FACE MASK DETECTION SYSTEM

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ABSTRACT

Efficient strategies to contain the Corona virus Disease- 2019 (COVID-19) or any pandemic in general, are peremptory to relieve the negatively impacted public health and global economy, with the full scope yet to unfold. In the absence of highly effective drugs and abundant medical resources, many measures are taken to manage the infection rate and avoid the depletion of limited hospital resources. Wearing masks is among the non-pharmaceutical intervention (NPI) measures that could be effectively implemented at a minimum cost and without dramatically disrupting social practices. Therefore, it is essential to develop a model that detects the citizens who wear a face mask and those who do not at public places like malls, hospitals, airports, etcetera in order to allow entry only to those people wearing masks to ensure the well-being of other people present. The system proposes a CNN model developed using Machine Learning and Deep Learning techniques that detects people wearing masks in an image or live video stream and allow entry only to those people as face masks are part of an infection control strategy to eliminate cross-contamination.

Keyword: - *Face mask Detection, CNN, Covid-19, MobileNetV2*

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1. INTRODUCTION

In 2019, the largest pandemic in recent history spread through the world: COVID-19. As of May 1st, 2022, there have already been 517 million cases and 6 million deaths around the world. In many regions, those numbers are considerably under-counted. Beyond that, many parts of the world have slowed or stopped due to the human, economic, and social impacts of distancing and protection measures. For the purpose of the ongoing pandemic and predictions for future pandemics, our project seeks to create a face mask detection system that is capable of recognizing whether the people in the surveillance-type video streams are correctly wearing their masks to allow entry in public places. Given the potential benefits of saving lives, improving mental health, and keeping the world going, face mask detection technologies could play an important role in bringing this pandemic to a control and preventing further spreading in the future and hence effectively improving our collective well-being.

1.1 Background History

In the recent history, due to the rapid spread of Coronavirus, the World Health Organization had declared Covid-19 as a global pandemic. Due to this contagious deadly virus, many people lost their lives and there is massive damage in the global economy and even unemployment has increased. To prevent or to keep this situation and future pandemics if any, in control, wearing a face mask has become very important. Many studies have proved that wearing a face mask helps to prevent the transmission of Covid-19. Despite this, people forget or avoid wearing masks, which effectively tones down any effort of bringing the pandemic under control.

1.2 Problem Statement

The COVID-19 pandemic which has been majorly affecting our day-to-day life has given an insight to the mankind of the intense consequences that any pandemic in general can cause, disrupting world trade and movements. Due to the severity of the ongoing pandemic, wearing a protective face mask has become a new normal. With every instance of a new variant of the disease arising, many public service providers have made it mandatory for the customers to wear masks correctly to avail their services, as face masks are a great protection against any pandemic that can spread via air. Therefore, Face Mask Detection has become a crucial task to help global society. This project develops a simplified approach to achieve this purpose using some basic Machine Learning packages like TensorFlow, Keras and OpenCV. The proposed model detects the face from the images, video streams correctly and then identifies if the person is wearing a mask or not at the entryways, to allow entry to only those wearing masks properly.

1.3 Existing System

The existing system for face mask detection is manual monitoring. Manual Monitoring is very difficult for officers to check whether the people are wearing masks or not. In the system designed by Adnane Cabani et al. , a method was proposed to feature detectors to individually determine the presence of nose and mouth from a detected face. This approach is efficient and intuitive but has severe limitations - it can only process full-frontal faces and one can easily trick the detector by covering their mouth and nose with their hand.

1.4 Proposed System

The Our proposed model is an integration between deep learning and classical machine learning techniques like OpenCV, Keras and TensorFlow and is interfaced with hardware components such as Arduino UNO and relay inorder to ensure the proper working of face mask detection followed by effective entryway opening system. Our model consists of about wide range of datasets which is split into ‘faces with mask and without mask’. By using these images as dataset, we are going to build a Convolutional Neural Network model. The built model is then used to detect whether the person in the image or live video stream is wearing a face mask or not, depending upon which the decision to open the entryway in public places is determined.

2. LITERATURE REVIEW

[1] “Robust real-time face detection”, Author(s): Paul Viola and Micha. Jones J, International Journal of Computer Vision, in 2004 proposed a method to detect faces that are capable of processing images rapidly while achieving a high detection rate. ‘‘integral image’’, Ada Boost learning, and finally, a technique to combine classifiers in ‘‘cascade’’ is performed. These three are the key contribution steps in face detection. This proposed method minimizes computation time while achieving high detection accuracy.

[2] “Study on face detection using Viola-jones algorithm in various backgrounds, angles and distances”, Author(s): Tanmoy Paul, Ummul Afia Shammi et al. in 2018 found the Viola-Jones Algorithm’s accuracy for images with different backgrounds, angles, and distances. Though the accuracy of detecting the objects\face is more in Viola-Jones Algorithm, depending upon the backgrounds, angles, and distances the accuracy results decrease.

[3] “Research on face recognition based on CNN”, Author(s): Jie Wang and Zihao Li in 2018 using Convolutional Neural Network built a face recognition model. They have simplified the CNN model by combining the convolution

and sampling layers. The advantage of this model is that the memory requirements are reduced, and the number of parameters to be trained is correspondingly reduced which also reduces the training time.

[4] "Face detection using viola-jones algorithm and neural networks", Author(s): Mrs. Monali Nitin Chaudhari et al. in 2018 presented an improvisation on the existing Viola-Jones algorithm. They have added the CNN technique with the Viola-Jones algorithm. This algorithm increases the accuracy of face detection to 90% where VLA's accuracy is just about 78.4%. Again this new algorithm also fails to detect faces under occlusions but is comparatively less than VLA.

[5] "Real time eye detector with cascaded convolutional neural networks", Author(s): Bin Li and Hong Fu in 2018 proposed an algorithm. First, a group of candidate regions with regional extreme points is quickly proposed; then, a set of convolution neural networks (CNNs) is adopted to determine the most likely eye region and classify the region as left or right eye; finally, the center of the eye is located with other CNNs. This method can deal with real-time problems that arise in realistic scenarios.

[6] "A study on various state of the art of the art face recognition system using deep learning techniques", Author(s): Sukhada Chokkadi et al in 2019 have carried out an exhaustive literature review on many face recognition techniques which use Deep Learning and along with the outcome of those techniques, its limitations were mentioned.

[7] "RetinaFaceMask: A face mask detector", Author(s): Mingjie Jiang et al in 2020 proposed the Retina Face Mask which is one of the first dedicated face mask detectors. The architecture of Retina Face Mask consists of ResNet or Mobile Net as the backbone. This method has improved the mask detection ability and is also able to detect small face masks. They also mentioned accuracy by comparing different models.

[8] "Multi-stage CNN architecture for face mask detection", Author(s): Amit Chavda, Jason Dsouzaet al. in 2020 with the help of dual-stage Convolutional Neural Network (CNN) architecture, carried out the detection of masked and unmasked faces. This model gives 5 FPS interference speed on a CPU. This system can be easily deployed for automated monitoring of the use of face masks at workplaces, which will help make them safer.

[9] "Identifying facemask-wearing condition using image super- resolution with classification network to prevent covid-19", Author(s): BoshengQin and Dongxiao Li in 2020 using CNN, deep learning, image super-resolution, SRCNet face mask-wearing condition are detected. The results obtained were more accurate but the numbers of datasets used were small and this model can't be tested on video stream because they haven't added video in the dataset.

3. REQUIREMENT SPECIFICATIONS

3.1 Software Requirements

- Operating System - Windows or Linux or FreeBSD or MacOS
- Platform - x86 – 64
- Language - Python, Arduino
- Libraries - TensorFlow, OpenCV, Scikit-learn,NumPy
- CNN Model – MobileNetV2

3.2 Hardware Requirements

- Clock speed - 2.5 GHz Minimum
- RAM - 512 MB
- Hard disk capacity - 8 GB Minimum
- Monitor Type - Color monitor (16 bit color) and above
- Microcontroller board - Arduino UNO

- Electromechanical switch – Relay
- Optical device - Liquid-crystal display
- Web Camera

4. METHODOLOGY

The proposed system aims to detect whether a person is wearing mask or not, and allow entry to only those wearing face-masks. This is a measure taken to contribute towards communal health by reducing the spread of Covid-19. The software modules in this system are dataset collection, extraction of datasets, training of the model and detection of face masks which works together along with hardware module to ensure efficient working of the system.

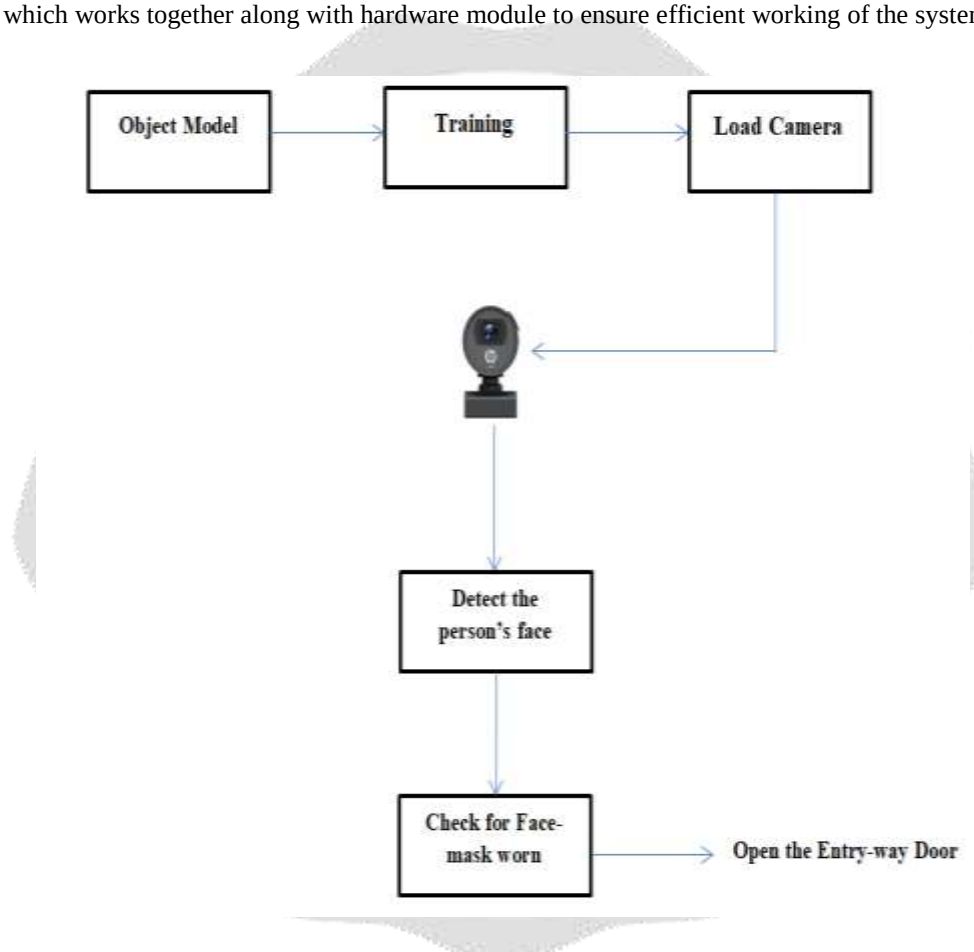

Fig -1: Workflow Diagram

4.1 Face mask detection module

4.1.1 Working Description

With every passing day, a new variant of the COVID-19 virus is appearing and healthcare practitioners are advising to practice wearing a face mask in outdoor spaces. Therefore, This Face mask detection module aims to use Deep learning and machine learning packages like OpenCV for Video Processing, NumPy and SciPy for Mathematical Operations, Matplotlib for Graphs, Scikit-learn for Separation of tests, Reprocessing, and Training Data, Keras and TensorFlow for training and modeling using Deep Learning and imutils for Basic Image Processing to efficiently detect whether a person is wearing face mask or not.

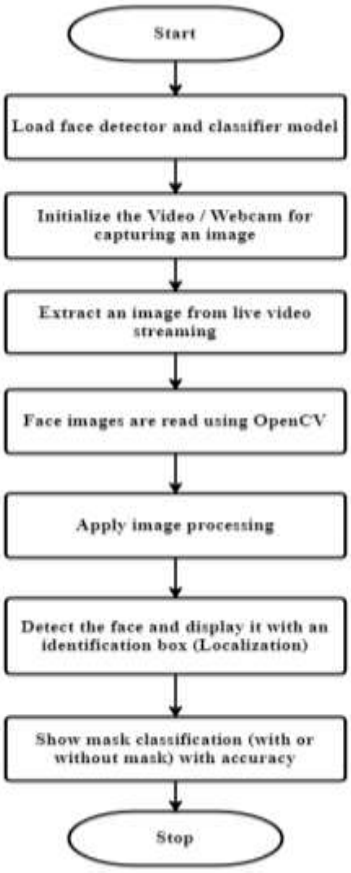

Fig -2: Flowchart of the face mask detection module

4.1.2 Collecting Datasets and pre-processing

Masks play a significant role in protecting the health of individuals against virus spread in air, as it is one of the few precautions available for COVID-19 in the absence of immunization. Hence, it is very important for us to detect whether an individual wears a mask or not and ensure they avail public services only under the former condition. The images with face mask and without masks, used as datasets in the proposed system are availed from Kaggle and various other sources. We can obtain high accuracy depending on the number of images collected.
The dataset for training contains a lot of noise and duplicates. The accuracy of the model depends on the dataset chosen for training. The dataset hence has to be pre-processed before being fed as input. The images are resized and the pixel representations of the images are converted into list format in accordance with the MobileNetV2 model. This list is then transformed to a NumPy array for quick mathematical operations.

4.1.3 Data Augmentation

Data augmentation improves network accuracy by randomly transforming the original data during the training phase. More variations to the training data can be added without having to increase the number of labeled training samples by using data augmentation thereby improving the performance and ability of the model to generalize. It performs flip, shift, rotate and zoom operations on images to increase the number of images. This is a technique to artificially create new training data from existing training data. Image data augmentation is used to expand the training dataset in order to improve the performance and ability of the model to generalize.. Image data augmentation is supported in the Keras deep learning library via the ImageDataGenerator class.

4.1.4 Building CNN model

CNN is a machine learning algorithm that can take an input image, assign learnable weights and biases to various objects in the image and be able to differentiate one from the other. Here the image dataset undergoes many layers of convolution and pooling which results in the flattening of the image. These flattened layers are fully connected in order to obtain a softmax. Features are identified and extracted during the convolution and pooling steps, whereas classification is done in the later steps.

4.1.5 Compiling and training the model

The model is fed with images with mask and without mask for training. Once the training is completed, the model is tested and validated**.**

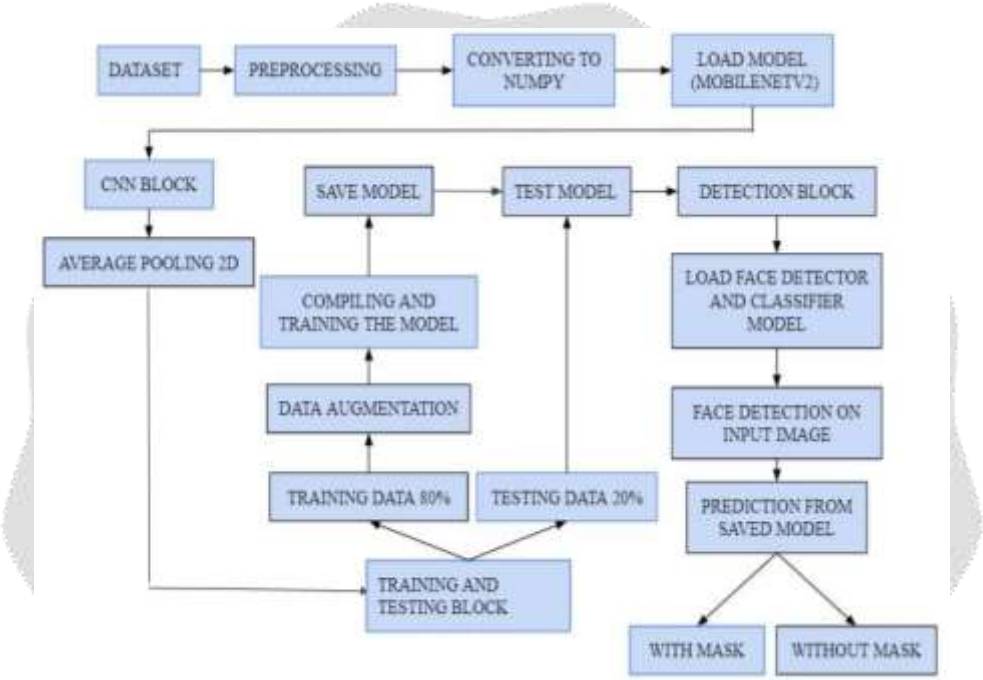

Fig-3: Workflow of the face mask detection module

4.2 Entryway opening module

4.2.1 Working Description

Face mask detection module is responsible for detecting whether a person has worn a face mask or not. Once it gets detected the software module sends signal by serial communication to the Arduino UNO connected to the system. Arduino UNO receives the signal which in turn triggers another signal to the relay interfacing with it. The relay is then responsible to open and close the entryway doors.

4.2.2 Arduino UNO R3

The Arduino Uno R3 is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Fig-4: Arduino UNO

4.2.3 Liquid Crystal Display

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock.

Fig-5: Liquid Crystal Display

4.2.4 Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. While we use normal switches to close or open a circuit manually, a Relay is a switch that connects or disconnects two circuits. But instead of a manual operation, a relay uses an electrical signal to control an electromagnet, which in turn connects or disconnects another circuit. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relay works on the principle of electromagnetic induction. When the electromagnet is applied with some current, it induces a magnetic field around it.

Fig-6: Relay

5. RESULT ANALYSIS AND DISCUSSION

5.1 Module 1: Face mask detection module

5.1.1 Output screen: Without face mask

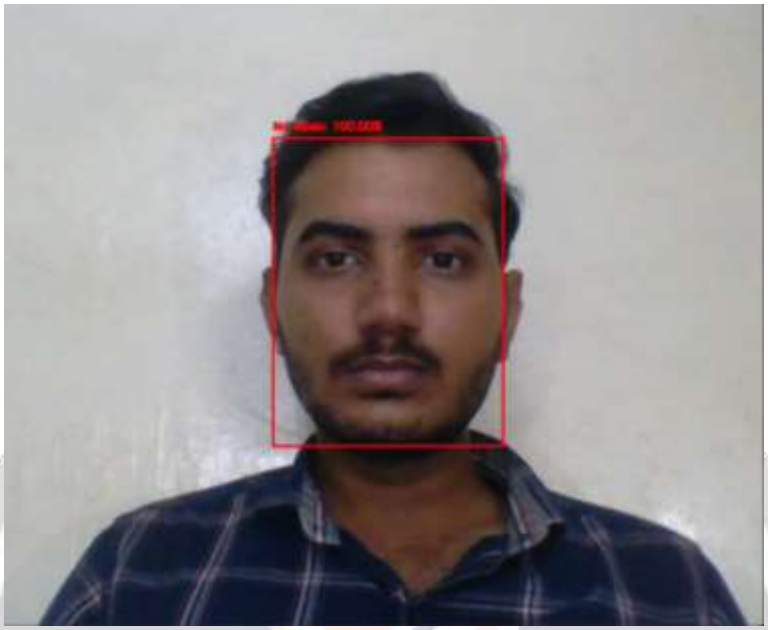

Fig - 7: Output screen – Without face mask

The above figure shows the output screen when the person in the image or live video stream is not wearing a face mask. When the person is not wearing a face mask, the output screen displays, 'No Mask: Accuracy%'.

5.1.2 Output screen: With face mask

Fig-8: Output screen – With face mask

The figure shows how the face mask detection module scans the input image or live video stream to identify the person wearing a face mask. The face mask detected is highlighted using a bounding box. On successful detection of

a person wearing face mask, the module displays, 'Mask: Accuracy%'. The output from the face mask detection system is fed to the entryway opening module to trigger effectual opening of the entryway door. The entryways are not opened if the person is not wearing a face mask.

5.2 Module 2: Entryway opening module

5.2.1 Entryway: Without face mask

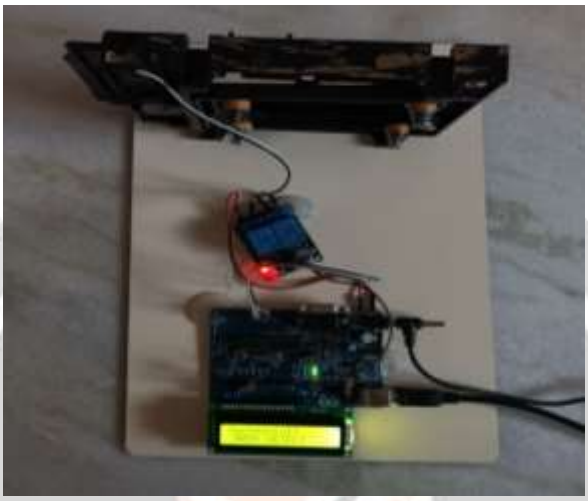

Fig- 9: Entryway – Without face mask

The figure represents the entryway opening module. The module does not open the entryway, as the person detected in the face mask detection module is not wearing a face mask. A disk drive is used to demonstrate an entryway in this module.

5.2.2 Entryway: With face mask

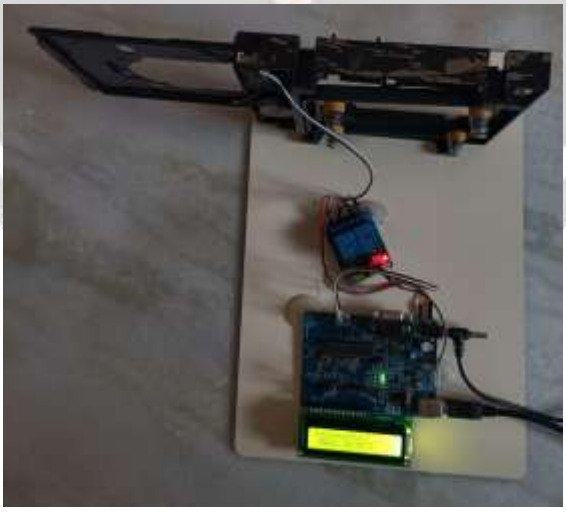

Fig-10: Entryway – With face mask

The figure shows the output of the entryway opening module. The module ensures successful opening of the the entryway, when the person detected via image or live video streaming in the face mask detection module is wearing a face mask.

5.3 Training loss and accuracy

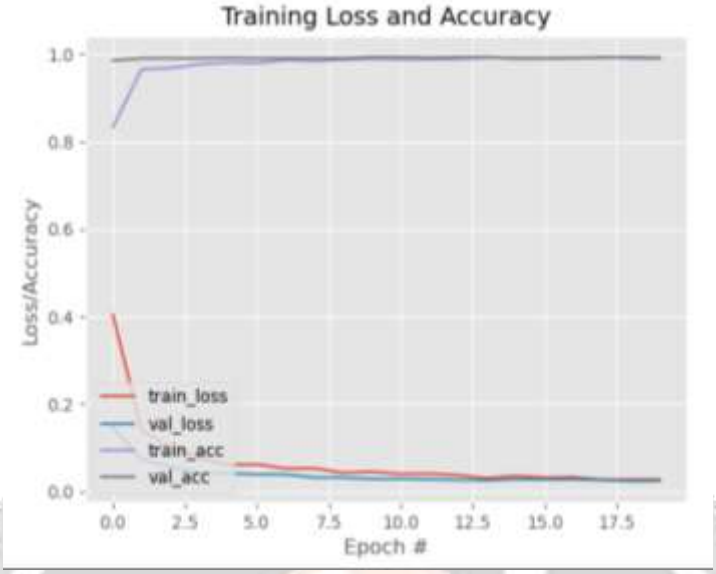

Fig-11: Training loss and accuracy

The above graph is plotted using Matplotlib which is a plotting library for the Python programming language and its numerical mathematics extension NumPy. In this graph, the loss/accuracy that occurs while training the datasets is plotted against Epoch. An epoch in machine learning means one complete pass of the training dataset through the algorithm. The epoch in a neural network or epoch number is typically an integer value that liews between one and infinity. Thus one can run the algorithm for any period of time. To stop the algorithm from running, one can use a fixed epoch number and also use the factor of rate of change of model error being zero over a period of time. In the proposed model, we have used Epochs = 20.

6. CONCLUSIONS

6.1 Summary

The proposed model on detection of face mask to automate the working of entry-way doors is developed with the model created with CNN architecture using MobileNetV2 which gives a good result with perfect accuracy of detection. The data is trained and tested for the model to gain good accuracy during detection. Similar projects are observed to have some complications in output, using the dataset, only some were able to get better accuracy. Wrong predictions are removed successfully from this model since majority of the datasets are obtained from a wide range of sources. The images that are used in the datasets are pre-processed well to get results with improved accuracy. This model can therefore be used in real-time applications which require face-mask detection for safety purposes in case of any pandemic outbreak like the Covid-19. This project is integrated with embedded systems for application in airports, railway stations, offices, schools, and public places to ensure that public safety guidelines are followed.

6.2 Recommendation for future project

The proposed model gives great accuracy for detection of single face with and without mask. It gives considerable accuracy for face mask detection of multiple faces too. It is compatible to be integrated with any entryways to be automated. Further, we can improve the accuracy for multiple face mask detection simultaneously and enable the feature to classify the faces into three categories - with mask, without mask and improper mask by adding datasets consisting images of people wearing masks without covering their noses properly, which in case of our project is categorized as ‘without mask’. We can also make improvement to the existing model by adding attendance marking feature using the detection of masked faces using the FaceNet model of Convolutional Neural Network. Further it

can be integrated with digital attendance marking registers at companies or institutions, so that the inhabitants not wearing masks can be detected and given a warning using their corresponding details stored in the database. Thus, if implemented with proper features and technologies, the 'Face Mask Detection System' has an immense potential for improved real-time applications in the near future.

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