"Mask Net: Deep Learning-based Face Mask Detection System using Convolutional Neural Networks"

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***Abstract*—During the COVID-19 pandemic, the facemask detection model has become the most important and necessary model. Manually checking whether individuals are wearing facemasks in public and busy places is time-consuming and inefficient, thereby increasing exposure to the virus. Using computer vision and deep learning, we want to create an automated model that recognizes whether people are wearing facemasks. In general, the majority of the publications concentrated on face detection utilizing some models and algorithms. The focus of our study is on determining whether or not people are wearing masks (detecting masks) to aid in the reduction of COVID-19 transmission and dissemination. We have found that there exist many methods to detect faces and masks with more than 90%. We aim to make a deep learning project aimed at achieving above 90% accuracy. We decided to utilize Tensorflow and OpenCV (python) to construct a face mask recognition system using Deep Learning after reading numerous research papers and comparing the accuracy and performance of the different models employed in them. We would use Convolutional Neural Network since it performs better than other models. In addition, we would construct a Keras (Python) model to compare performance with the Tensorflow model.**

***Key Words*— CNN (Convolutional Neural Network), Keras, Open CV, Tensor Flow.**

1. Introduction

COVID-19 is an infectious illness spread by respiratory droplets from an infected sick person who talks, sneezes, or coughs. This virus spreads by intimate contact with somebody who is sick, or by touching things or surfaces that have been contaminated with a virus. Avoiding exposure to the virus can be accomplished by wearing a facemask that covers the nose and mouth in public, as well as often washing hands and using sanitizers. Face Masks have become an essential part of our daily life in order to combat this sickness. These Masks have the ability to inhibit the transmission of this deadly illness, which will aid in the control of the spread. As we've progressed in this 'new normal' society, the importance of the face mask has grown. So, we will create a model that can determine whether or not a person is wearing a mask. This type is suitable for usage in congested places such as malls, bus stops, and so on other Public Places. As a result, it is critical to design an automatic face mask recognition system to recognise persons using facemasks, which will aid in monitoring. This may be accomplished by employing CNN and deep learning methods, as well as computer vision techniques. We will look at the study on face mask identification using CNN and deep learning in this article.

2. Motivation & Research

It has been demonstrated that face masks can effectively lower COVID-19 transmission. AI can support the fight against COVID-19 in a number of ways, including by encouraging people to wear masks. Models that effectively manage detection, tracking, and validation can be made using machine learning (ML) and deep learning (DL) approaches.Modern deep learning algorithms can be used with geometric techniques to create excellent models for observing public spaces and recognising people who are in fact wearing masks.. Additionally, data analysis and epidemic prediction can be done using AI-based algorithms. This can assist authorities in concentrating their efforts on the regions that are most at danger and in taking steps to stop the virus's spread.Predictive models that can be used to find those who are most likely to get the virus can also be created using machine learning. This enables medical practitioners to concentrate their efforts on the most vulnerable people.People can receive correct information about COVID-19 and safety tips through chatbots powered by AI. By ensuring that people have access to accurate information, this can aid in the fight against false information. Last but not least, AI can hasten the creation of COVID-19 vaccines and treatments. Researchers can find potential chemicals and quicken the development process by utilising machine learning to examine data.In conclusion, machine learning and deep learning methods based on AI have a tremendous potential to contribute to the struggle against COVID-19. With the use of these technologies, we can promote the use of masks, keep track of whether or not mask-wearing regulations are being followed, forecast outbreaks, identify those who are most at risk, inform the public with reliable information, and hasten the development of vaccines and cures.

3. Related Work

Sr. No.	Name	Dataset	The model used and key contributions	Results
1	A Mask Detection Method for Shoppers Under the Threat of COVID-19	Made a new dataset (5000 images)	Presenting a lightweight backbone network for feature extraction, which is based on spatial separable convolution, aiming to improve the	Mean average Precision: 90.9%
2	A Novel Approach to Detect Face Mask using CNN	1,376 images (from GitHub)	CNN	Accuracy: 96.37%
3	A Deep Learning-Based Assistive System to Classify COVID-19 Face Mask for Human Safety with YOLOv3	650 images (Using web-scraping tool)	YOLOv3 Divides the input into a grid and from that grid it'll analyze the target object's features	mean average precision :96% (over 4000 epochs)
	Real-Time Facemask Recognition with Alarm System using Deep Learning	The dataset collected contains 25,000 images using 224x224 pixel resolution. (12,500 per class)	VGG-16 CNN model VGG16 is a pre-trained model that takes in (224,224) RGB images and converts them into features. It comes out of the box from the Keras library and has been trained on millions of images from ImageNet.	Accuracy: 96%
	Control The COVID-19 Pandemic: Face Mask Detection Using Transfer Learning	Made a new dataset (1376 images i.e. faces with masks 690 faces without masks 686)	compared 3 deep convolutional neural networks to find out the optimal deep learning model and MobileNetV2 – SVM is the best mode	MobileNetV2 – SVM :97.11 % VGG19 – K-NN: 96.65 % MobileNetV2 – K-NN: 94.92 % Xception - SVM: 94.57%
	Face Mask Detection by using Optimistic Convolutional Neural Network	The dataset consists of 3918 images. These datasets are taken from Kaggle.	This model uses MobileNet performing as a backbone and train the model using TensorFlow	mean average precision:96.5% (over 4 epochs
	A hybrid deep transfer learning model with machine learning methods for face mask detection in the era of the COVID-19 pandemic	3 Dataset are made (RMFD) consists 5000 images, (SMFD) consists of 1570 images and (LFW) contains 13,000 masked faces	SVM classifier achieved a higher validation accuracy for all datasets than the decision trees classifier	It achieved 99.64%, 88.21%, 95.93, and 99.95% for DS1, DS2, DS3, and DS4 respectively where DS1,DS2,DS3,D S4 are different dataset
	A Novel Detection Framework About Conditions of Wearing Face Mask for Helping Control the Spread of COVID-19	The dataset used here consists of 4672 images: 4188 from MAFA public dataset and the rest are downloaded from the internet.	Context-Attention R-CNN model is used. Key contribution includes detection of face masks, whether it is correctly worn or not.	It achieved standard average mean precision of 0.841
	Thor: A Deep Learning Approach for Face Mask Detection to Prevent the COVID-19 Pandemic	COCO dataset.with 330,000 images.of human subjects CelebA and WIDER FACE dataset with 600,000 facial images. CMCD containing 1,376 masked & unmasked facial images	The models used are: ResNet-50 and Feature Pyramid Network for feature extraction. MultiTask Convolutional Neural Network (MT-CNN)	It achieved a mask detection accuracy of 81.3% Recall: 99.2%

4. DATASET DESCRIPTION

The face mask detection dataset is a collection of images that can be used to train and evaluate machine learning models for the purpose of detecting whether a person is wearing a face mask or not. The dataset contains a total of 503 images, which are divided into three main folders: train, test, and validation.The training folder contains the largest number of images, with a total of 600 images. These images are further divided into two subfolders: Mask and Non-Mask. The Mask subfolder contains 300 images of people wearing face masks, while the Non-Mask subfolder contains 300 images of people not wearing face masks. The purpose of this division is to provide a balanced dataset for training the model, so that it can learn to accurately distinguish between images of people wearing masks and those not wearing masks.The testing folder contains a total of 100 images, which are further divided into two subfolders: Mask and Non-Mask. Each of these subfolders contains 50 images of people wearing and not wearing masks, respectively. The testing dataset is used to evaluate the performance of the trained model on new, unseen data.Finally, the validation folder contains a total of 306 images, which are also divided into two subfolders: Mask and Non-Mask. The purpose of the validation dataset is to ensure that the trained model is not overfitting to the training dataset. Overfitting occurs when the model performs well on the training data, but poorly on new, unseen data. By evaluating the model on the validation dataset, we can ensure that it is generalizing well to new data.Each image in the dataset is labeled as either Mask or Non-Mask, depending on whether the person in the image is wearing a face mask or not. The labels are provided as separate files in each of the three folders.The images in the dataset were collected from a variety of sources, including public domain images and images captured specifically for the purpose of building the dataset. The images were captured using a variety of cameras and under a variety of lighting conditions, in order to ensure that the dataset is representative of real-world scenarios

5. DEEP LEARNING

Deep learning methods aim to learn feature hierarchies with a high-level hierarchy which is structured by the construction of lower-level features. Automated learning at multiple levels of extraction allows a system to learn complex tasks to do input mapping directly from data to output, without relying entirely on man-made features.Deep learning algorithms capture unspecified structure inside the input distribution to find better characterization frequently at multiple levels, with high-level learning features in the context of low-level features.Inputs and outputs are in-depth study of the analog Excel problem domain. Meaning, they are not some size in table format, but they are pixel data, text data documents or data from audio files. Deep learning empower logical and mathematical models to find representations of data with numerous levels of abstraction, multiple processing layers

6. OPEN CV

OpenCV is a library which is use to develop computer based real-time applications. It majorly focuses on analysis including features like image processing, video capture and object detection and face detection. Fig-3- OpenCV We use the OpenCV library to execute infinite loops using our webcam, which detects faces using cascade classifications. The library has over 2000 optimized and advance algorithms for computer vision based machine learning. These algorithms can be used for face detection and recognition, object detection, classifying human movements in video, tracking camera actions, tracking objects,taking 3D objects, adaptive thresholding and assembling together to produce high resolution image. It can also be useful in finding similar images from the database, removal of red eyes from photos taken with flash, follow the facial movements, and add tags to transition with advanced reality. It is continuously adding new modules to the latest algorithms from machine learning.

7. TENSARFLOW

Tensor Flow is a standalone and open-source software library for Dataflow for a variety of tasks and a wide variety of programming. It is also used for machine learning applications such as the Symbolic Mathematics Library, and Neural Networks. TensorFlow is a great system for handling all aspects of a machine learning system.However, this class focuses on using the unique Tensor Flow API to train and deploy machine learning models. We used TensorFlow and Keras to train the classifier to automatically identify if a person is wearing a mask. Since reference implementation runs on single devices, TensorFlow is able to runs on multiple Processing Units and GPUs having extensions regarding general use.

8. KERAS

Keras is an API for high level neural networking. It follows best practices to reduce the major burden and provides consistent and flexible APIs that reduce the number of user actions required for normal usage situations and provide clear and actionable error messages. It is written in Python programming language and has a large developer community and support. Keras includes several implementations of commonly used neural-network architecture, such as hosting devices to simplify the coding required to write layers, targets, optimizers, activation tasks, and an intensive neural network. It make easy to work with image and text data. The Keras models are easily deployable among various platforms.

9. PROPOSED SYSTEM

This system works to recognise masked faces in this COVID-19 condition in order to play a vital role in the transmission of coronavirus from one person to another. In our project, the CNN method is utilised to recognise the mask face, which provides greater accuracy. This project is capable of quickly detecting the mask's faces from any angle. If a person enters the monitoring area without wearing a mask, the system will take his photo, which will be kept, and he will be punished for not wearing a mask in public areas. This study provides a geminate mask face detector that can recognise mask faces regardless of arrangement and train it in a suitable neural system to obtain exact results. It uses an RGB input picture of any orientation to generate output. This function's main job is to extract features from photos and forecast which class they belong to. The image is sketched and formed into a new image in the feature extraction system, where the resultant image is more efficient than the prior image. In this section, a huge number of photos are reduced dimensionally to an efficient representation in which an interesting component of the image is captured

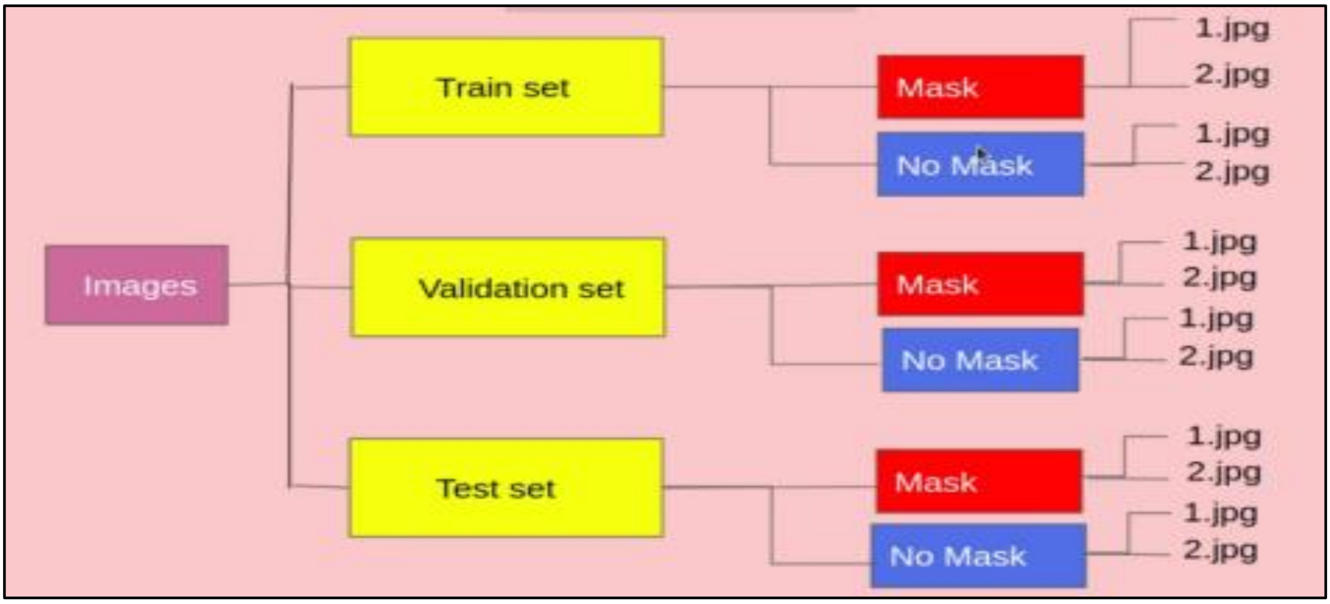

Fig 1: Flow structure of dataset

After extracting features in each convolutional layer, it produces an output that works better for the picture and displays those images as a series of labelled images. In our suggested model, the mask face may be recognised using either the segmented picture or the webcam. First, resize the input image to 100*100 and then do feature extraction and prediction.

After the training procedure is completed, we are given some model data with their accuracy level. To finish the procedure, three elements operate together in this system: the first connects with the dataset, the second creates some accurate models, and the third detects the mask face.

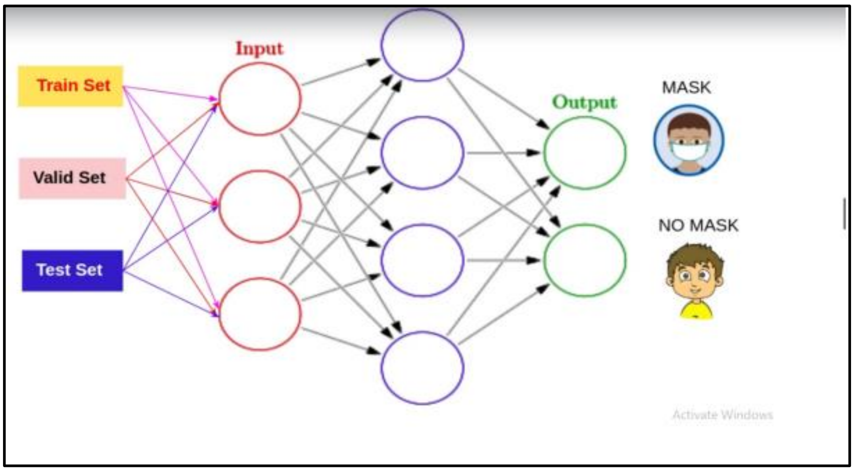

Fig 2: Structure of Neural Network

Model: "sequential"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 150, 150, 32)	896
max_pooling2d (MaxPooling2D)	(None, 75, 75, 32)	0
dropout (Dropout)	(None, 75, 75, 32)	0
conv2d_1 (Conv2D)	(None, 75, 75, 64)	18496
max_pooling2d_1 (MaxPooling2	(None, 37, 37, 64)	0
dropout_1 (Dropout)	(None, 37, 37, 64)	0
flatten (Flatten)	(None, 87616)	0
dense (Dense)	(None, 256)	22429952
dropout_2 (Dropout)	(None, 256)	0
dense_1 (Dense)	(None, 1)	257

Total params: 22,449,601
Trainable params: 22,449,601
Non-trainable params: 0

Fig 3: CNN Model Architecture

10. SYSTEM OPERATION

The working architecture for our suggested model will be discussed in this section. Load the training and testing photos into our Google Colab Environment first. While the dataset is being processed, it will yield some models with varying degrees of accuracy. For improved speed, the algorithm is now working with a higher accuracy model. Initially, certain pixels from an input picture are routed through a first convolutional layer, and then those convoluted pixels are routed through a second max-polling layer. The max-polling layer's output is ready for the complete second convolutional layer. The pixels are ready for the fully linked layer when the second max-polling layer is computed.

11. EXPERIMENTAL ANALYSIS

This suggested research will be completed in three stages. Because of the restricted masked face dataset, learning improved characteristics about the masked face detector has become more difficult. A much bigger dataset is required for higher accuracy and performance, although we employed 690 mask face photos and 686 sans mask face images in our dataset. The initial layer of our app connects to the dataset and converts the photographs to grayscale with a size of 100*100, as well as categorises the images into a list. The dataset stored from the previous layer is loaded again in the second layer. It burns into the system and creates 20 models with varying degrees of accuracy.This model is utilised to provide more accuracy for further processing and generates an alarm if the user is not wearing the mask.

Fig 4: Images with face mask and without face mask

RESULT

According to the study, a mixed convolutional neural network (CNN) for facial recognition is more accurate than previous approaches. Accuracy can be increased using the fundamental strategy of integrating convolutional layers into a single layer. Also, compared to other algorithms, the mixed CNN is rather rapid, giving it a promising option for real-time face identification applications. The model showed good accuracy rates when it came to detecting masked faces and was quicker than optical detection in identifying faces with and without masks. This facilitates the systematic identification of an individual and may be especially helpful in circumstances where the wearing of a mask is required, such as during the COVID-19 epidemic. The model was post-processed, which produced certain models with a high frequency of accuracy.Through additional processing, accuracy was further increased, and the model ended up with an accuracy rate of 0.98. It is important to remember that this gain came at the expense of a validation accuracy of 0.937 and a validation loss of 0.0855. Overall, the findings show the potential of deep learning techniques for creating precise and effective face recognition systems, especially when it comes to identifying masked faces. These models can be used in real-world circumstances to monitor compliance with mask-wearing regulations and stop the spread of COVID-19, for example.

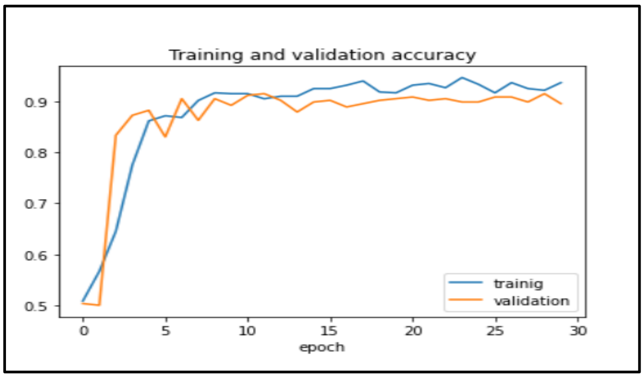

Fig 5: Training and validation accuracy

Fig 6: Training and validation loss

12. FUTURE WORK

Although the suggested deep learning model has demonstrated promising results in the detection and recognition of masked faces, there is still room for development to guarantee that the model can recognise faces from all angles, particularly in public settings. The goal of future work can be to improve the model's recognition of faces in a variety of lighting, camera, and facial orientation scenarios. The model may be created to recognise people who are not wearing masks in public settings in addition to detecting masked faces. It is essential to check that people are adhering to the necessary safety precautions during the ongoing COVID-19 pandemic in order to stop the virus from spreading. The suggested methodology can help in enforcing mask-wearing laws and identifying people who are breaking these laws. The model may be trained on facial recognition data to recognise the faces of people who are not wearing masks, enabling the identification of people who are not wearing them. Real-time face detection and recognition can be achieved by combining facial recognition and object detection algorithms.When someone is seen without wearing a mask, the proper course of action can be taken, such as giving them a mask or enforcing a fee or other penalty for non-compliance. This can be accomplished by connecting the model with current surveillance systems and notifying the appropriate authorities immediately when someone is seen without a mask.Overall, the creation of sophisticated deep learning models for face mask detection and recognition has a tremendous potential to help enforce mask-wearing laws and stop the spread of contagious diseases like COVID-19.

13. CONCLUSION

In conclusion,use of convolutional neural networks (CNN) for the detection and identification of masked faces has been the main focus of this study. The suggested model has superior accuracy in identifying masked faces and has showed potential in enforcing laws against mask use in public areas by utilising deep learning techniques. It has been difficult because there aren't many tiny datasets available for this assignment, but the model has been able to get around this problem and deliver reliable findings. Future research in this field can be based on the mixed convolutional neural network utilised in this study because it has proven to be successful in identifying faces that have been masks. The anticipated project layer's implementation was successful in ensuring the model's accuracy. The post-processing methods employed in this study served to increase the models' accuracy rate, which now stands at 0.98. Overall, this study's findings indicate that convolutional neural networks, a type of deep learning technology, can be a useful tool for detecting and identifying masked faces. This has significant consequences for public health and safety during the ongoing COVID-19 epidemic, and by enforcing mask-wearing laws in public places, it may assist to slow the spread of the virus. Future research can concentrate on enhancing the model's accuracy by utilising more datasets and enhancing the deep learning methods employed in this study. The model can also be connected to already-installed surveillance systems to enable real-time monitoring and enforcing of laws against wearing masks in public.

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