Face Mask Detection System

Project Report submitted in the partial fulfillment

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In

Electronics and Telecommunications Engineering

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CERTIFICATE

This is to certify that the project titled **"Face Mask Detection System"**, issubmitted by **Kurien Varghese** and **Aditya Maheshwari**, under my guidance and is submitted in partial fulfillment towards minor project in the semester VI of Bachelor of Technology in Electronics and Telecommunication Engineering, MPSTME, Mumbai, India.

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Date:_____

Place: Mumbai

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Table of Contents

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ABSTRACT

In the current pandemic scenario, wearing masks has become very important. COVID-19 spreads mainly from person to person through respiratory droplets. Respiratory droplets travel into the air when you cough, sneeze, talk, shout, or sing. These droplets can then land in the mouths or noses of people who are near you or they may breathe these droplets in. Masks are a simple barrier to help prevent your respiratory droplets from reaching others. Studies show that masks reduce the spray of droplets when worn over the nose and mouth. Hence to conquer this pandemic and ensure public safety, it is of atmost importance to create a system that can verify whether an individual is wearing a mask or not and thereby alert the necessary authorities of same.

This project aims to create such a face mask detection system with the help of neural networks. By feeding a dataset into the neural network, we aim to create and train a model that can provide accurate and instantaneous alerts. This project involves the use of Python and its vast collection of machine learning and image/video processing libraries along with which we itergrated the python code to an ARDUINO UNO to help give an audio visual alert.

This is a simple image classification project trained on the top of Keras/Tensorflow API with MobileNetV2 deep neural network architecture having weights considered as pre-trained 'ImageNet' weights. The trained model takes the real-time video from webcam as an input and predicts if the face landmarks in Region of Interest (ROI) is 'Mask' or 'No Mask' with a real-time A/V (Audio/Visual) output using the Arduino Uno module. Alongside this, we have used basic concepts of transfer learning in neural networks to finally output presence or absence of a face mask in an image or a video stream. Experimental results show that our model performs well on the test data with 99% and 98%,precision and recall, respectively.

Key concepts – machine learning, image and video processing, neural networks and Arduino Uno.

Chapter 1
Introduction

Introduction

Owing to the ongoing pandemic, it has become crucial for us to create and implement various face mask detection system. Efficient, prompt and accurate alerts can help enforce covid appropriate behavior in the masses and thus reduce the spread of this disease.In our day to day lives, most airports, railway stations and housing societies need to monitor the constant inflow of various personnel entering the premise so as to ensure that everyone is wearing a mask.Masks have become mandatory everywhere and hence and efficient system can help track and penalize the offenders. In this project, we try and understand how this technology actually works, and how we can create a face mask detection system using python and then integrate it to an arduino uno to give us an audio visual alert.

1.1 Background

The novel human coronavirus disease COVID-19 has become the fifth documented pandemic since the 1918 flu pandemic. COVID-19 was first reported in Wuhan, China, and subsequently spread worldwide. The coronavirus was officially named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) by the International Committee on Taxonomy of Viruses based on phylogenetic analysis. SARS-CoV-2 is believed to be a spillover of an animal coronavirus and later adapted the ability of human-to-human transmission. Because the virus is highly contagious, it rapidly spreads and continuously evolves in the human population.

Throughout 2020, the virus has spread to **219** Countries and Territories with a total of **134,483,245** confirmed cases of the coronavirus COVID-19 and a death toll of **2,913,824 deaths**. Thus it has become the need of the hour to curb the spread of this virus. According to the WHO, one of the most effective methods of preventing

the spread of the virus is by wearing a mask whilst an individual comes in contact with another individual.

In recent years, artificial intelligence and machine learning have become major topics of interest and research. Machine learning in particular seeks to replicate the process of thinking like the human brain and eyes. It also identify various anomalies using computer vision. A trained model can function like a human brain and make decision on the basis of what the computer can see using various concepts of computer visio. In case of the face mask detection system, neural networks and computer vision are the core of this project. The accuracy of these softwares largely depends on such algorithms.

Through the use of programming languages like Python, we can create our own face mask detection. In this project we have used Python, since it has a large collection of libraries that have been specifically developed for machine learning, neural networks, image and video processing and Arduino implementation. These libraries contain inbuilt functions which carry out complex algorithms to give us the desired result.

1.2 Motivation and Scope of the project

Globally, the coronavirus statistics say it has more than 134M confirmed cases and claimed over 2.9M lives so far, according to the World Health Organization. As many as 76.2 M people have recovered. After the second wave, India's coronavirus cases are increasing in an unimaginable rate and is breaking the record in the highest single-day increase so far, every new day. The country's tally rose to 13.1M and claimed over 1,68,000 deaths as on 9th April,2021. India is now the third worst-affected country by the pandemic and has overtaken Italy, according to WHO. The World Health Organization said that new information showed that protective masks could be a barrier for potentially infectious droplets. The coronavirus primarily spreads through the transmission of respiratory droplets from infected people. On 5th June 2020, WHO changed its guidelines about the use of protective face masks in public, saying that they must be worn at all places where physical distancing is not possible. The global

health body had said in April last year that there was not enough evidence to show that healthy people should wear masks to shield themselves from the coronavirus.

WHO also said that high-risk groups should wear medical grade masks in cases where physical distancing is not possible? Several countries, including India, have made wearing masks in public compulsory. In many states, people have been fined for not wearing masks. Maintaining hygiene and using protective equipment has become even more important ahead of the reopening of religious places, malls, and restaurants in India. This motivated us to create a the COVID-19 Mask Detector with some of our ML/DL skills and making it such accurate that it could potentially be used to help ensure your safety and the safety of others (Leaving it on to the medical professionals to decide on, implement in public places).

1.3 Problem statement

"The covid 19 pandemic has spread globally at a rapid rate. Wearing masks have proved to be an effective and crucial method of prevention in battling the spread of this virus and various other viruses. In this project, we aim to create a face mask detection system in Python, using machine learning, neural networks and computer vision. We further implement this output onto an Arduino Uno to give an audio alert(via a buzzer) and a visual output (via a LED). By doing so we hope to create a face mask detection and alert system that can help curb the spread if the virus and promote covid appropriate behavior in the future."

Chapter 2

Literature survey

2.1Introduction to topic

Face Mask Detection System is a system developed using machine learning, computer vision and neural networks. It takes the live feed from the webcam and using it as input determines whether an individual is wearing a mask or not and gives an audio visual output using an Arduino Uno. This audio visual alert can help identify and penalize offenders in public places. Thus we can conquer the rapid spread of the virus and embrace this new normal that we are getting accustomed to.

There numerous ways to develop a Face mask detection system. Various types of neural networks such as CNN, MobileNet, ResNet and MobileNet V2 can be used. Out of these we will be working with MobileNet V2.

2.2Exhaustive literature survey

[1]To distinguish the individuals wearing Face Mask, various identification procedures are available. This proposal depends on the present idea about the job respiratory beads that play a main role in the spread of the COVID-19 infection, matched with developing proof from clinical and research center examinations that show covers and decrease the splash of drops, when worn over the nose and mouth. Coronavirus spreads essentially among individuals who are in close contact with each other (inside around 6 feet), so the utilization of veils is especially significant in settings where individuals are near one another or where social removing is hard to keep up. CDC's suggestions for masks will be updated as new logical proof. Our project is more of a real-world application, the proposed face mask detection platform utilizes artificial network to identify the person with and without mask. If a person is not wearing a mask, then the proposed platform will send a notification to the person if he or she is in the database of the platform. MobileNet_V2 neural networks are used as our classification algorithm and the face recognition module is also used for the person identification model

[2] An application for tracking and detecting faces in videos and in cameras which can be used for multipurpose activities. The intention of the paper is deep study of face detection using open CV. A tabular comparison is performed in order to under-
stand the algorithms in an easier manner. It talks about various algorithms like Adaboost, Haar cascades. This paper aims to help in understanding the best prerequisites for face detection.

[3] There is very high and ever ncreasing demand for deep learning in the industry, academics and research and development of products. There are wide range of DL frameworks available, each having its own functions and characteristics. The combination of frameworks and algorithms together provides the desired output.Thus selecting the right framework is very crucial. In this paper, two frameworks such as TensorFlow and Caffe are implemented in specific applications and results are analysed to choose the best framework based on application.

[4] Corona Virus Disease (COVID-19) pandemic has become a huge humanitarian and health crisis. One of the effective methods against the virus is wearing a face mask. This paper introduces face mask detection that can be used by the authorities to make mitigation, evaluation, prevention, and action planning against COVID-19. The face mask recognition in this study is developed with a machine learning algorithm through the image classification method: MobileNetV2. The steps for building the model are collecting the data, pre-processing, split the data, testing the model, and implement the model. The built model can detect people who are wearing a face mask and not wearing it at an accuracy of 96,85 percent. After the model implemented in 25 cities from various source of image, the percentage of people wearing face mask in the cities has a strong correlation to the vigilance index of COVID-19 which is 0,62.

2.3 Applications

Many countries around the world have recently initiated wearing face masks compulsory. People must cover their faces in public, supermarkets, public transports, offices, and stores. Retail companies often use software to count the number of people entering their stores. They may also like to measure impressions on digital displays and promotional screens. Our Face Mask Detection systemcan be released as an open-source project. Our software can be equated to any existing USB, IP cameras, and CCTV cameras to detect people without a mask. This detection live video feed can be implemented in web and desktop applications so that the operator can see notice messages. Software operators can also get an image in case someone is not wearing a mask. This software can also be connected to the entrance gates and only people wearing face masks can come in.

Chapter 3
Methodology and Implementation

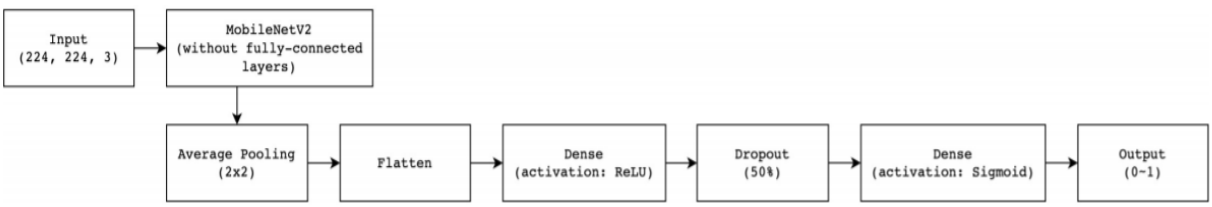
3.1 Methodology

To train a Face Mask Detector, we need to break our project into two distinct phases, each with its own respective sub-steps:

• Training: Here we focus on loading our face mask detection dataset from disk, training a model (using Keras/TensorFlow) on this dataset, and then serializing the face mask detector to disk.

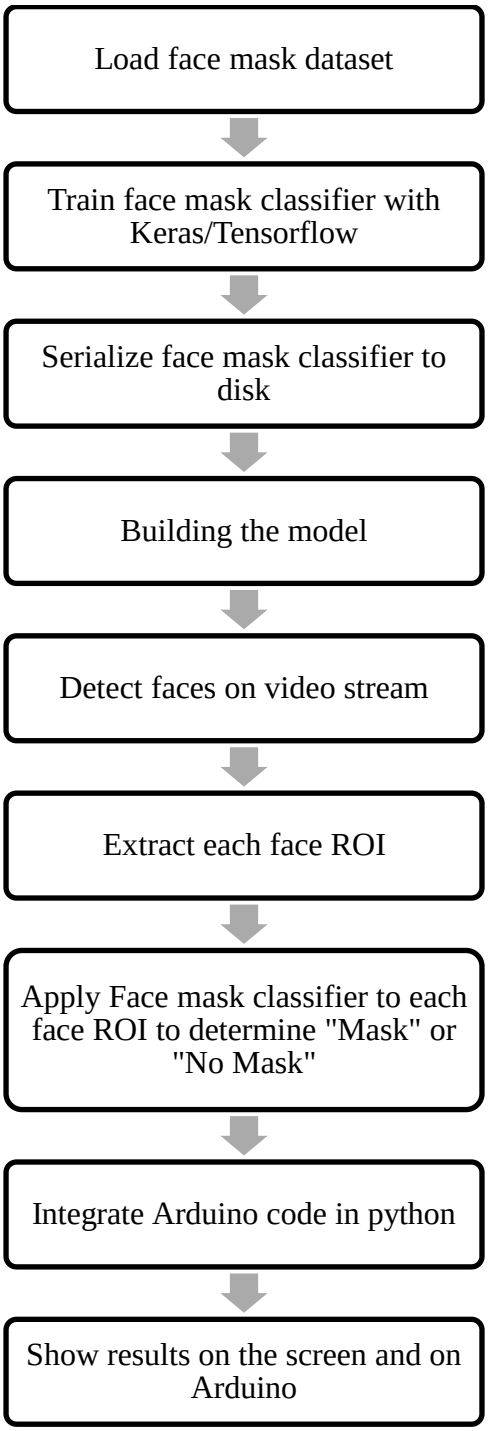
• Deployment: Once the face mask detector is trained, we can then move on to loading the mask detector, performing face detection, and then classifying each face as with_mask or without_mask using the webcam.

The base model that we have used here is MobileNetV2 with the given 'ImageNet' weights. ImageNet is an image database that has been trained on hundreds of thousands of images hence it helps a lot in Image classification. For the base model, we truncate the head and use a series of our selfdefined layers. We used an average pooling layer, a flatten layer, a dense layer with output shape (None, 128), and activation ReLU, a 50% dropout layer for optimization, finally another dense layer 5 with output shape (None, 2), and Sigmoid activation is used. The overall process flow diagram of the algorithm is shown below.



3.2Flowchart

The overall process flow diagram of the algorithm is shown below:



3.3 Software descriptionand Implementation

Tensorflow is an open-source library developed by Google primarily for deep learning applications. It also supports traditional machine learning. TensorFlow was originally developed for large numerical computations without keeping deep learning in mind. However, it proved to be very useful for deep learning development as well, and therefore Google open-sourced it.TensorFlow accepts data in the form of multi-dimensional arrays of higher dimensions called tensors. Multi-dimensional arrays are very handy in handling large amounts of data.TensorFlow works based on data flow graphs that have nodes and edges. As the execution mechanism is in the form of graphs, it is much easier to execute TensorFlow code in a distributed manner across a cluster of computers while using GPUs.

Keras is a high-level, deep learning API developed by Google for implementing neural networks. It is written in Python and is used to make the implementation of neural networks easy. It also supports multiple backend neural network computation. Keras is relatively easy to learn and work with because it provides a python frontend with a high level of abstraction while having the option of multiple back-ends for computation purposes. This makes Keras slower than other deep learning frameworks, but extremely beginner friendly.

OpenCV is an open-source library. It is supported by various programming languages such as R, Python. It runs on most of the platforms such as Windows, Linux and MacOS.

Advantages of OpenCV:

- OpenCV is an open-source library and is free of cost.
- As compared to other libraries, it is fast since it is written in C/C++.
- It works better on System with lesser RAM.
- It supports most of the Operating Systems such as Windows, Linux and MacOS

The function ***cv2.dnn.blobFromImages*** performs two functions:

1. Mean Subtraction - Mean subtraction is used to help combat illumination changes in the input images in our dataset. We can therefore view mean subtraction as a technique used to aid our Convolutional Neural Networks.
2. Scaling - A scaling factor,σ, which adds in a normalization.The value of σmay be the standard deviation across the training set (thereby turning the preprocessing step into a standard score/z-score). However,σ may also be manually setto scale the input image space into a particular range.

DNN Face Detector in OpenCV

It is a Caffe model which is based on the Single Shot-Multibox Detector (SSD) and uses ResNet-10 architecture as its backbone. It was introduced post OpenCV 3.3 in its deep neural network module.

Our dataset is taken as input and fine-tuning is done with MobileNetV2 DNN architecture upon it to create our maskdetectormodel.A training history containing accuracy/loss curves is also produced for better visualization of Model Evaluation through a plot.

Some important processes which we performed here:

- Data augmentation
- Loading the MobilNetV2 classifier (fine-tune this model with pre-trained ImageNet weights)
- Building a new fully-connected (FC) head.
- Pre-processing
- Loading image data

Then we used our webcam to apply face mask detection to every frame in the stream using webcam to read the real-time video.

Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. This device can take many types of input and turns it into a output -

activating a buzzer, turning on an LED, sending an automate message,etc. Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments.

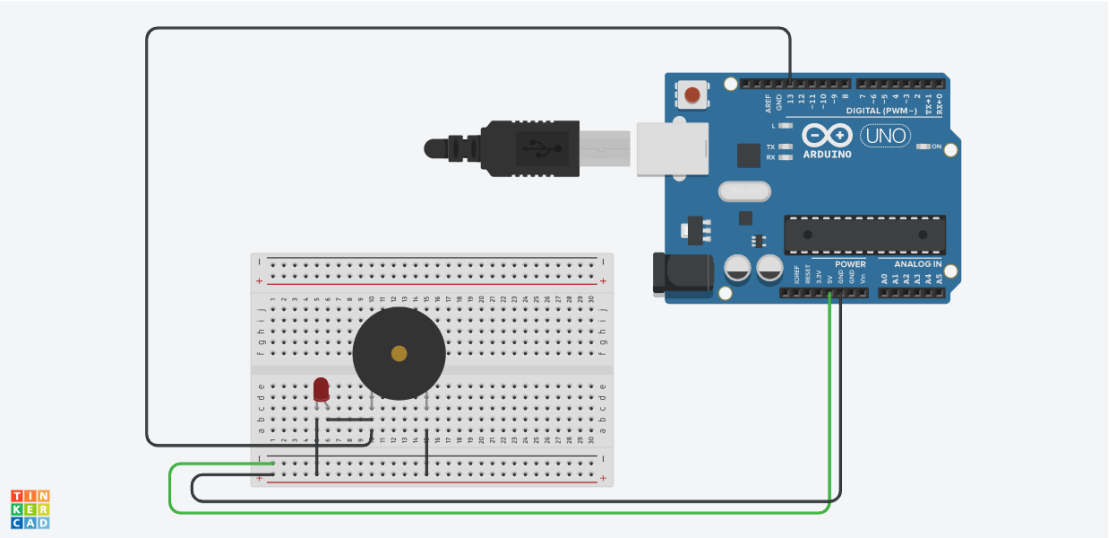


Fig 3.3.1(The implemented Arduino circuit to give an output via the buzzer and LED)

Pyserial

This module helps us to communicate via the serial ports to various devices such as an Arduino Uno.

- Access to the port settings through Python properties.
- Support for different byte sizes, stop bits, parity and flow control with RTS/CTS and/or Xon/Xoff.
- Working with or without receive timeout

We use this package to integrate our python code to the Arduino Uno. We communicate the output, i.e whether the individual/s in front of the camera are wearing a mask or no, to the serial port to which the Arduino is connected. The Arduino is further connected to a buzzer and an LED. The LED and buzzer give an alert if there is someone who is not wearing a mask in the camera frame.

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Chapter 4

Results and Analysis

4.1 Evaluation

We tried using abase model for detecting ‘mask’ or ‘no mask’. The evaluation process consists of first looking at the classification report which gives us insight towards precision, recall and F1 score.

$$\text{F1-score} = \left(\frac{\text{Recall}^{-1} + \text{Precision}^{-1}}{2}\right)^{-1} = 2 * \frac{(\text{Precision} * \text{Recall})}{(\text{Precision} + \text{Recall})}$$

The equations of these three metrics are as follows:

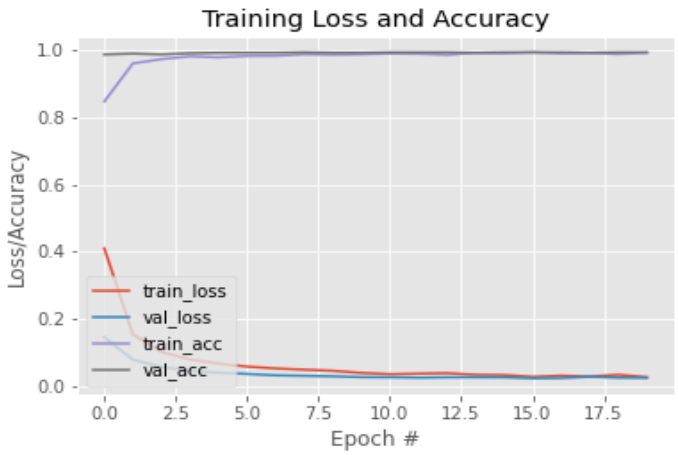
$$Precision = \frac{True\ Positives}{Positives + False\ Positives}$$

$$Recall = \frac{True\ Positives}{Positives + False\ Negatives}$$

$$Accuracy = \frac{True\ Positives + True\ Negatives}{Positives + Negatives}$$

Using these three metrics, we can conclude how our model is performing. The second part consists of plotting the train loss, validation loss, train accuracy and validation accuracy which also proves helpful in choosing a final model. The results of different choices are shown below.

	precision	recall	f1-score	support
with mask	0.98	0.99	0.99	138
without mask	0.99	0.98	0.99	138
accuracy			0.99	276
macro avg	0.99	0.99	0.99	276
weighted avg	0.99	0.99	0.99	276



4.2 Working Prototype Images

Fig.4.2.1 shows the Face Mask Detection system detecting a person not wearing a mask.

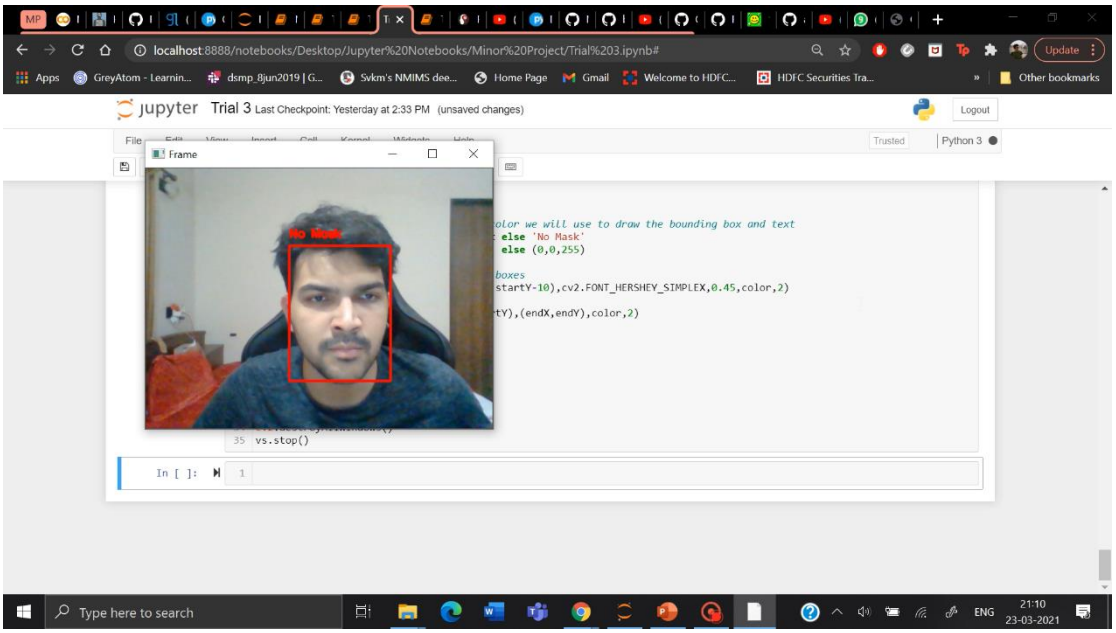


Fig.4.2.1

Fig.4.2.2 shows the Face Mask Detection system detecting a person wearing a face mask.

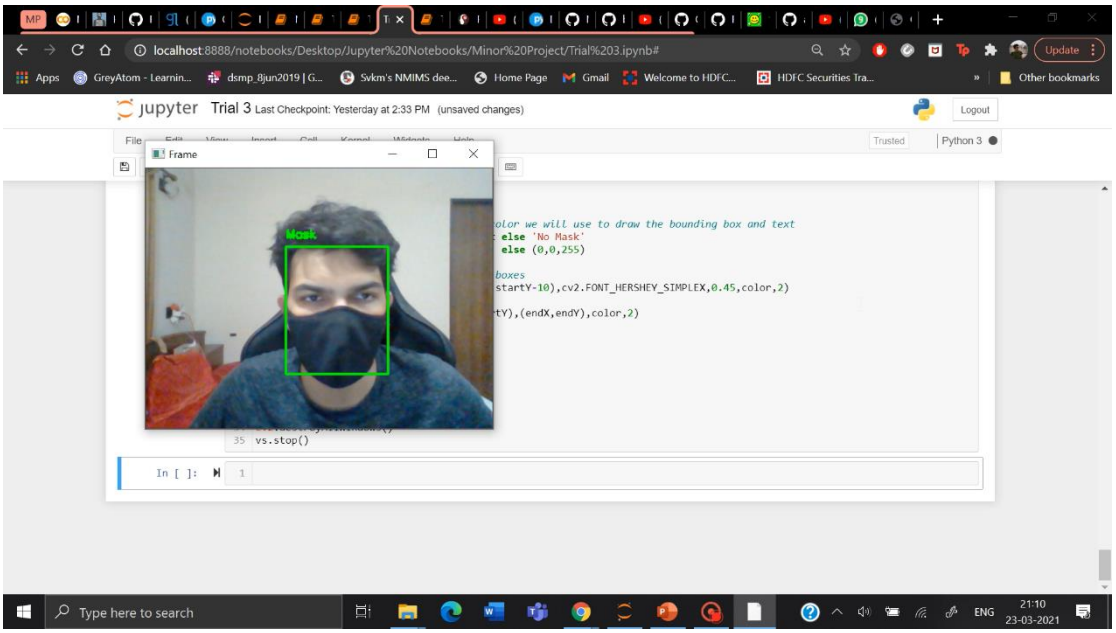


Fig.4.2.2

Fig.4.2.3 shows the Buzzer and LED used in the Face Mask Detection system

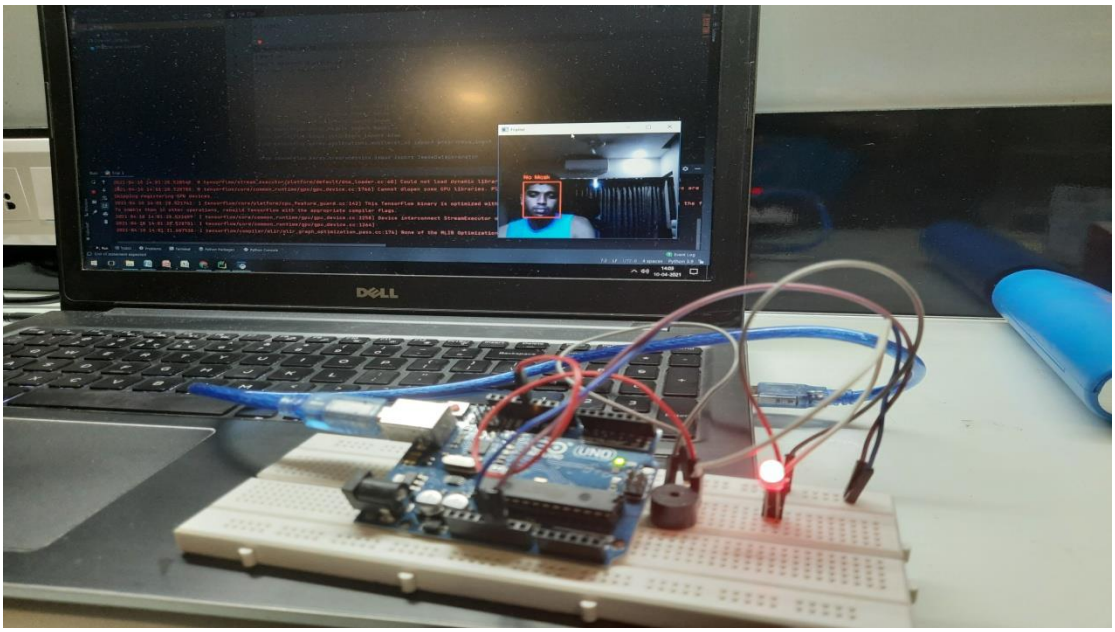


Fig.4.2.3

4.3Investigation

This approach reduces our computer vision pipeline to a single step — rather than applying face detection and then our face mask detector model, all we need to do is apply the object detector to give us bounding boxes for people both with_mask and without_mask in a single forward pass of the network. An integration of this project to a web app/android app or any IoT devices to create a barricade like system to restrict the entry of peoples without mask at public places.

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