FACE MASK DETECTION USING IOT AND DEEP LEARNING FOR SAFTEY OF COVID-19

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ABSTRACT

The spread of COVID-19 has reached pandemic proportions, with the virus already infecting over 200 nations in the past one year. The virus spreads swiftly via direct and indirect contacts and thus precautions are still required, particularly when vaccines are not yet accessible to many nations and most of the countries where vaccines are available are still in the initial phase of their vaccination drive. The World Health Organization (WHO) has issued standard guidelines for decreasing the transmission of COVID-19, pertinent amongst which is the appropriate use of face masks for protection against the virus [11]. The present ongoing study is designed on an Io T (Internet of Things)-based solution system related to face mask identification and classification. The IoT-based screening system is based on real-time deep learning models. Using a transfer learning technique, the proposed module can help to identify and distinguish persons who wear the face mask appropriately from those who use it poorly or those who do not use face mask, by using VGG-16, MobileNetV2, Inception v3, ResNet-50, and CNN models. The highest accuracy of 99.81 percent has been reported using VGG-16 model followed by an accuracy of 99.6 percent using MobileNetV2 version. A further categorization of the participants masks will be done as N-95 or surgical masks. We intend to compare the outcomes of our proposed system to currently established approaches, and we strongly believe that our system might yield beneficial information related to methods for curtailing local transmission of COVID-19 and also decrease human carriers.

Key Words: COVID-19 Rapid Screening; Face Mask Detection; IoT; Deep Learning; VGG-16, MobileNetV2.

1. INTRODUCTION

COVID 19 is caused by a highly contagious virus that transmits quickly amongst people via contact, droplet and aerosol transmission and has rapidly emerged as an important healthcare problem world over [1]. Before its appearance in December 2019, this unique pathogen and the illness caused thereof was largely unknown. COVID19 is now a global pandemic impacting almost all nations in the world. The infection may result in a broad variety of symptoms, ranging from mild to severe sickness and usually manifests anywhere from two to fourteen days following exposure to the virus. COVID-19 frequently presents with symptoms of fever, dry cough, sore throat, headache, muscular or body pains, congestion or runny nose, nausea, vomiting, diarrhoea, and tiredness. Patients with severe COVID 19 develop pneumonia like features with difficulty in breathing which often can lead to death of the individual despite available treatments. Asymptomatic carriers are persons who exhibit mild or no symptoms while being sick. Whereas symptomatic patients are often quarantined to limit the spread of the disease, asymptomatic carriers can transmit the virus though they themselves do not manifest the disease and thus pose a problem to the society because it is difficult to track them down. According to the World Health Organization 80 percent of infections are mild or asymptomatic, 15% are severe, and 5% need oxygen or ventilation [2].

COVID-19 has been reported to spread in three ways viz: direct/indirect contact, short-range droplet transmission, and long-range aerosol transmission, also known as airborne transmission. Short-range transmission allows the virus to pass from person to person by droplets from the nose or mouth, by coughing and sneezing. "These droplets may fly up to 1.8 meters (6 feet) before reaching back to surface. These droplets cling to objects and surfaces, such as table handles or railings." Humans may get the disease by touching a contaminated surface and then contacting their eyes, nose, or mouth with their contaminated body parts. It has also been reported that the virus can spread from animal to human and vice versa, but the chances of the latter being slim. There is also some evidence that the virus can pass from humans to pets. Contact isolation and sanitization are two important methods of curtailing the spread of COVID19. China employs drones to spray disinfectant liquid over public locations and automobiles in COVID-19 infested zones as a mode of sanitization [4].

The Internet of Things (IoT) and Artificial Intelligence (AI) have altered living standards and ushered a paradigm shift in healthcare system. The IoT and AI healthcare systems have evolved from conventional healthcare systems and help in lowering the cost of healthcare and increases its reliability. Smart cities, smart security systems, and smart grids are just a few of the systems and technological disciplines where IoT applications are deployed. One such approach used in the healthcare system is the use of monitors using various IoT sensors, such as heartbeat sensors that measure pulse rate, blood pressure, and ECG detection sensors, and stores the data in a database, where the raw data is further processed. This study is being carried out as a method of application of IoT based system and AI technology to assess the appropriateness of use of masks.

1.1 Aim

To detect and rapidly screen the face mask usage by public in crowded areas. The information can be used by security personnel in public areas mitigating the spread of COVID-19.

1.2 Objective

To design the software that can detect face mask usage by public with three outcomes - Proper Mask, Improper Mask, and No Mask.

Problem Statements

The Public places & crowded area requires people to wear face masks, some people often forget to put their masks on with resultant:

a) Increased Risk of Covid Transmission.
b) Challenge of Authorities to screen thousands of people to wear masks.

2. LITERATURE REVIEW

2.1 COVID 19 Its Modes of Spread and Possible Research Applications

COVID-19 is a relatively new infectious illness, and scientists are currently researching and testing how it spreads. According to the US Centers for Disease Control and Prevention (CDC), COVID-19 may spread in three ways [1]. The first source of spread is direct or indirect touch, the second source is short-range droplet spray, and the third source is long-range aerosol transmission via airborne spray.

Minor precipitation from the nose or mouth of an infected person, which are thrown out when an infected person coughs, sneezes, or talks, distributes the illness from person to person. These precipitations are usually heavy, may travel a long distance, and stick to the surface quickly. If humans inhale these droplets, they will get infected with the virus. As a result, it is required to maintain a distance of at least 1 meter between persons. Individuals may get infected by touching these items or any other surfaces and then touching their mouths, noses, or eyes. Airborne transmission is not the same as droplet transmission, according to WHO, since big respiratory droplets are larger than five micrometers and can only stay in the air for a short period and travel small distances. These drops may usually travel up to 1 meter. Airborne droplets, on the other hand, may linger in the air for a long time and move across enormous distances, such as more than 1 m. (more than 3.3 feet). As a consequence, after the findings of their trials, the WHO proclaimed it obligatory to wear a face mask in their suggested SOPs to prevent COVID-19 transmission.

A research on the spread of droplets was carried out at a restaurant where customers were sitting more than 1 meter apart. It was discovered that the air conditioner's powerful airflow was the cause of droplet proliferation. In the research, further studies revealed that temperature and humidity control virus proliferation by modifying their features, such as viral surface protein and lipid membrane. The research also discovered a strong link between the stability of winter viruses and low RH (20–50%), but the stability of summer or all-year viruses improved with greater RH (80 percent) [3].

COVID-19 patient wards in hospitals are the most challenging places where dissemination of the virus can occur by aerosol. COVID-19 has been identified in the air and also on the surfaces of objects in ICU and general wards, according to a study issued by the CDC (GW). Thus, these zones and equipment in these areas can pose a high-risk for infection of medical personnel and anybody who comes into touch with it. Further research is required to evaluate whether or not samples from patient rooms can be utilized to identify COVID-19. The COVID-19 positivity rate related to all functioning items in ICU (intensive care unit) and GW (general ward), has been tabulated in Table 1 [9].

Table 1: Objects and Surfaces Found Positive of COVID-19

Types of Object Surfaces	Objects	Positivity Rate of COVID-19
ICU and GW items	Computer Mouse	(ICU 6/8, 75%; GW 1/5, 20%)
	Trash Cans	(ICU 3/5, 60%; GW 0/8)
	Sickbed Handrails	(ICU 6/14, 42.9%; GW0/12)
	Doorknobs	(GW 1/12, 8.3%)
	Shoes	(50% positive)
Miscellaneous Personal item	Exercise Equipment Medical Equipment PC and iPods Reading Glasses	(81.3% were positive by PCR)
Other objects	Cellular Phones	(83.3% positive for viral RNA)
	Remote controls for in-room TVs	(64.7% positive)
	Toilets	(81.0% positive)
	Room surfaces	(80.4% of all sampled)
	Bedside Tables, Bed, rails	(75.0% positive)
	Window ledges	(81.8% positive)

IoT is being employed in a variety of industries, such as mechanical and electrical control, smart security, and healthcare systems. In this section, we will discuss several IoT-based application systems, and AI approaches for improving living standards in numerous spheres of life and their suggested applications in the context of COVID 19 pandemic.

2.2 IoT Healthcare Systems and Their Applications Relevant to COVID 19

Arduino and ultrasonic sensor have been used to detect impediments in order to create a cane and shoe for visually impaired people [5]. The suggested SSDWG concept proposes to utilize the Arduino and ultrasonic sensors to identify the presence of people.

In another research a healthcare monitoring system was presented in which different IoT sensors were utilized to examine patient status and their basic data was stored in the cloud [5]. In this database, we also propose to employ a similar way to store the data of vulnerable persons who travel through SSDWG.

The availability of healthcare personnel is critical for patients, but they cannot be present at all times. A suggested system of monitoring employs an IR-based heartbeat sensor and an Arduino Uno for heartbeat monitoring, as well as a GSM module to communicate real-time data to medical personnel through SMS. These types of technologies may be used by healthcare authorities to remotely monitor the health of COVID-19 patients. Alternatively reports exist of medical sensors being interwoven on a shirt in order to aid detection of heart beat, electrodermal activity, and temperature [6]. Such techniques can provide insight into the seriousness of patient’s health status, and may also be used to detect the temperature of COVID-19 suspects. An IoT-based health monitoring system that is configured to continuously check the health of a sick individual has been suggested to monitor and regulate the health parameters of patients, such as blood pressure, haemoglobin, and abnormal cellular growth in the body [5].

Similarly, scientists have employed piezo sensors to detect footfall in a 9m area of floor to monitor the movement of people in huge manufacturing facilities and buildings for emergency safety. Quarantine facilities might benefit from this kind of approach. Despite the increasing growth of the Internet of Things in the healthcare sector, the security and integrity of health data remains a major concern. As a result, a cross-safety structure method for safeguarding patient diagnostic data has been proposed [5].

We propose that IoT-based healthcare systems might play a critical role in the COVID-19 pandemic after examining literature relevant to IoT-based healthcare systems.

2.3. Role of Artificial Intelligence (AI) in COVID-19 Pandemic

One of the proposed models is to employ machine learning techniques is to help identifications of COVID-19 suspects in a short period of time using a mobile phone-based network survey. This will also help to reduce the spread of the disease among susceptible populations.

Appropriate knowledge and sensitization of people with accurate information can help in reducing the transmission of COVID-19. One such application employs natural language processing (NLP) and machine learning to extract correct information on COVID-19 from reliable sources such as WHO daily bulletins and convey material in local language (Hindi) using text-to-speech software. An automated finding system can help in quick prediction and help in appropriate decision-making strategies to prevent spread of COVID-19 among individuals.

Use of distinct convolutional neural network-based upon models for detecting new COVID-19 patients using chest X-ray radiographs can emerge as another such arena of interest [6]. Similarly, java can be used to create a back-propagation neural network to handle a difficult image classification issue using the CIFAR-10 image dataset and assess the functionality layer and rectified linear neuron of the dropout.

3. PROPOSED MODEL

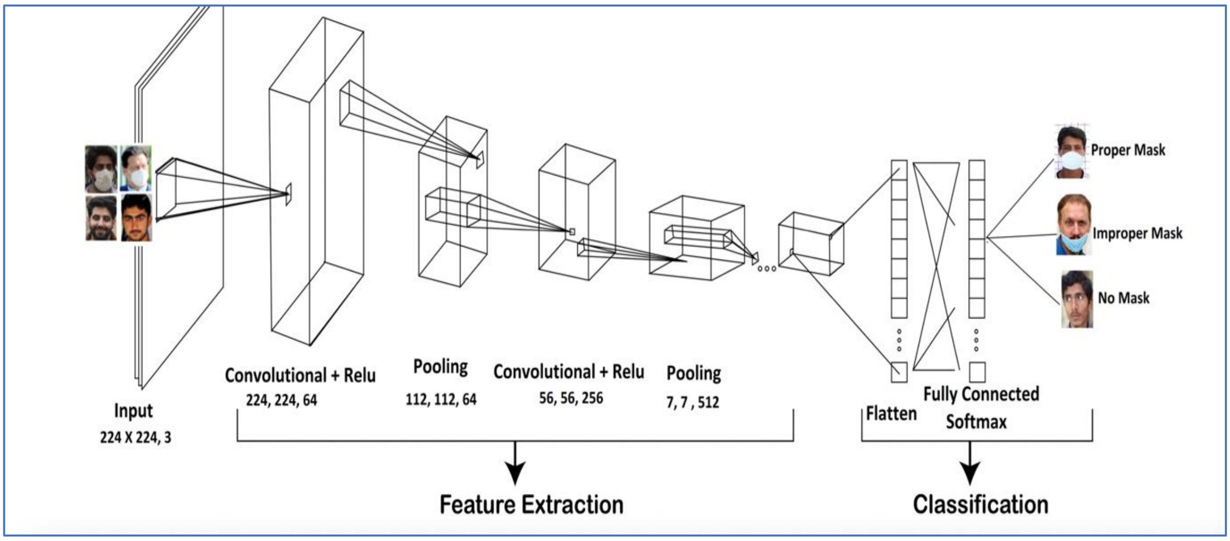


Figure :1

The second module of SSDWG detects persons wearing masks as they pass through it. To identify a face mask use in three classes: face with appropriate mask (FWPM), face with incorrect mask (FWIPM), and face without a mask, we employed five pre-trained deep learning models: VGG-16, MobileNetV2, Inception V3, ResNet-50, and Convolutional Neural Network (CNN) (FWOM). Furthermore, our suggested model divides and classifies face masks into two categories: N-95 and surgical masks. Transfer learning was used to fine-tune these five pre-trained models, which is significantly quicker and simpler than training a model from start with randomly initialized weights. The scientists employed a deep neural network to monitor vibration signals created by walking people on the floor to identify human location in huge buildings in a similar fashion. When we feed our dataset, we set the output layer of these models as non-trainable by freezing the weights and other trainable parameters in each layer so that they are not trained or changed. We also added an output layer to our dataset to train on. In our new model, this output layer would be the only one that could be trained. With a learning rate of 0.0001, cross-entropy for our loss, and accuracy for our matrix, we employed the Adam optimizer. The CNN model's architecture is shown.

VGG16 is a convolutional neural network model which achieves 92.7% top-5 test accuracy in ImageNet, a dataset of over 14 million images belonging to 1000 classes.

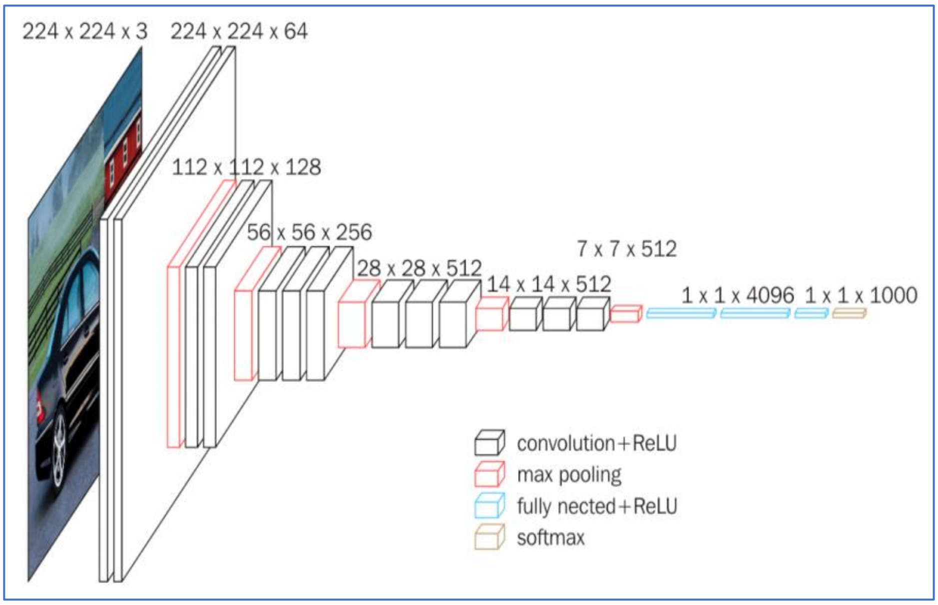


Figure: 2

MobileNetV2 is a convolutional neural network architecture performs best on mobile devices and is based on an inverted residual structure**.**

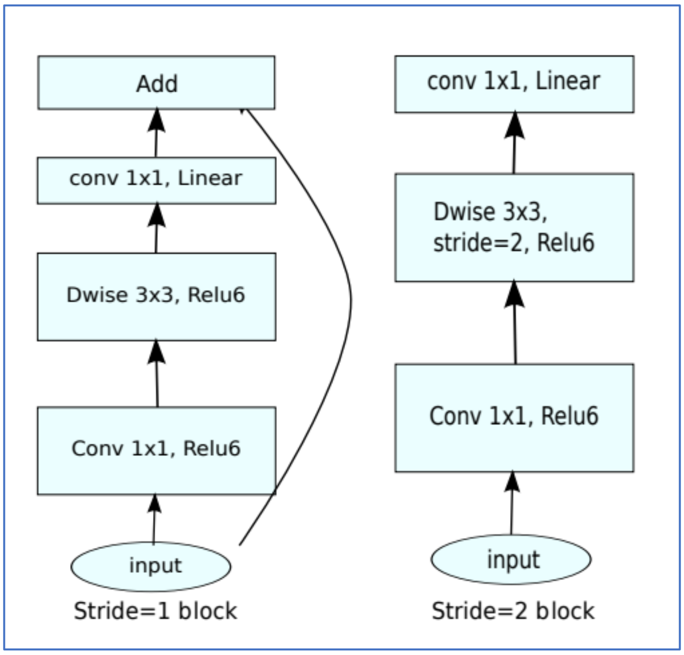


Figure: 3

InceptionV3 an image recognition model with 78.1% accuracy on the ImageNet dataset.

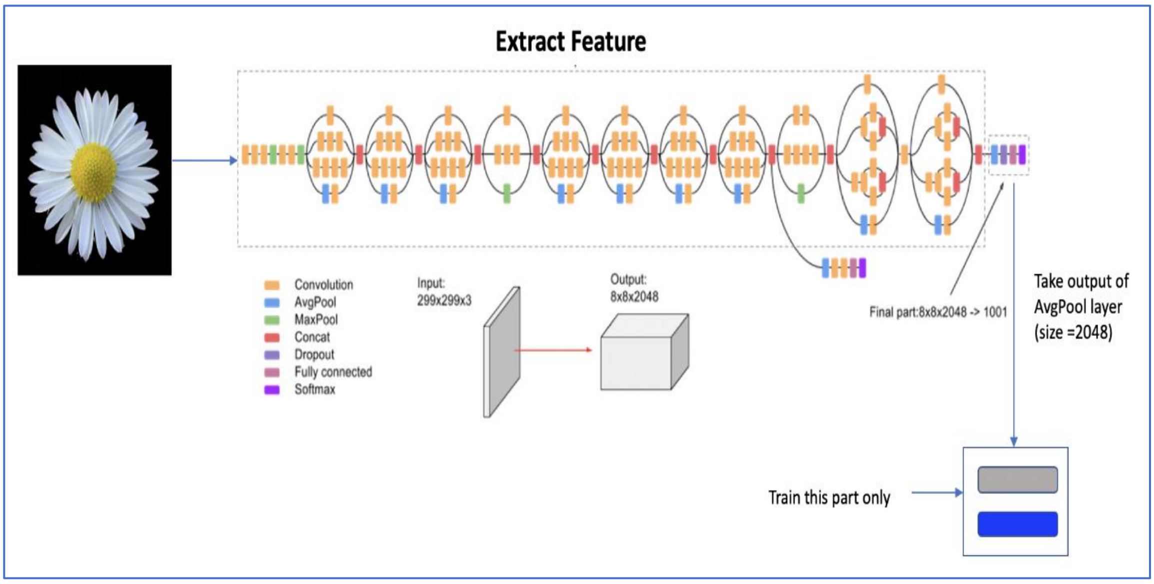


Figure: 4

ResNet50 is a 50-layer Residual Network which is a deep convolutional neural network in which several layers are stacked and are trained to the task at hand.

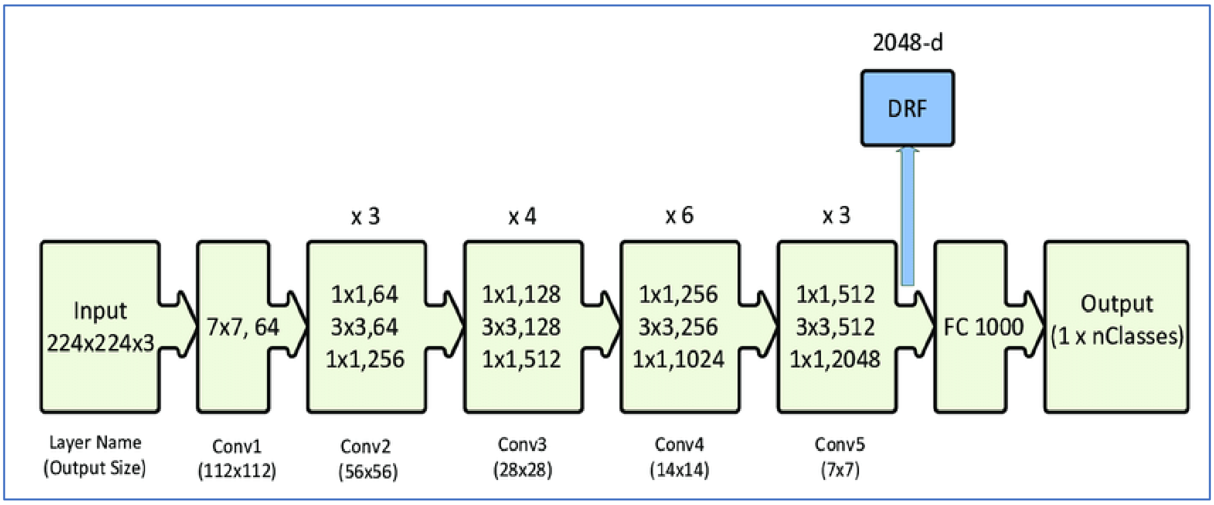


Figure: 5

Smart Screening and Disinfection Walkthrough Gate (SSDWG) is designed to do rapid screening, using a contact-free sensor for face mask use and storing individual record for further control and monitoring

4. MATERIAL AND METHODS IMPLEMENTATION

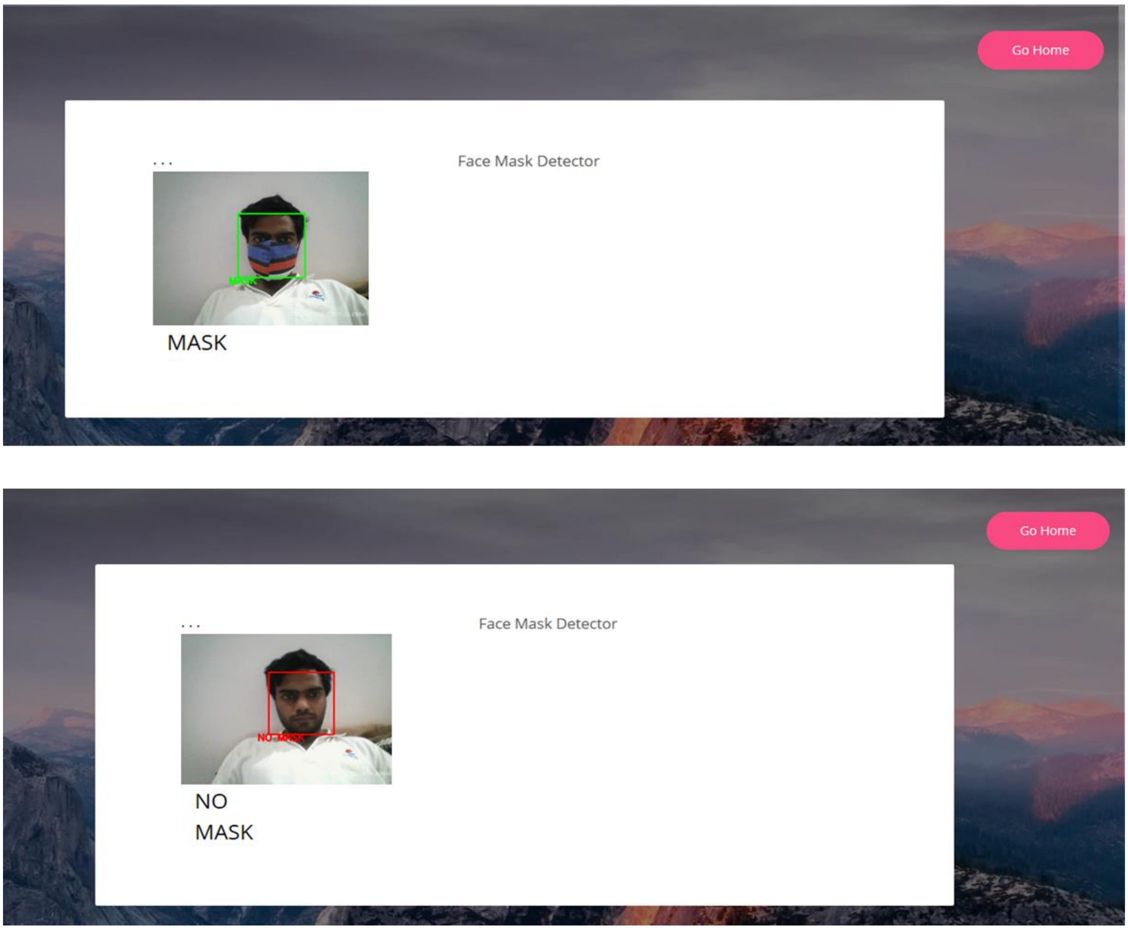


Figure: 6

Our working methodology is a data science approach in which we use the Google colab resource which is an online platform to execute machine learning quotes with a very high speed of operation which can be downloaded. The system can evaluate a model by importing an image dataset and, training an image classifier on it. The steps of which is shown below:

1. Open a new terminal on Pi by pressing Ctrl-T.
2. Run the pre-made model trained with over 1,000 images in terminal after changing directory (cd) into a directory cloned from GitHub.

```
cd face_mask_detection
```

3. Run the Python 3 code to open webcam and start mask detection algorithm.

```
python3 detect_mask_webcam.py
```

After a few seconds, camera view pop-up window is seen wherein a green box indicates presence of face mask and a red box indicates lack of face mask.

Face Mask Model Training

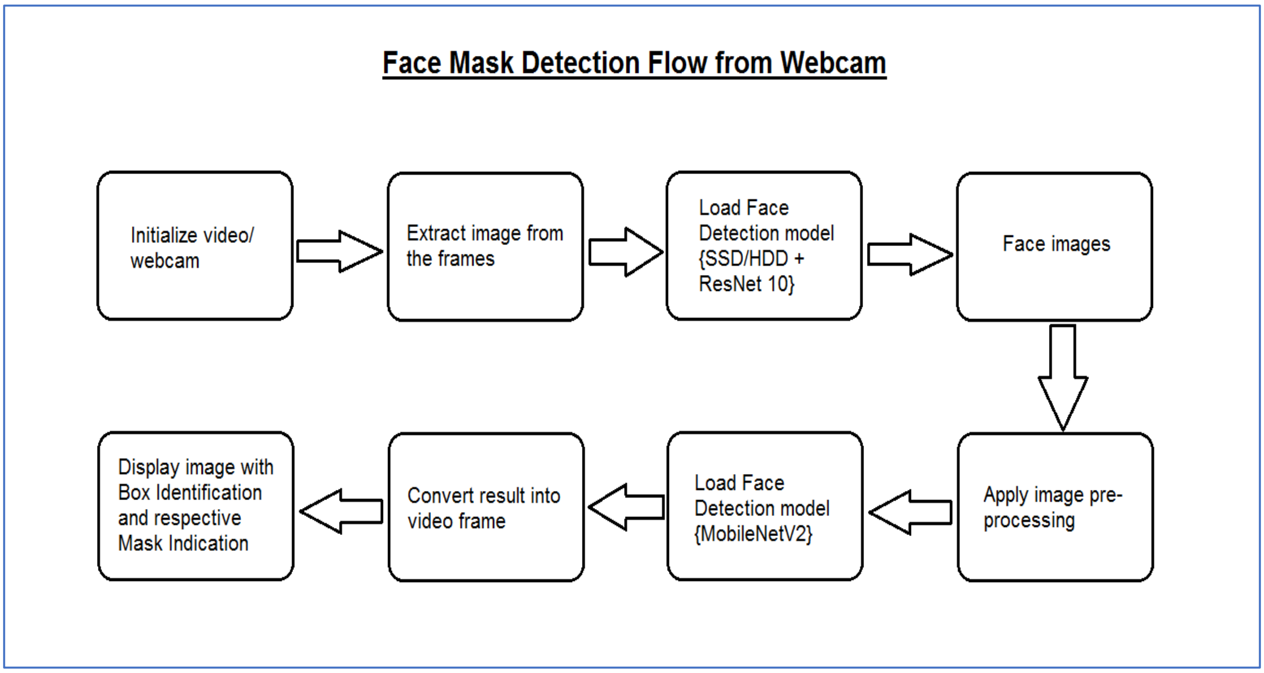


Figure: 7 More than a thousand photographs were applied to train the model as follows:

"detect_mask_webcam.py" to discriminate between mask or no mask. More the number of images were used, the better was the machine learning process and accuracy.

Photos were classified into 2 folders in our dataset, a) with_mask b) without_mask and the training algorithm created a model of mask vs. no mask based on the dataset. The sample photographs used in the dataset folder were downloaded from GitHub.

The Raspberry Pi Mask Detection system was trained on 20 photographs in our study. The presence of a pre-trained model to test out from face_mask_detection folder in the terminal was helpful and the Python 3 code was run to open webcam with the 20-photo model. [10]

```
python3 detect_mask_webcam.py --model mask_detector-20. model
If you are using a Pi Camera:
enter python3 detect_mask_picam
```

4.1 Training the Raspberry Pi Face Mask Model

To train the Pi with photos, we saved photos of face of people wearing or not wearing face masks to the appropriate folder.

1. ***Steps To Take Photos with Raspberry Pi***

a) **To open a terminal**, press Ctrl-T.

b) **Change directories** to the face_mask_detection folder.

```
cd face_mask_detection
```

c) **Run Python code and take photos** wearing a mask as well as no mask photos.

```
If using a webcam run:
python withMaskDataset.py
or
python withoutMaskDataset.py

If using a pi camera run:
python withMaskDataset-picam.py
or
```

d) **Press your spacebar** to take a photo.

e) **Press Q to quit** when you are done taking photos.

2. ***Install sklearn and matplotlib packages in your Pi***

```
sudo pip3 install sklearn
```

```
sudo pip3 install matplotlib
```

3. Training the model

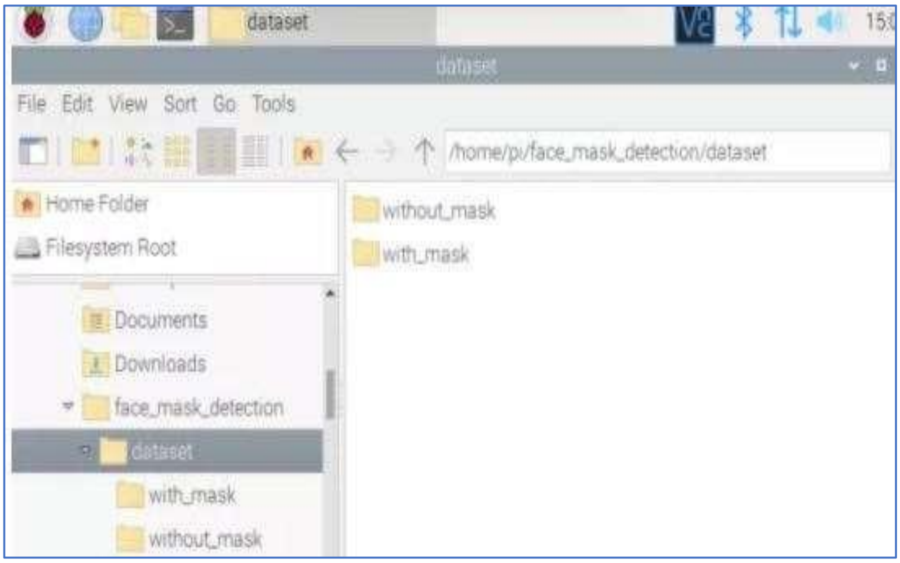
It needs to be noted that the more the number of photos are present in the dataset folder, the longer it will take to create the model and if an out of memory error code appears, reduce the number of photos till the Python code runs successfully.

```
cd face_mask_detection
python3 train_mask_detector.py --dataset dataset --plot mymode
```

4.2 Testing the Raspberry Pi Face Mask Model

Once the model has been trained it can be put to test. The same detection script is run by specifying the model instead of the default model from the same Terminal window:

```
python3 detect_mask_webcam.py --model my_mask_detector.model
If you are using a Pi Camera enter:
python3 detect_mask_picam.py --model my_mask_detector.model
```



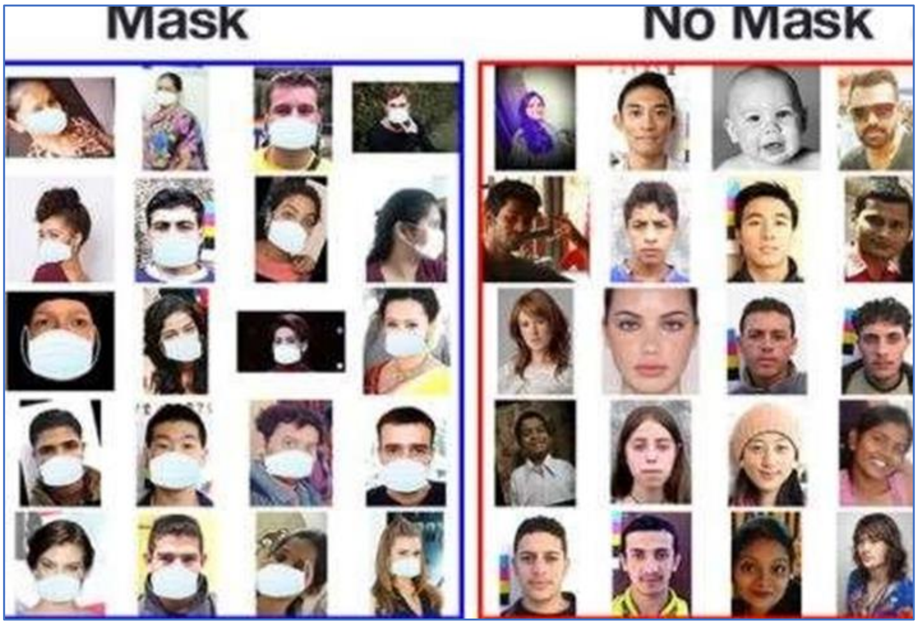


Figure: 8

4.3 Adding Buzzer and LED

Further continuing a buzzer and 2 LEDs can be added to quickly identify if someone is wearing their face mask or not. For this step, additional paraphernalia needed are:

- Small Breadboard
- Two 330 Ohm resistors
- 1 Red LED
- 2 Green LED
- 1 Buzzer

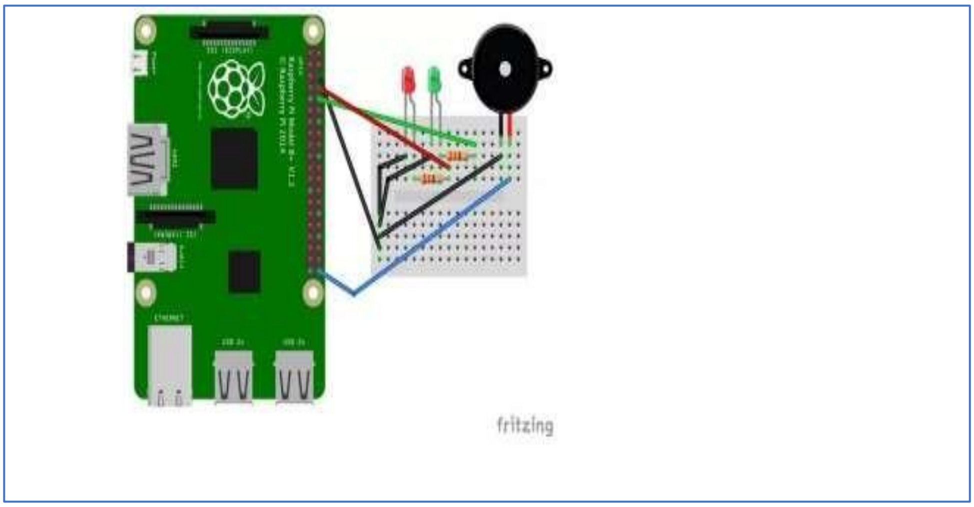


Figure: 9

4.4 Block Diagram

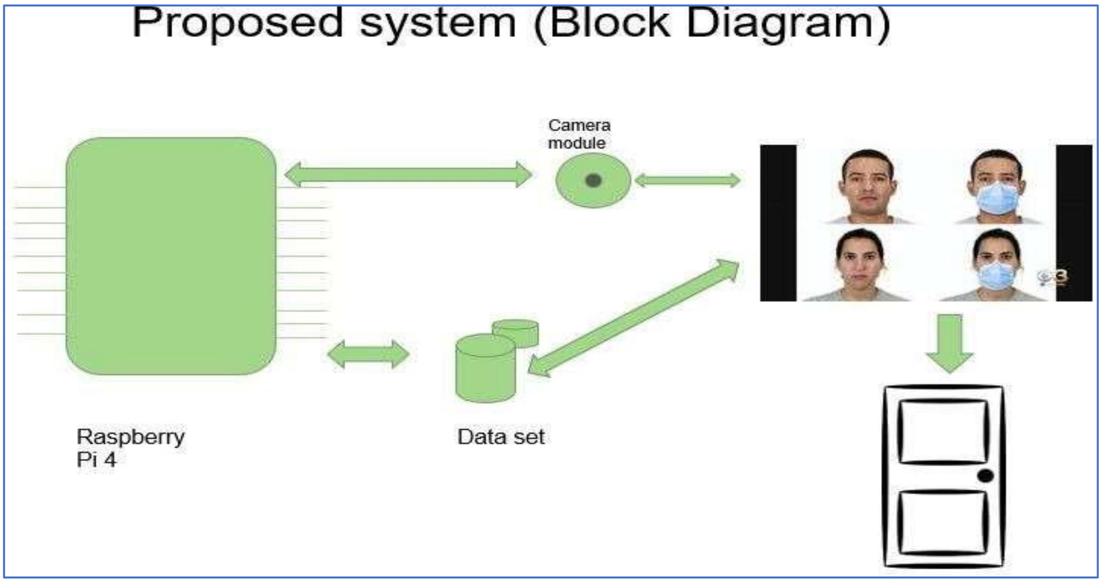


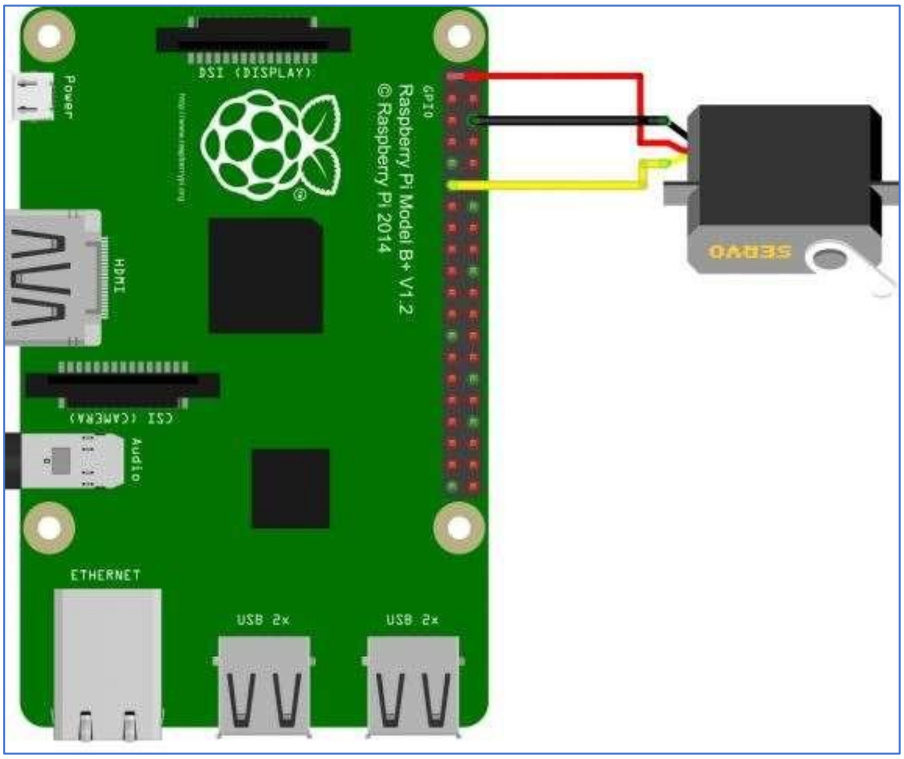
Figure: 10 ***Description of Block Diagram***

In the Block diagram we have shown that:

- There is a Raspberry Pi board containing 40 g p i/o pin and on-board Ethernet, consisting display and processing boards which is fed with the camera and web camera input
- As soon as the user approaches the camera, he is evaluated by open CV library for the face recognition then
- The face recognition data is sent to the deep learning model using **tensorflow** wherein it is evaluated by the existing thousand images of data sets and the signal is sent to Raspberry Pi board. If the person is wearing the face mask, on-screen terminal will show face mask is on or else it will show mask is not on.

4.5 Circuit Diagram

Raspberry pi interfacing with servo motor.



	FUNCTION	PIN	PIN	FUNCTION	
3V3	3V3	1	2	5V	5V
GPIO2	SPI3 MOSI/SDA3	3	4	5V	5V
GPIO3	SPI3 SCLK/SCL3	5	6	GND	GND
GPIO4	SPI4 CE0 N/SDA 3	7	8	TXD1/SPI5 MOSI	GPIO14
GND	GND	9	10	RXD1/SPI5 SCLK	GPIO15
GPIO17		11	12	SPI6 CE0 N	GPIO18
GPIO27	SPI6 CE1 N	13	14	GND	GND
GPIO22	SDA6	15	16	SCL6	GPIO23
3V3	3V3	17	18	SPI3 CE1 N	GPIO24
GPIO10	SDA5	19	20	GND	GND
GPIO9	RXD4/SCL4	21	22	SPI4 CE1 N	GPIO25
GPIO11	SCL5	23	24	SDA4/TXD4	GPIO8
GND	GND	25	26	SCL4/SPI4 SCLK	GPIO7
GPIO0	SPI3 CE0 N/TXD2/SDA6	27	28	SPI3 MISO/SCL6/RXD2	GPIO1
GPIO5	SPI4 MISO/RXD3/SCL3	29	30	GND	GND
GPIO6	SPI4 MOSI/SDA4	31	32	SDA5/SPI5 CE0 N/TXD5	GPIO12
GPIO13	SPI5 MISO/RXD5/SCL5	33	34	GND	GND
GPIO19	SPI6 MISO	35	36	SPI1 CE2 N	GPIO16
GPIO26	SPI5 CE1 N	37	38	SPI6 MOSI	GPIO20
GND	GND	39	40	SPI6 SCLK	GPIO21
	I2C			Ground	
	UART			5V Power	
	SPI			3V3 Power	

Figure: 11

Raspberry pi interfacing with HDMI cable and camera

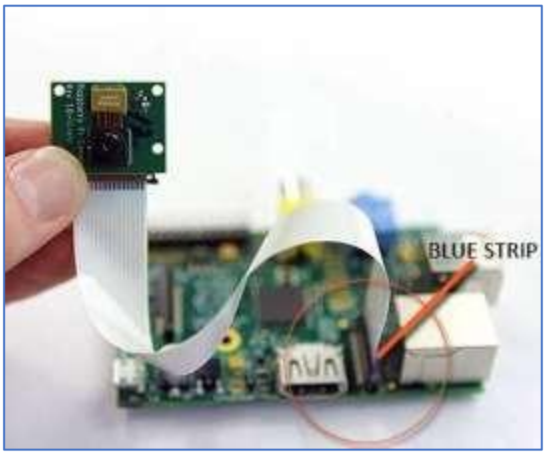


Figure: 12

4.6 Working of the Program

Following is the working model:

Raspberry Pi mask detector works as: When a person approaches the webcam, the python code using Tensorflow, OpenCV, Also, imutils bundles will recognize if he or she is wearing a face cover and will be instantaneously assigned with a red box or a green box around their face accordingly and a veil with the content shows for example: "Much obliged to you Veil On". Those who are not wearing the mask will see the red box around their face with, "no face veil identified".

Time the Raspberry Pi veil identifier project takes: Beginning with a new introduce of the Raspberry Pi to complete all components of this venture it takes around 5 hours. If Raspberry Pi Face recognition is completed, 1.5 hours for the install of OpenCV can be deducted. Using a pretrained model for the task is better because it bounces straight to a working Pi cover discovery framework.

Installing Conditions for Raspberry Pi Face Cover Detection

Introduction to OpenCV, imutils, and Tensor flow:

- OpenCV is an open-source programming library for creating continuous picture and video with AI capabilities.
- Imutils is a progression of comfort capacities to facilitate OpenCV registering on the Raspberry Pi module.
- Tensor flow is a resource for deep learning and machine learning at AI stage.

New duplicate of the Raspberry Pi working framework is installed in 16GB or bigger micro SD card. The webcam is plugged into one of the USB ports of Raspberry Pi. When utilizing a Raspberry Pi camera rather than a webcam, one can use lace link to interface it to the Pi. Booting the Raspberry Pi.

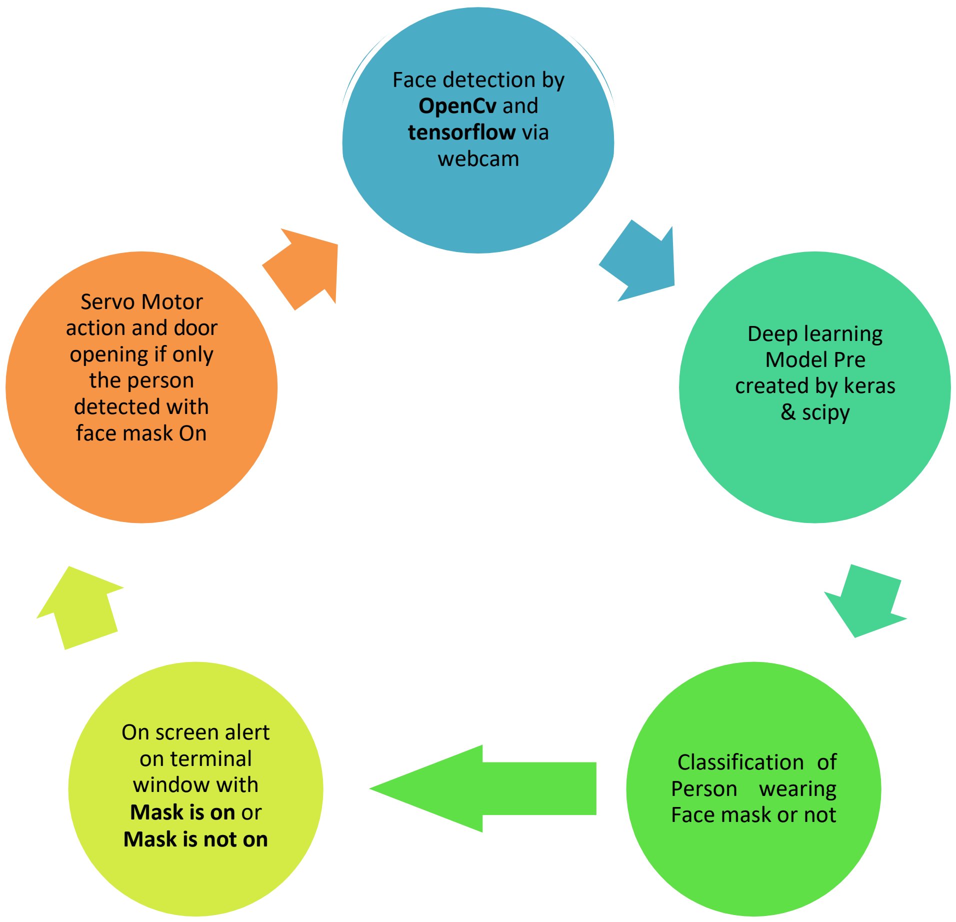


Figure: 13

5. FURTHER INNOVATION & IMPROVEMENTS

Further improvements and innovations done by us are:

- The dynamic creation of face mask library that is the function and the data set of over 2,000 people who are wearing mask and 2008 asset of people not wearing a face mask.
- Implementation of the hardware by placing a Raspberry Pi as sole microcontroller.
- When a person's face mask is on a buzzer and a green and red LED light indicates whether the mask is on or not, when the mask is on the green LED blinks and the screen is founded by the contribution and when the face mask is not on the red LED closed and the buzzer alerts the user to put the mask on.

Advantages

- It is portable.
- Smart & IoT enabled.
- Use of AI & Deep learning overcomes the need for human presence.
- Prevents unnecessary manual labour & supervision.
- Data analytics can be used to gather data for prediction statistics.

Disadvantages

- Power limitation
- Accuracy of detection.
- Requires a continuous Internet connection to scan the data sets.

6. APPLICATIONS

The applications of our developed project & its technology in real world are as follows:

- Fast surveillance and detection systems for appropriate face mask use
- It can be used at large public gathering such as airport bus stations railway stations sports events public events marriage concerts music concerts where the manual instructions and surveillance of face mask use is not possible
- To leverage the power of Artificial Intelligence and deep learning to put into Practical uses such as crowd screening.
- Creation of deep learning library and models
- It can be also integrated with microcontroller and processes to an IOT controlled environment

7. LIMITATIONS

Implementation of the project will be only on software.
The implementation will be presented with the help of dataset.

8. FUTURE WORK

As a preventative measure against the spread of the COVID-19, we will offer a deep learning system that uses pre-trained deep learning models to monitor the physical contact (social distance) between persons in a real-time setting. A clear translucent face mask should also be considered by anybody with a hearing impairment, according to the CDC (Centres for Disease Control and Prevention). "As a result, we'll concentrate on detecting and classifying transparent face masks." According to WHO recommendations, sneezing and coughing are the primary symptoms of COVID-19. In the future, we will use deep learning models to analyse persons who are coughing and sneezing, which will aid in the management of COVID-19 spread.

9. CONCLUSION

The aim of this study is to stop COVID-19 from spreading by avoiding and decreasing local transmission carriers. Our suggested model is a realistic technique to identifying whether or not a person is wearing a face mask appropriately based upon three classes: face with appropriate mask (FWPM), face without a suitable mask (FWOPM), and face without a mask (FWOM), which may play a critical role in regulating and tracking COVID-19 suspects. Both of the modules that we offered are included. We conclude that every complicated issue may be broken down into distinct, much smaller pieces and addressed by concentrating on each of these tiny solutions. When all of these little answers are combined, we have a solution to a much larger issue.

In this project, we use AI, specifically Face detection, to create an efficient and accurate system to detect the presence of face masks in order to prevent the spread of coronavirus disease in times of high public traffic. As everything has been unlocked to return to normal, there is a high risk of transmission because large public bodies are difficult to address.

We utilized the idea of face detection in conjunction with deep learning models and libraries such as tensor flow and keras to dynamically forecast the contour area of a person's space and identify whether or not he or she is wearing a face mask. "Thank you, your mask is on," is the prompt given when the face mask is detected on the person space. For the hardware implementation, we used the action of Servo Motors controlled by GP IO pins of the Raspberry Pi to operate a motor that acts as a Lever of a door to grant access to people wearing masks, and those who are not wearing the mask are prompted by these wear the mask is not on an alert.

It may also be utilized in a variety of inter-disciplinary areas, including military and security, education, and student training in practical IOT-based operations.

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