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AN ADVANCED DEEP LEARNING FACIAL MASK DETECTION APPROACH FOR CONTROLLING COVID-19

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ABSTRACT

The COVID-19 outbreak has wreaked havoc on our daily lives, impacting global trade and mobility. Wearing face masks has become a new norm as it aids in reducing the transmission of Covid-19 by up to 80 to 90%. Unfortunately, there are number of people who doesn't wear masks properly because of various health issues or negligence and hence create obstruct in achieving the goal. Therefore, in this paper an efficient and highly accurate face mask detection model has been proposed in which work has been done on enhancing Image Quality and classification rate. The main objective of the proposed model is to enhance the quality of images so that features can be extracted effectively which ultimately improves the accuracy rate as well. In the proposed work, an adaptive histogram equalization technique has been used for enhancing the quality of images. Moreover, to improve the classification accuracy rate of the proposed model Residual Neural Network is employed. The efficiency of the proposed model is validated on hybrid dataset that is formed by combining two datasets. Finally, the performance of the proposed approach is examined and compared with few state of art methods in MATLAB software. The simulated outcomes were attained in terms of accuracy, precision, sensitivity, specificity, recall and Fscore. The results revealed that proposed model was able to detect masked and non-masked faces effectively with an accuracy of 99%.

Keywords: Disease detection, biomedical applications, Artificial Intelligence, Machine learning, etc.

I. INTRODUCTION

Corona-virus disease that emerged in the year 2019, and is also known as COVID-19, is basically a respiratory illness that's an outcome of the severe acute respiratory syndrome corona-virus-2 (abbreviated as SARS-COV-2). This disease is caused by virus namely corona-viridae that belongs to a positive sense RNA, single-stranded family of viruses. The disease Coronavirus takes its title from the crown-like patterns that are clearly visible under electronic microscope. Envelopes containing helical nucleo-capsids and nucleoproteins (N) are connected with the RNA genome in the virus architecture.

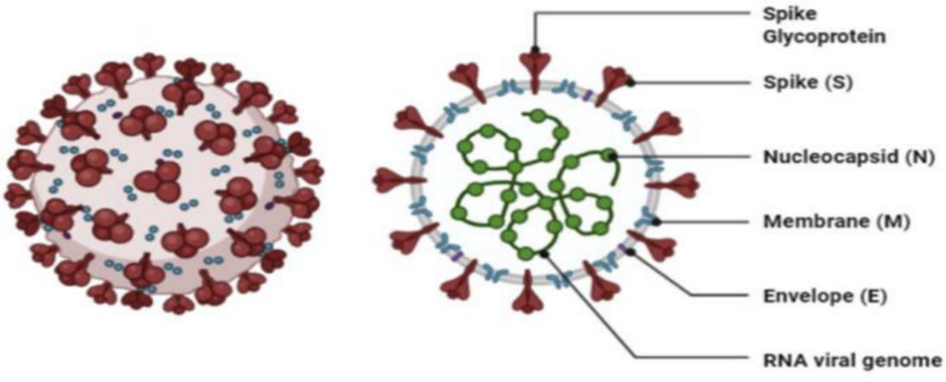

Figure 1. Structural diagram of COVID-19

Moreover, a 2 nm long trimer of spike glycoproteins (S) is also inserted in the envelopes which acts as the primary source of virus's adherence to the receptors of the human host. Integral membranes (M) and envelope proteins (E) are also found within the virus. Hemagglutinin esterase is yet another glycoprotein membrane that is mostly found in beta-coronaviruses in which spikes are near about 5–7 nm long [1]. The structural diagram of the COVID-19 is shown in figure 1.

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Symptoms and Guidelines issued for combating COVID-19 transmission

The symptoms of COVID-19 are much similar to the influenza virus, and causes same problems like cough, fever, fatigue and breathlessness. Since the outbreak of COVID-19, many scientists are trying to find the origin of the virus, however, the exact origin of the virus is still not known, but many scientists have categorized genome sequence of SARS-COV-2 as a member of the β-CoV genera, which usually derives their genes from the rodents and bats. The first positive case of COVID-19 was confirmed on December 2019 in Wuhan city of China. Soon after its outbreak in December, the virus spreaded with a lightning speed and effected around 213 countries and other independent territories around the globe [2]. The COVID-19 emerged in various ways and levels of intensity that range from mild to severe. The mild symptoms of COVID-19 may cause self-limiting respiratory illness while as the severe symptoms may result in pneumonia, organ failure or can even cause death. The authorities are worried about the Consequences of this pandemic as the situation becomes alarming with the huge rise in number of positive cases and persons experiencing respiratory and cardiovascular complications. Thus, the need for finding the solutions that can prevent the spread of COVID-19 emerged. Furthermore, the main challenge that scientists have to deal with, is huge rise in number of COVID positive cases, also called as big data [3]. As per the report generated by the World Health organization (WHO) on 6th April, 2022, the total number of confirmed cases around the globe is 492,189, 439 with 6,159,474 deaths. Various efforts were put forward by the authorities to fight against the pandemic. The officials established the lockdown in their areas so that the virus cannot be transmitted further, healthcare systems were given attention to deal with the pandemic, packages were released to ease the economic crises and adoption of several COVID-19 policies were recommended [4].

Several guidelines were issued by the WHO which included; washing hands regularly with soap, maintaining a distance of 1 meter, avoid touching mouth, eyes and nose, sanitizing hands regularly, covering mouth while sneezing and most importantly reporting immediately to the nearest health center if any COVID related symptom occurs, wearing face masks in public places [5]. These measures can restrict the human to human transmission of Corona-virus. Among all these guidelines, wearing a face mask is one of the most effective means for preventing the transmission of Covid-19. Studies have shown that the transmission of COVID-19 is reduced by around 96% when individuals are wearing face masks properly [6]. Officials all across the world have imposed strict laws requiring everyone to wear masks when stepping outside. If worn appropriately, the face mask reduces the pace of droplets emitted during coughing and sneezing, preventing the infection from occurring [7]. Yet, because of many of factors such as underlying health problems that make breathing difficult, insufficient sanitation, social instability, socioeconomic concerns, illiteracy, and a shortage of face masks, frequent use of face masks has proven difficult [8,9 &10]. Furthermore, some people do not wear face masks even when they do not have any health issues. Therefore, it is important detect the face masks effectively and automatically and this can be accomplished by the computer vison.

Role of AI in detecting facemasks

Computer vision is among the emerging approaches in the field of object recognition, and it's already been employed in a variety of AI-based applications. Specialists, researchers, and engineers have employed AI techniques to greatly improve the testing regime for the Covid-19 pandemic throughout the years [11-12]. Just like any other detection system, the face mask detection system undergoes through different phases of data collection, pre-processing, feature extraction and classification. In the first stage, the inputs are received or collected from the various image acquisition devices such as camera or live video stream. In the next stage, the image received a san input is pre-processed by removing the unnecessary features and by fixing the light. In the next module, features of the image are extracted to make a feature vector and finally classification is done by using the ML or DL based classifiers. With the continuous development in the field of AI, a number of ML and DL based face mask detection techniques have been proposed. Some of the recently published papers are analyzed in the next section of this paper.

II. LITERATURE REVIEW

In the past few years, a number of approaches have been developed for detecting the face masks on individuals effectively and efficiently. Some of them are discussed here; **Oumina, A et al. [13],** proposed a effective face mask detection approach in which features of face were extracted from images by using the Convolutional Neural network (CNN). The classification of the masked and non-masked images was through SVM and KNN individually. The results revealed that when SVM was combined with the MobileNetV2, the classification rate was mounted at 97.1%. **Rao, T. Subhamastan, et al. [14],** suggested a scheme in which they used CNN for identifying the individuals who are not wearing mask in public places. This information is then sent to the public administration database where its information is gather and the fined amount is sent to concerned phone number and address. The proposed model achieved an accuracy of 91.21%. **Peishu Wu et al. [15],** proposed FMD-Yolo model in order to recognize and identify masked and non-masked faces of individuals in public places. They used the Res2Net-101 along with the res2Net and ResNet for extracting features from images. The features were then fused together by using the En-PAN. **Jiang, Xinbei, et al. [16], proposed** a new face mask identification dataset and named it as, Properly Wearing Masked Face Detection Dataset (PWMFD). To detect and classify masked and non-masked images, the authors proposed Squeeze and Excitation (SE)-YOLOv3 model which was integrated with the darknet53 for extracting only important and critical features. **Singh, S et al. [17],** analyzed the performance of two traditional model which included YOLOv3 and R-CNN on specific datasets for identifying the masked and non-masked individuals. **M. Sarma, et al. [18],** suggested an effective DL based face mask detection mechanism in which they utilized the Histogram of Oriented gradients (HOG) and CNN for extracting features from images and classifying them accordingly. **Gupta S et al. [19],** proposed a ML based face mask detection model for identifying the masked and non-masked persons. The proposed model was connected to the CCTV so that it can effectively identify persons without mask and stop them from entering into building. **Chen, Yuzhen, et al. [20],** proposed a ML based face mask detection method in which they extracted important features by using the GLCM technique and then classification was done with KNN algorithm. The proposed model was able to achieve a precision rate of 82.87%. **M. Loey et al. [21],** proposed a new and effective face mask detection model in which they integrated DL techniques along with traditional ML algorithms. The features were extracted from images using Resnet50 and then DT, SVM and ensemble techniques were used for classifying the masked and non-masked individuals. The efficacy of the suggested scheme was analyzed on Real-World Masked Face Dataset (RMFD), the Simulated Masked Face Dataset (SMFD), and the Labeled Faces in the Wild (LFW) databases, wherein SVM yielded an accuracy of 99.64% when trained with RMFD dataset. **M. Loey et al. [22],** presented a hybrid face mask recognition model in which ResNet-50 was used for extracting features and YOLO V2 was used for classifying and categorizing the masked and non-masked persons. In addition to this, the total number of anchor boxes were calculated in the proposed model through mean IOU.

From the literature study, it has been observed that over the past few years, a substantial number of ML and DL based face mask detection models were proposed. Each technique has its own advantages and disadvantages. Although, these models were generating effective results but it was analyzed that there was still a scope of improvement in these methods. Majority of the current face mask detection systems are utilizing classifiers that do not perform well with the image datasets which had a direct impact on the accuracy and efficacy of the system. Some face mask detection models also used ML classifiers in their work which doesn't work effectively when the size of data is huge and also ten to lose a lot of important and critical information during feature extraction face. In addition to this, majority of the classifiers doesn't have the ability for retaining the information about object location and direction. All these factors significantly affected the accuracy and precision of the current face mask detection system and hence need for an improved and effective model raised.

III. PROPOSED WORK

In order to overcome the limitations of the traditional face mask detection systems, a new, effective and highly accurate Deep learning model is proposed in this paper. The main goal of the proposed Dl method is to enhance the classification accuracy rate while also reducing the intricacy of the overall model. To combat this task, modifications has been done on two important phases of detection system i.e. image quality and classification in this work. The proposed face mask detection systems quite similar to that of other automatic facemask detection systems. Initially, important and relevant data is collected from the two datasets, whose information is given in the methodology section of this paper. Since, these images are in raw form and contain huge noisy and unnecessary data, therefore it needs to be processed. In the proposed work, the quality of images is enhanced by using the Adaptive Histogram Equalization technique which aids the model to detect faces from given images with less complexity and better visualization. In the second phase, an improved deep learning based residual neural Network (ResNet) is used for classifying and categorizing the images with masked and non-masked individuals. The main reason for employing the ResNet in the proposed model is its ability to enhance the accuracy rate of the model by using its deeper training capabilities. Moreover, the residual neural network was chosen because residual networks have a common feature in convolutional neural network models. Additionally, the gradient flow in the network is improved by using a residual connection network which aids the deeper layers to get trained effectively. Therefore, by combining the enhancing the image quality and utilizing the benefits of ResNet model, the suggested resNet model is able to improve the accuracy detection rate while reducing the systems overall complexity. The next section of this paper discusses the step by step working of proposed face mask detection approach.

IV. METHODOLOGY

In order to achieve the desired objectives, the proposed ResNet model undergoes through a series of steps which included data collection, preprocessing and image enhancement, feature extraction and finally classification, and are describes briefly below.

Step 1: In the beginning, the relevant and necessary information is gathered from the two datasets. In the first dataset, a maximum of 1539 images are present in which 1589 images contain masked person and 681 images belong to non-masked individuals respectively. Secondly, the MAFA database is employed in the suggested work, wherein a total of 23, 845 images are included. Figure 2, shows the original masked and non-masked images taken from two datasets.

Step 2: Since, the original dataset images contain a lot of unnecessary, redundant and noisy data, therefore these images need to be pre-processed. To accomplish this task, the proposed model crops the original image so that the face portion is clearly visible and only important and critical features are extracted from it. By doing so, the dimensionality of the dataset is reduced which in return also reduces its intricacy.

Figure 2. Original masked and Non-masked images

Step 3: After this, the quality of the image is improved in which an Adaptive Histogram equalization technique is implemented. The histogram technique converts the cropped images into Lab Color Space images so that the images looks vibrant and lively without actually altering the saturation slider. Figure 3, shows the lab color space converted images.

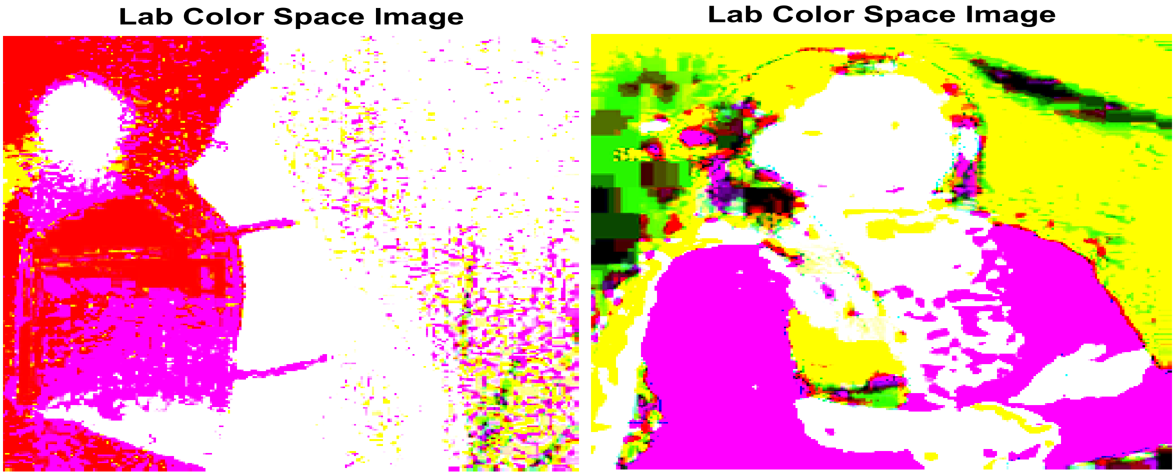

Figure 3. Lab color Space converted images

By improving the colors in the images, the quality of image is actually enhanced which assist in extracting only critical and related features. The enhanced images attained after implementing the adaptive histogram technique is shown in figure 4.

Table 1: Network Configuration parameters and their values

Parameters	Values
Image Size	32x32x3
Pixel Range	-4 to 4
Mini Batch Size	32
Learn Rate	0.001
Max Epochs	200
Shuffle	Every Epoch
Learn Rate Drop Factor	0.01
Learn Rate Drop Period	20

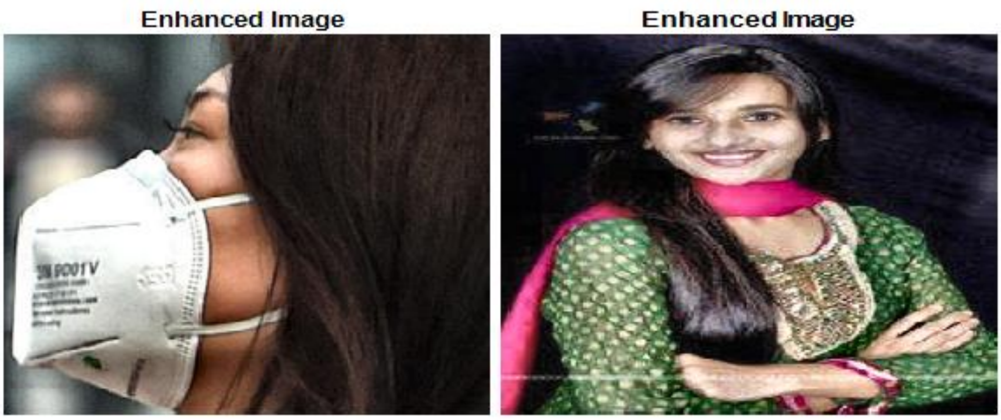

Figure 4 Enhanced quality images

Step 4: After this, the final processed and enhanced image data is spitted into two categories of training and testing in the ration of 80:20.

Step 5: In the next phase of the proposed model, the proposed ResNet model is initialized wherein different parameters including image size, pixel range, batch size, maximum epochs, learning rate and other important parameters that are mentioned in table 1 are defined.

Step 6: Once the model is initialized, training data is passed to it so that it can train itself. The performance of the trained model is the and validated by passing the testing data to it. The trained ResNet model analyzes the testing data and classifying and categorizes images as masked and non-masked images.

Step 7: Finally, the effectiveness of the suggested ResNet model is analyzed and validated by comparing it with traditional models in terms of various dependency factors like accuracy, precision, recall, sensitivity, specificity and Fscore. The detailed description of the results attained is given in the next section of this paper.

V. RESULTS AND DISCUSSION

The effectiveness of the suggested ResNet face mask detection model is analyzed and compared with the conventional similar models in the MATLAB software. The experimental results were obtained in terms of accuracy, precision, recall, sensitivity, specificity and Fscore, whose detailed description is given in this section.

5.1 Performance Evaluation

The efficacy of the suggested ResNet model is firstly analyzed in terms of Receiver Operating Characteristic (ROC). Figure 5 represent the ROC curve for the proposed ResNet model which demonstrates the prediction ability of the proposed ResNet classifier at different threshold levels. After analyzing the given graph, it is observed that when the proposed model predicts with 100% accuracy, its AUC curve is mounted at 1, whereas, the value of AUC curve comes down to 0, when the proposed model predicts wrongly.

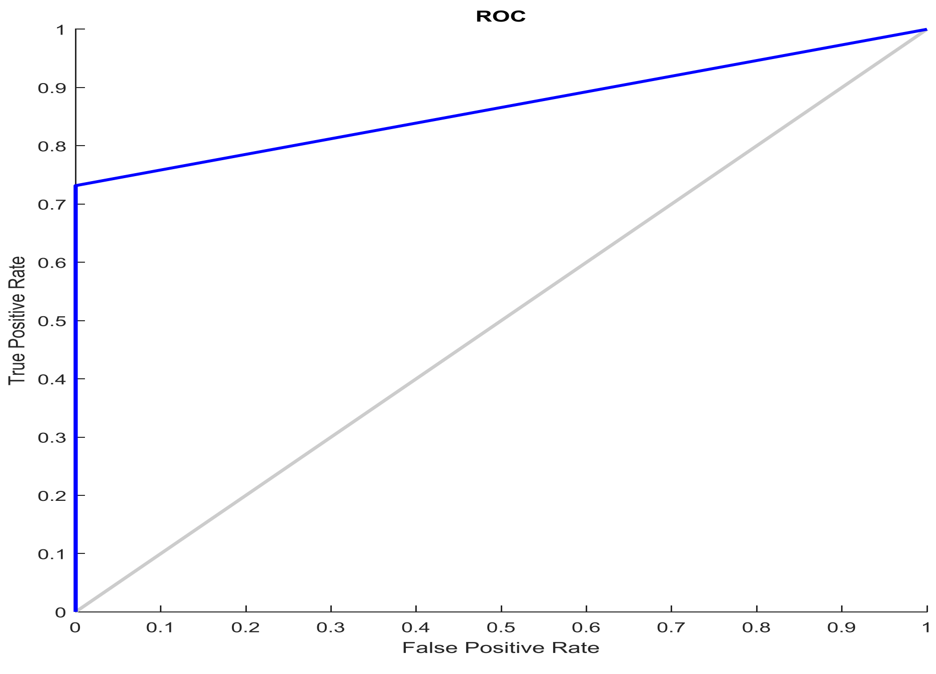

Figure 5 ROC curve for the proposed model

Furthermore, in order to prove the efficacy of the proposed ResNet facemask detection model, its performance is compared with the traditional similar models in terms of accuracy. The graph obtained for the accuracy rate is shown in figure 6.

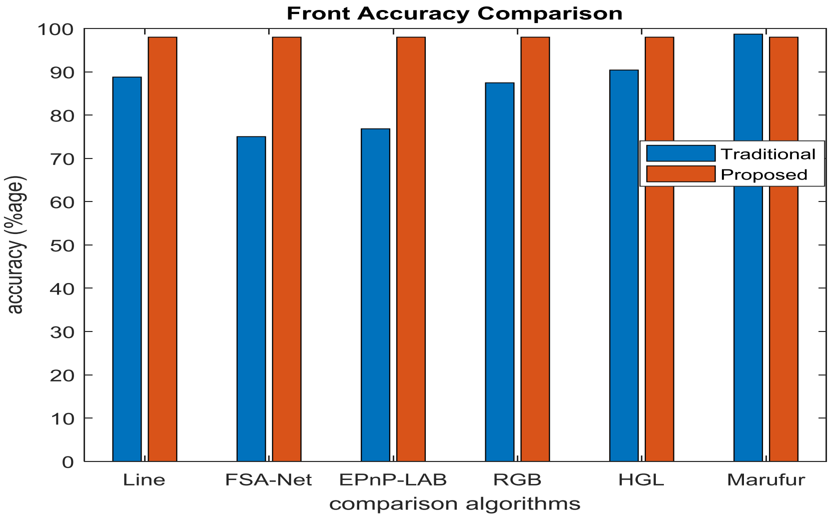

Figure 6. Comparison graph for accuracy

Above figure illustrates the comparison graph of the proposed model with conventional Line, FSA-Net, EPnP-LAB, RGB, HGL and Marufur in terms of their overall accuracy rate. From the given graph, it is observed that the value or accuracy yielded in traditional Line, FSA-Net, EPnP-LAB, RGB, HGL and Marufur face mask detection models came out to be 75.0250% for Line model, 76.8350% for FSA-Net , 88.7800% in EPnP-LAB, 87.4600% in RGB, 0.4050% in HGL and 98.7% in Marufur facemask detection models respectively. While as, in case of proposed ResNet model, the value of accuracy is mounted at 99.25% for detecting and recognizing the masked and non-masked individuals effectively. Table 2 represents the values attained for accuracy in each model.

Algorithm Name	Value in %age
Line [23]	88.7800
FSA-Net [24]	75.0250
EPnP-LAB[25]	76.8350
RGB	87.4600
HGL	90.4050
Marufur	98.7
Proposed	99.25

In addition to this, the performance of the proposed model is analyzed in terms of precision, recall, sensitivity, specificity and Fscore. The values attained for each paramters are recorded and mentioned in table 3 below.

Table 3: Exact values of different performance metrics in proposed model

Parameter	Values
Accuracy	99%
Precision	98.5207100591716
Recall	99.1071428571429
Fscore	98.8130563798220
Sensitivity	99.1071428571429
Specificity	99.1071428571429

From the given tables, it is observed that the value for each parameter in proposed ResNet based face mask detection model is in between 98 and 99%. These values in itself are optimum therefore, proving the supremacy of proposed approach over other similar approaches.

VI. CONCLUSION

In this paper, an effective and highly accurate face mask detection model is proposed that is based on residual neural networks (ResNet). The efficacy and efficiency of the proposed model is validated and compared with conventional models in the MATLAB software under different performance metrics like ROC, accuracy, sensitivity, specificity, precision, recall and Fscore. Through extensive experimentation, it is observed that the value of ROC curve in the proposed model is mounted at 1 which means it is detecting masked and non-masked faces quite appropriately. Also, the results attained showcased the accuracy rate in traditional conventional Line, FSA-Net, EPnP-LAB and RGB model came out to be 88.7800%, 75.0250%, 76.8350% and 87.4600% respectively. While as, the value of accuracy obtained in standard HGL and MArufur face mask detection models were accounted at 90.4050% and 98.7% respectively. In comparison to this, when the value of accuracy is analyzed for proposed model, it came out to be 99.25%, which is almost 0.55% higher than marufur and 8.845% higher than HGL models. In addition to this, the effectiveness of the suggested method was delineated in terms of precision, recall, fscore, sensitivity and specificity as well, whose values came out to be 98.52%, 99.107%, 98.813%,99.107% and 99.107% respectively. These values prove the effectiveness and efficiency of the suggested model in determining masked and non-masked faces.

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