done. Finally, the result is compared with specified threshold. If the requirement is met, then the function considers the result as success. Each single pixel in the feature areas must be obtained for each computation in Haar-feature. Append(startX, startY, endX, endY) is the addition of the intensity in the given (erect or inverted or rotated) rectangle encompassed in a target object, where startX, startY, endX, endY are the starting and ending coordinates of that rectangle box, respectively. Haar Wavelets, a box classifier is used to extract facial features from the complex images.

### *The Feature-Extraction Stage*

By extracting features from pre-processed facial images and translating them to a lower dimension without destroying image properties, Feature Extraction enhances model accuracy. The classification of human faces is possible at this point.

*The classification stage*

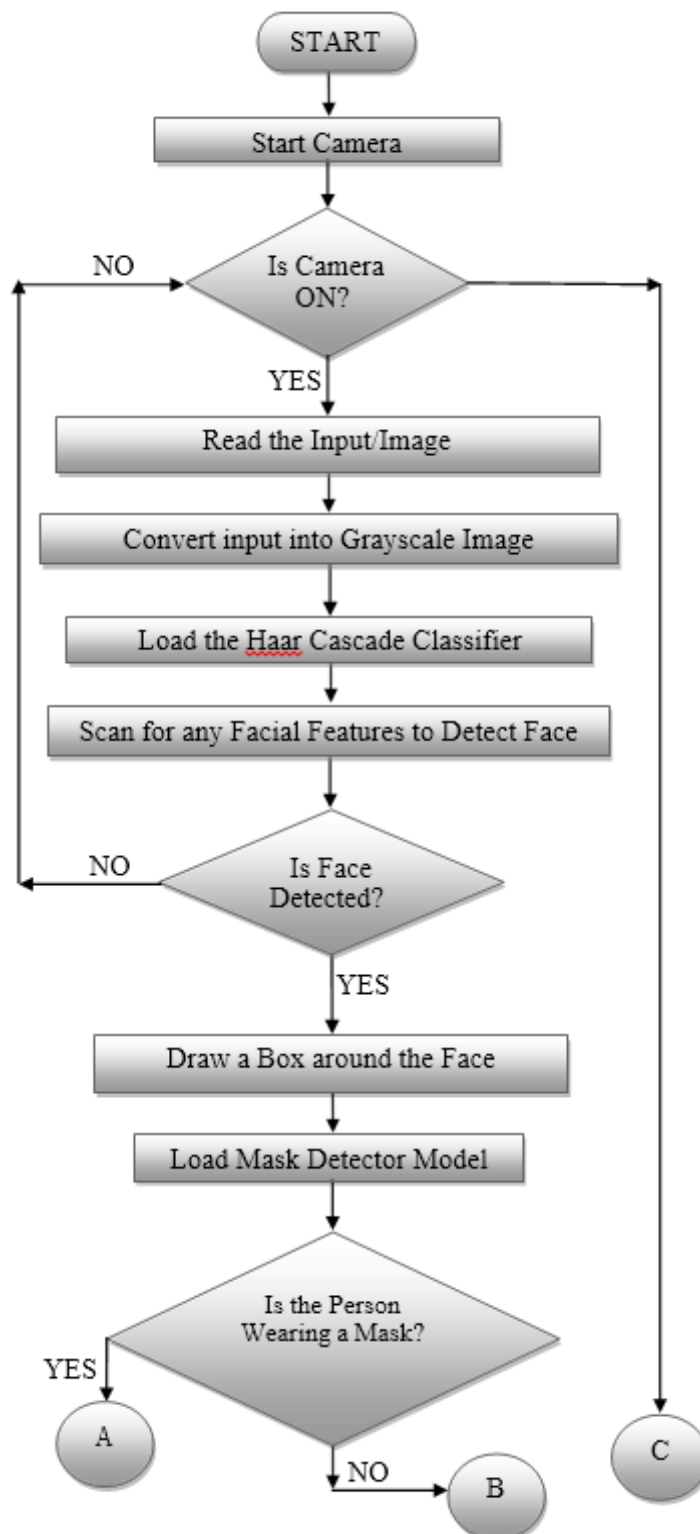
After an image recognition model has been trained to identify facial images, Principal Component Analysis (PCA) is used to classify them. PCA comes into play and proves to be the perfect approach for dealing with the problem of face recognition. PCA does not classify facial images purely on geometrical qualities; instead, it examines all elements that could impact the faces in an image. In the field of pattern recognition, PCA was frequently utilised to solve classification difficulties. In terms of data reduction and perception, PCA shows its value.

*Training stage*

This method is built on the idea that it gets training from the pre-processed facial images and then uses a Convolutional Neural Network (CNN) model to build a framework for classifying the images into groups. This qualifying model is saved for further and will be utilized later in the prediction phase. The steps of feature extraction are done by PCA and feature selection is done by Sobel Edge Detector in the CNN model, which increases the training model's classification efficiency and accuracy.

*Prediction stage*

The stored model recognizes the face mask picture acquired by the webcam or camera at this stage. For guessing the person behind the mask, the saved model and pre-processed data are loaded. Face detection, categorization, and identification are all performed with great accuracy using CNN, resulting in accurate and perfect results. For human face prediction, the CNN model uses a sequential model and the Keras Library in Python.





## Results and Discussions

This research proposes using a sequential CNN to detect and recognize human faces with both wearing a mask and not wearing a mask. The Haar Cascade Algorithm and the CNN model facilitate automatic identification as well as recognition of human faces, by removing the noise and background fluctuations induced by the environment to offer more accurate and exact results. It also aids in overcoming the existing facial recognition and detection trend's uneven nature. When compared to alternative designs, the suggested CNN obtains a high level of accuracy, according to the testing. The proposed approach is successful for a large variety of image kinds. These findings show that the suggested CNN model decreases complexity while increasing the computational efficiency of the approach. The proposed technique works well for both the grayscale and the colour images, with and without masks. The proposed project can identify many people wearing a mask as well as not wearing a mask. If the person is wearing a mask then a green colour rectangular box will be created around his face and the accuracy (in percentage) of wearing the mask will be shown. The rectangular box will be labelled as "MASK" along with the percentage of wearing the mask in green colour. Similarly, if a person is not wearing a mask then a red colour rectangular box will be created around his face and the accuracy (in percentage) of not wearing the mask will be shown. The rectangular box will be labelled as "NO MASK" along with the percentage of not wearing the mask in red colour.

The project will detect the person and the rectangular box will be labelled as "MASK" if and only if the person is wearing the mask in the proper manner. Otherwise, it will detect the person as not wearing the mask and the rectangular box will be labelled as "No MASK". Figure 7(b) shows that the project can recognize a large number of persons using the mask, as well as the precision with which they are wearing or not wearing it. Similarly, we can observe in figure 7(c) that it can recognize everyone who isn't wearing a mask. Figure 7(d) shows that it can also detect a single person. The individual in this figure has not correctly worn their mask, hence it displays as "NO MASK" alongwith the high precision. This project can be used in schools, colleges, hospitals, military, banking, defence organizations, universities, airlines, etc.

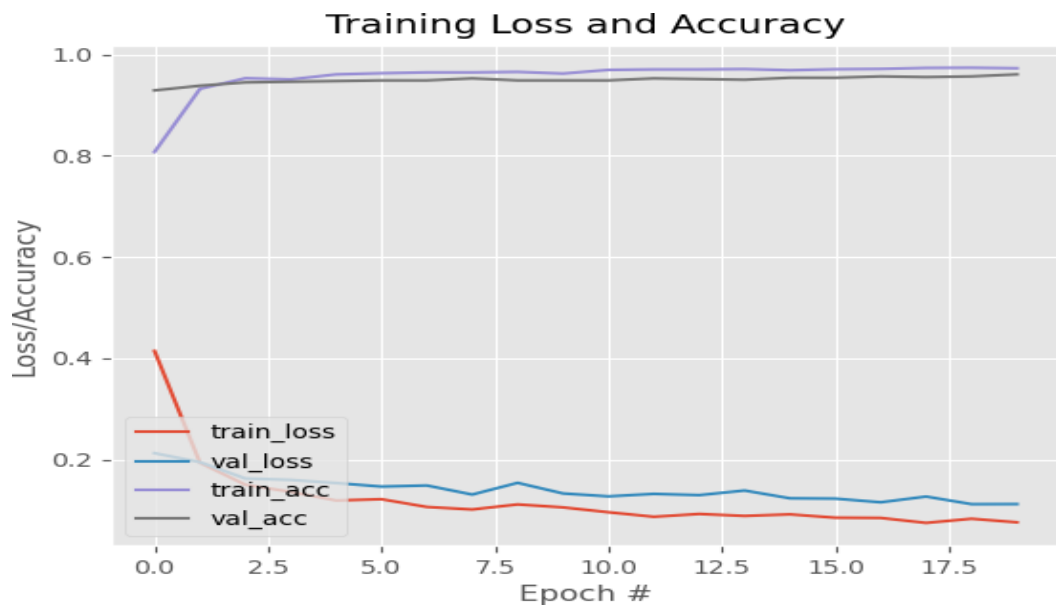


Figure 3(a): Loss Graph

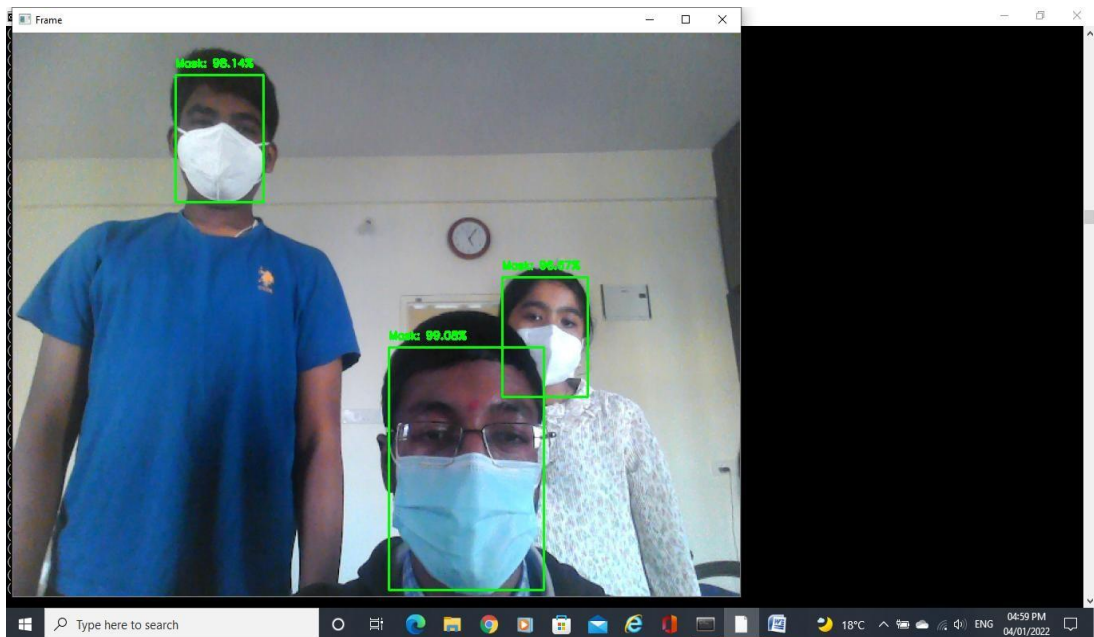


Figure 3(b): Detect many people (All the people are wearing the mask)

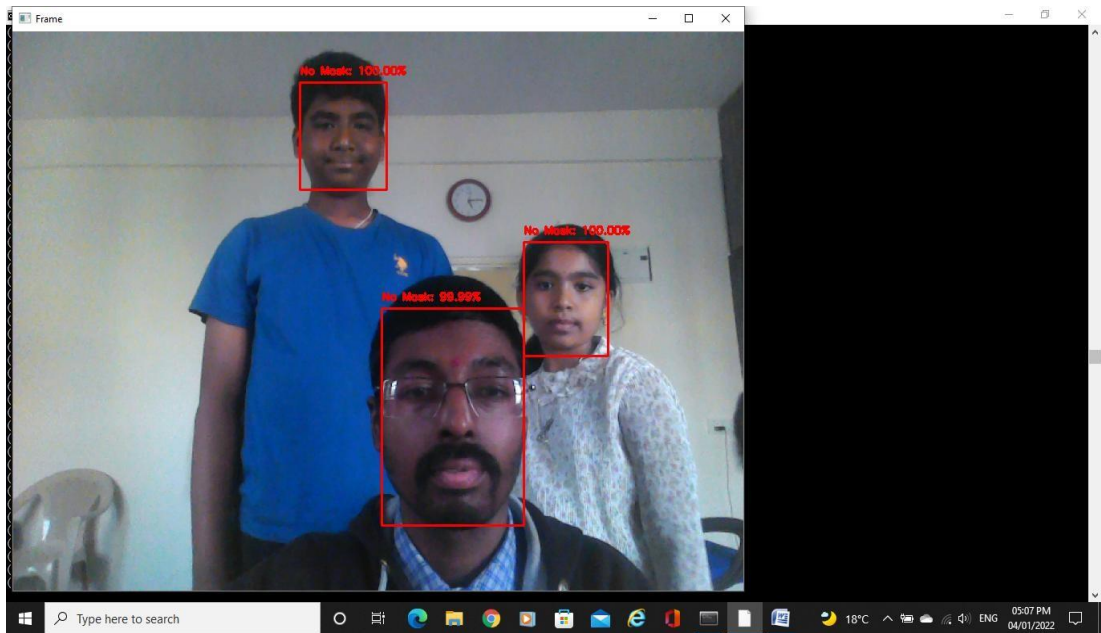


Figure 3(c): All the people are not wearing the mask

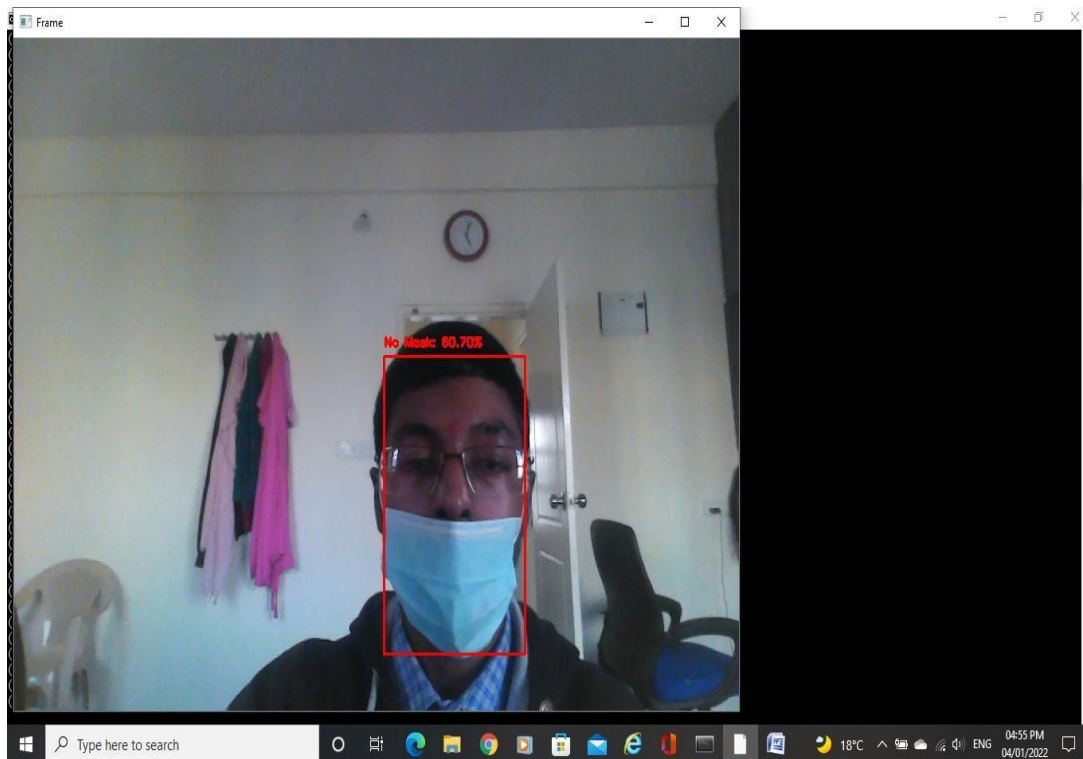


Figure 3(d): Mask not covered the nose

## Conclusion

In real-time, the proposed system can identify and recognize human faces wearing a mask as well as human faces not wearing a mask with better accuracy. CNN model with Python Keras library provides a shorter detection time as well as recognition time and also is stronger in robustness than common face detection and recognition systems, which can lower the error rate. In this modern era, it can still guarantee a high test rate, and a high detection speed which can satisfy the real-time needs by achieving good results. For the identification as well as recognition of human faces with wearing mask and without wearing mask, the suggested CNN model has higher accuracy and prediction. As a result, this technique is valuable in surveillance applications during this pandemic situation.

## Acknowledgements

We extend our deep sense of sincere gratitude to Dr. Channakesavalu K, Principal, East West Institute of Technology, Bengaluru, for having permitted to carry out the project entitled “REAL TIME COVID- 19 FACE MASK DETECTION USING DEEP LEARNING” successfully. We express our heartfelt sincere gratitude to HOD, Department of Computer Science and Engineering, and all the Teaching, Technical faculty and supporting staff members of Department of Computer Science and Engineering, East West Institute of Technology, Bengaluru, for their valuable suggestions and support. Finally, we would like to thank our Parents and Cousins for their support.

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