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**Ain Shams University**  
**Faculty of Computer & Information Sciences**

**Computer Science Department**

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**July 2021**

Crowd counting and Facemask

detector

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**Ain Shams University**  
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**Computer Science Department**

**July 2021**

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Crowd counting and Facemask

detector

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* Finally, We would thank our friends and all people who gave us support and encouragement

# Abstract

Because of rapid spreading of Covid-19 in our lives with its deadly consequence and that the world needs to adopt with it and move on with our lives,

A tool is needed so that it helps organizations to monitor this spreading by counting the number of people within a certain area and to detect as well whether they wear face masks or not so it can help control the affection spreading.

In this project we develop an application that takes an image,

do some preprocessing on it, count the number of people within it, then we detect faces of each person then detect the masks if it is worn or not and if worn correctly a green boundary box is added to this face if person is not wearing or wear it incorrectly it will do red boundary box on the face.

The output of project is main input image along with output image with count and the boundary boxes, we do this by using three different models “SDC-net” for counting “Retina-net” for face detection finally “Nas-net” for mask detection and classification.

The results obtained by counting model are for MSE equals “100,50.3,195.1” For shanghai partA, partB, UCF-QNRF datasets. The accuracy obtained by face mask detection model is 99% for Face Mask Detection by larxel dataset and [Face Mask Detection (OMKAR GURAV)](#_Toc76290202) dataset.

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# List of Abbreviations

CCFM Crowd counting and Facemask

CNN Convolutional neural network

COVID\_19   Coronavirus disease of 2019

CSRNet Congested Scene Recognition Network

DCNN Deep-Convolutional Neural Network

MCNN Multi- Convolutional Neural Network

NASNet Mobile Neural Search Architecture Network

S-CNN Switch- Convolutional Neural Network

SDC-net Spatial Divide-and-Conquer Network

SGD Stochastic gradient descent

UNet U-shaped Convolutional Neural Network

VGG16 Visual Geometry Group With 16 Layer

YOLOv3 You only look once Version 3

MSE Mean Square error

mAp Mean average precision

FMY3 Facemask detection yolov3

FMNMobile Facemask detection nasnetmobile

# Introduction

## Motivation

COVID-19 still has no solutions or any medication and world need to live with it and because of the increasing number of injuries and that people no longer make the precaution procedures [1]. So, we decided to do this project to help people in charge to control spreading of the virus through using it in their buildings.  
 It’s useful as it will ease the process of monitoring number of people and that they are wearing masks without too much effort, Detection of people who are not wearing masks is a challenge due to Outbreak of the Coronavirus pandemic has created various the large number of populations. This project can be used in schools, hospitals, banks, airports, and etc. as a digitalized scanning tool.

## Problem Definition

COVID-19 is keeping spread in the world but we need to live with it anyway so we can do our work, continue our education and live the normal life we used to living.

People no longer make the precaution procedures[2]. And it is a challenge to keep track of People number and whether they wear masks or not.

## 1.3 Objective

Do a software that help institutes to count the number of people in a certain area and detect if people wear masks or not and if worn correctly or just on the ears.

## 1.4 Time Plan

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Figure1 Our Time Plan

1.5 Document Organization

[Chapter 2: Background](#_Background)

In this chapter, we introduce the following:• A detailed description of the field of the project.• All the scientific background related to the project.• Results of similar models.

[Chapter 3: Analysis and design](#_Analysis_and_Design)

In this chapter, we introduce the following:• a System Overview and the System Analysis & Design• A description of all the functions in the system.

[Chapter 4: Implementation](#_Implementation_and_Testing)

In this chapter, we introduce the following:• A detailed description of all the techniques and algorithms implemented.• Flowchart for the main functions.

• Datasets used to train each model.

• Results of used models.

[Chapter 5: User Manual](#_User_Manual)

In this chapter, we introduce the following:• Describes in detail how to operate the project along with screen shots of the project representing all steps.• This chapter also include a "Steps" that would describe how to Use the App.

[Chapter 6: Conclusions and Future Work](#_Conclusion_and_Future)

Finally, we introduce a complete summary of the whole project

And Features would be helpful if added to the application in the future.

# Background

2.1 Description of project field

Deep learning is an artificial intelligence function that imitates the workings of the human brain in processing data and creating patterns for use in decision making.[3]

Deep learning algorithms run data through several “layers” of neural network algorithms, each of which passes a simplified representation of the data to the next layer.

Deep learning algorithms learn progressively more about the image as it goes through each neural network layer.

Early layers learn how to detect low-level features like edges, and subsequent layers combine features from earlier layers into a more holistic representation.[3]

For example, a middle layer might identify edges to detect parts of an object in the photo such as a leg or a branch, while a deep layer will detect the full object such as a dog or a tree.

2.1.2 Introduction to SDC-net

A Single Stage Spatial Divide and Conquer Network invented by Haipeng Xiong and his colleagues[4] used to do counting of people in certain area , it depend on learning from a closed set but can generalize well to open-set scenarios to avoid repeatedly computing sub-region convolutional features,As shown in figure 2 the architecture of the SDC-net it adopts a VGG16 [5]-based encoder and an UNet-like decoder to generate multi-resolution feature maps.All feature maps share the same counting predictor.

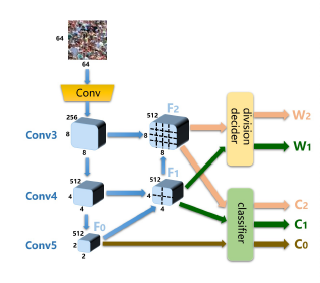


Figure 2 SDC\_net Architecture

2.1.3 Introduction to Retina Face:

As used in [5] single stage pixel wise face localization method employs extra supervised and self supervised multi task learning in parallel with existing box classification and regression branches each positive anchor outputs:(a face score, a face box, a five facial landmarks, dense 3D face vertices projected on the image plane)

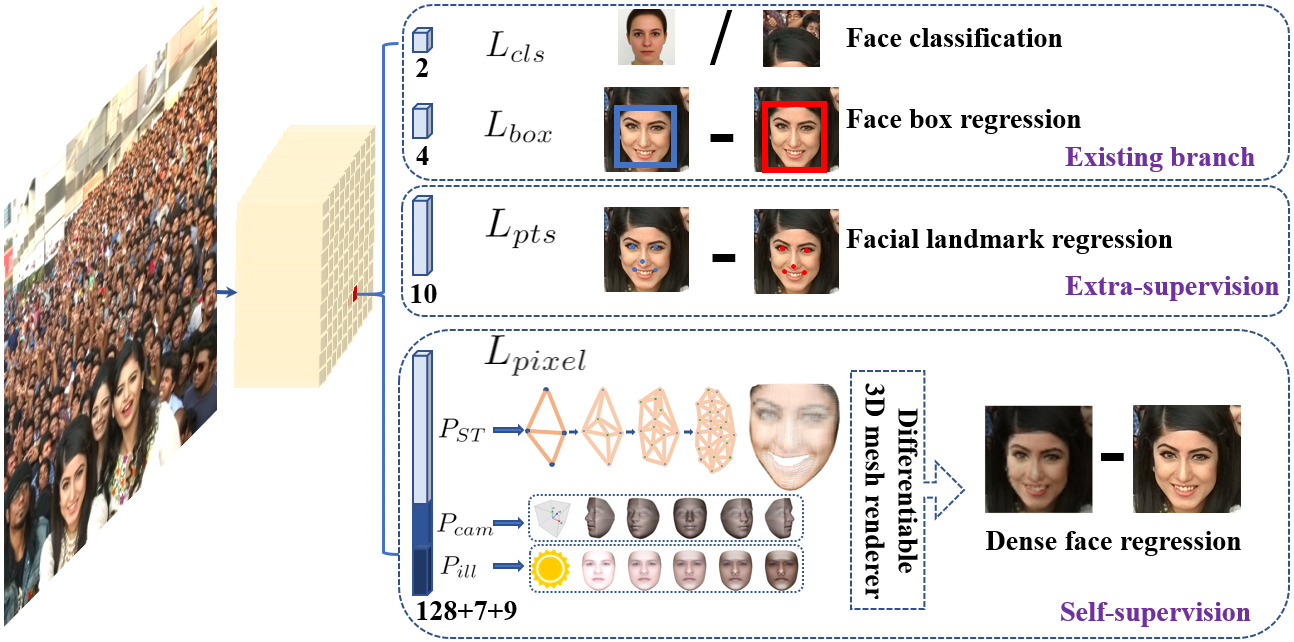


Figure 3RetinaFace Architecture

2.1.4 Introduction to NasNet Mobile [6]:

The usage of the deep learning using CNN based algorithms its became easier compare to the Computer vision based algorithm. Here in this approach[4] we have taken the NasNet Mobile that’s Deep Convolutional based networks for object detection and classification mask. that consists of basic building blocks(cells) that are optimized using reinforcement learning.

The example of cell structured is shown in this Figure.

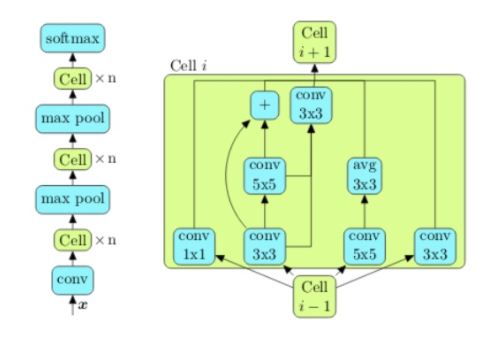


Figure 4 Neural Architecture Search (NasNet)

2.2 Related work

2.2.1 : Counting :

**YOLOv3: An Incremental Improvement [7]:** it implements yolo algorithm which is a real-time object detection algorithm that identifies specific objects in videos or images, it is a CNN that is classifier-based systems that can process input images as structured arrays of data and identify patterns between them and “score” regions based on their similarities to predefined classes. High-scoring regions are noted as positive detections of whatever class they most closely identify with. It first separates an image into a grid. Each grid cell predicts some number of boundary boxes around objects that score highly with the predefined classes. Each boundary box has a respective confidence score of how accurate it assumes that prediction should be and detects only one object per bounding box. The boundary boxes are generated by clustering the dimensions of the ground truth boxes from the original dataset to find the most common shapes and sizes.

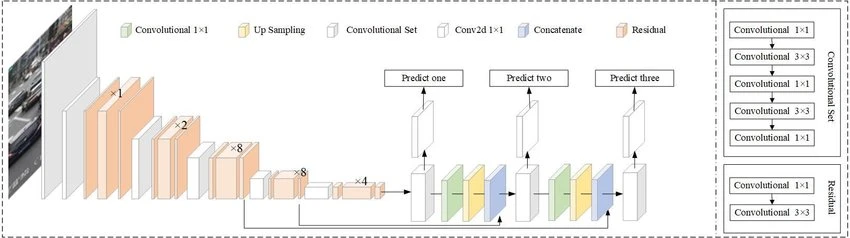


Figure 5 YOLOv3 Architecture

**Monitoring COVID-19 social distancing with person detection and tracking via fine-tuned YOLOv3 and Deepsort techniques[8]:** a deep learning based framework is proposed that utilizes object detection and tracking models uses YOLO v3 alongside the Deepsort are utilized as object detection and tracking approaches while surrounding each detected object with the bounding boxes. Later, these bounding boxes are utilized to compute the pairwise L2 norm with computationally efficient vectorized representation for identifying the clusters of people not obeying the order of social distancing.

Table 1 YOLOv3 and Deepsort Result

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**Near Real-time Crowd Counting using Deep Learning Approach [9]:** It provide an end to end application for crowd counting through surveillance video by running the crowd-counting algorithm on frames every second which allows to achieve near real-time processing in this system, It purposed using DCNN architecture used for crowd counting which is 10 convolution layers and 3 max pooling layers of VGG-16 are used in the front end. The output of it is then fed into the dilated convolution back-end network which helps to maintain the resolution and generate high-quality density maps then output the crowd count.

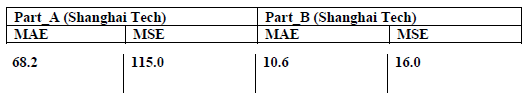
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Table 2 Neural Result

**The Comparison of Crowd Counting Algorithms based on Computer**

**Vision [10]** in this paper, they compared Switch-CNN, MCNN, and CSRNet based on the perspective of network structure and experimental performance

MCNN can achieve adaptation to different sizes of heads.

Switch-CNN can classify crowd image patches. By using dilated convolutional layers and local density variation.

CSRNet expands the receptive field without reducing spatial resolution, while also enabling density detection for high-density populations.

At the end of the overall results, CSRNet is the most condensed and best performing, they make the experiments on crowd counting dataset with stateof-the-art performance (ShanghaiTech dataset).

Diagram, engineering drawing

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Figure 6structure of the proposed multi-column convolutional neural network OF MCNN

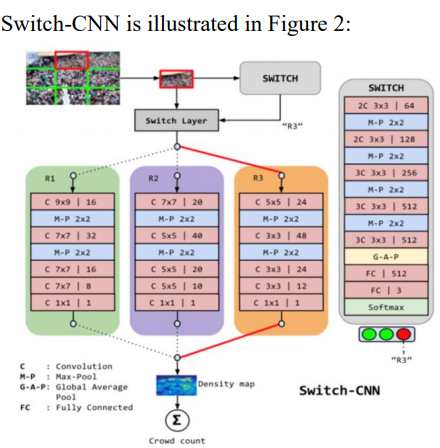
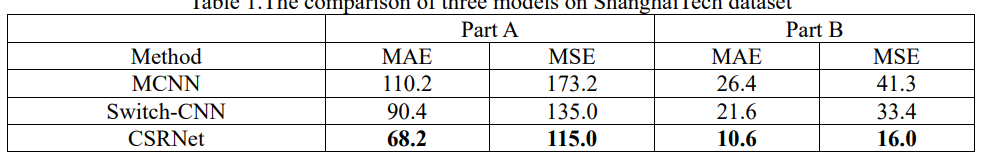


Figure 7 The structure of the proposed switch convolutional neural network for crowd density map estimation.

Table 3The comparison of three models on ShanghaiTech dataset

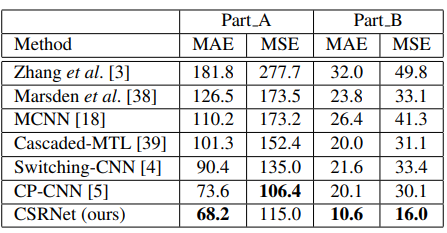


**Csrnet: Dilated convolutional neural networks for understanding the highly congested scenes [11]:** In this paper, The fundamental idea of the design that they used, is to deploy a deeper CNN for capturing high-level features with larger receptive fields, on the other side, they generating a high-quality density map, by using pure convolutional layers to support input images with flexible resolutions, that can easily happen when they taking advantage of the dilated convolutional layers. they make the experiments on four crowd counting datasets with state-of-the-art performance(ShanghaiTech dataset,UCF CC 50 dataset, The UCSD dataset, The WorldExpo’10 dataset)  
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Figure 8. Comparison between dilated convolution and max pooling, convolution, up sampling

Table 4 Estimation errors on ShanghaiTech dataset



**ATTENTION GUIDED REGION DIVISION FOR CROWD COUNTING[12]:**

this paper makes a combination between two branches, the regression branch, and the detection branch to count people.

The regression branch is used to divide the image into dense and sparse areas and predict a density map in the dense area, by using the first ten layers of VGG-16 as the front-end. and they enhance it by Following the front-end with two parallel back-ends and introduce an attention map to make the network focus on dense areas.

In a parallel way, The detection branch tries to be responsible for detecting heads in the sparse area, and they enhance it by avoiding low resolution of the output feature map which made the network unable to detect small heads, as a result of having too much down sampling layers, by adjusting the allocation of layers and parameters, Meanwhile, they reduce the depth and channels for saving memory, they make the experiments on two crowd counting datasets with state-of-the-art performance(ShanghaiTech dataset, The UCSD dataset)

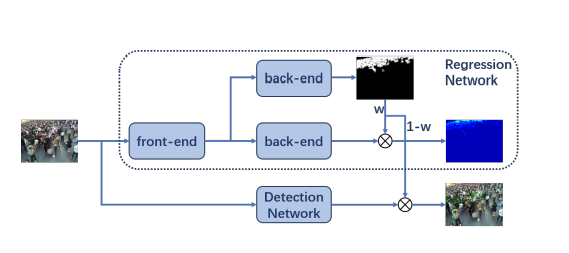
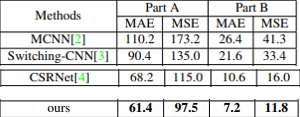


Figure 9 Two Branches of Combined Model

Table comparison between different models using ShanghaiTech dataset



In this section we have reviewed various face mask detections techniques for various applications.

2.2.2 : Face Detection :

**Multi-Stage CNN Architecture for Face Detection[13]:**

In this paper define CNN architecture face detector try three different models: 1-Dlib :The Dlib Deep Learning face detector , 2-MTCNN : architecture with three stages of CNN for detecting and localizing faces and facial key points, 3-RetinaFace : single stage design predict face box, face score, and facial key points.

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Table 7 : Face Detector Inference Speed

Three models has a good result from s short distance ,Dlib is poor when detected masked or covered faces , MTCNN and Retina Face perform better than Dlib and can detect multiple faces in images. But MTCNN has poor accuracy detecting faces from the side view. For that Retina Face is good model for face detection. Retina Face decreases the failure rate from 26.31% to 9.37%

2.2.3 : Mask Detection :

**Facial Mask Classification Using Deep Transfer Learning Techniques [6]:** Here in this paper have taken the NasNet Mobile and YoloV3 are Deep Convolutional based networks for object detection.

Yolo which is state-of-the-art single stage object detection technique.

NasNet was developed by Google brain team, which uses the two main functionalities are 1) Normal cell 2) Reduction cell which shown in image.

Diagram

Description automatically generated

Figure 10: NasNet Normal and Reduction Cell Architecture

try NasNet on the small dataset and then transfer its block to the large dataset to get a greater mAP. We can increase NasNet's performance by using a modified drop path called Scheduled drop path for effective regularization, and used the ImageNet pre-trained network weights for transfer learning process to detect the face masks.

After train and validate 20 epochs and achieved the considerable detection accuracy. The following shows various detection results for FMY3 model.

![Table

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHlhc21lbgAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzgyAACSkgACAAAAAzgyAADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Table 5 Accuracy Measures For The Fmy3 Model

![Table

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHlhc21lbgAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzU2AACSkgACAAAAAzU2AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Table 6 Accuracy Measures For The FMNMobile Model

Training and validation loss show in the Figure for the FMNMobile

![Chart, line chart

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHlhc21lbgAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzQ1AACSkgACAAAAAzQ1AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Figure 11: FMNMobile-Training and Validation curve(loss and Accuracy)

FMNMobile achieves higher accuracy compares to the FMY3

**Multi-Stage CNN Architecture for Mask Detection[13]:**

In this paper Face mask detection was trained, by three different image classification models: MobileNetV2, DenseNet121, NasNet. These models have high performance with lightweight architecture with low latency.

Each model was trained for 50 epochs and the weights from the epoch with the lowest validation loss were selected.

![Table

Description automatically generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAYABgAAD/4RDgRXhpZgAATU0AKgAAAAgABAE7AAIAAAAHAAAISodpAAQAAAABAAAIUpydAAEAAAAOAAAQyuocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAHlhc21lbgAAAAWQAwACAAAAFAAAEKCQBAACAAAAFAAAELSSkQACAAAAAzU4AACSkgACAAAAAzU4AADqHAAHAAAIDAAACJQAAAAAHOoAAAAIAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Table 8 : FaceMask Classifier Training Statistics

![Table

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AUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRXzV8YtZ1nR/jkupaZeXSw6Pp9tfy2ySsEkQTBWBXOOjc079oXxVe6reWlt4d1CeG00zTV1G4ktpSm/wA6REjBIPoc/jU391Pu2v6+5lW963l/l/mj6ToryjU/idqNr4g03wh4XtdOn1JdNju7u71a6MMEQKDC8AlmOR+Y98YHir4va5qvwX1fVNEtI9O1Owujp+ptHdZNqcgCSFh97JOB6c9cVUvdv5f52/MmPvW8/wDK/wCR7tRkA4zXjuo/FPxJ4O8G+ELjWtDhu7zWJVgMcVyXd02JtcHHLtu5B71DquuXj/EbwBH448J2Ueu3U84glhvZCLNQRggKdrkjrn0quX3+XzsK/uc3lc9oorym9+J/ijWPEuvaf8PvDtpqVt4eOy8mu7hlaeQZzHEqjr8rAZ64+lHiP4wX+l6R4ZWHQBpur6+zp5OuSNbRWZQgN5jEAkEkY6ZHPtUJ3Sa6/qU9Hb+tD1aiuT8Fa94m1ZryDxToltZmDaYL6wuRNbXan+5n5hj3rrKqxIUUUUhhRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAeV618P9S13406nqN3ZZ0G+8OvpzXPmp/rGPTbndx1zjHvXBWfwe8Yp8HvElpf2H2jxHqE9rBBD9pi5trcqE+fdtHAPBOeBX0jRStpb+t7/ANeQ763/AK2t+i+Z4P4n+G2pWXxEtfFD+EIPF2n3OmRWt3p7Sxh7eZEVQ43HB+6ORnqfar2q+ANa1T4G67ptn4S0rQNVv5kli03T3HzIjqQHfO0vgHocdPw9qopy95Nf1vcUfdaa6f5WPENa8NeL/Fmi/DuRvDMtjNoeoxG9hlu4iUijEY8z7wyDtb5Rk8V0njrwlres/F3wPrWm2XnafpUkpvJvNRfKBxj5SQT07A16XRVc3vKXnf52sK3u8vlb5bnidjovjj4a+MPFknhvwz/wkNl4gnN1Zzx3ccf2eUljiQMQcAv+nXnjW8TaZ4u1HwlosXi3wdpHi9jvfUra3kEMtux+75LM2OBgEg5OOOOa9WoqLe6l6fgVfW/9ankHwd8E6v4b8U65qP8AZFx4c8P3kaLaaPcXouHEgxmTgnHQjk559q9fooqr6JE21CiiikMKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigD//2Q==)

Table 9:FaceMask Classifier Performance Metrics

NasNet Mobile and DenseNet121 results is good than MobileNetV2 .

NasNet performs much faster than DenseNet121, And the model size of NasNet is lighter than DenseNet121. That NasNet Mobile is more suited for application compared to DenseNet121.

# Analysis and Design

## 3.1 System Overview

### 3.1.1 System Architecture

Diagram, shape

Description automatically generated with medium confidence

Figure 12 our Architecture

### Preprocessing:

In data preprocessing, the main objective was to convert the ground truth that we generate into density maps. The generated image provided a sparse matrix consisting of the head annotations in that image. This sparse matrix was converted into a 2D density map by passing through a Gaussian Filter. The sum of all the cells in the density map results in the actual count of people in that particular image.

### Counting:

In this phase we take the preprocessed image and apply the SDC-Net to count the number of people, and return the image added to it the count of people labeled on the image.

### Face Detection:

In this phase we take the image and apply the Retina Face to detect the faces of people, and return image with only cropped faces.

### Mask Classification:

load image that has only face cropped by past phase. we apply face detection to compute the bounding box location of the face in the image, classifying each face as with mask or without mask by NasNet model then add boundary box colored red or green depending on mask class.

### 3.1.2 System Users

1. *Intended Users:* To any institute need to keep track of people count and whether they wear facemasks or not.
2. *User Characteristics*

Have basic computer skills to add the image to application, it is user friendly so any institution worker can use it easily.

## 3.2 System Analysis & Design

### 3.2.1 Use Case Diagram

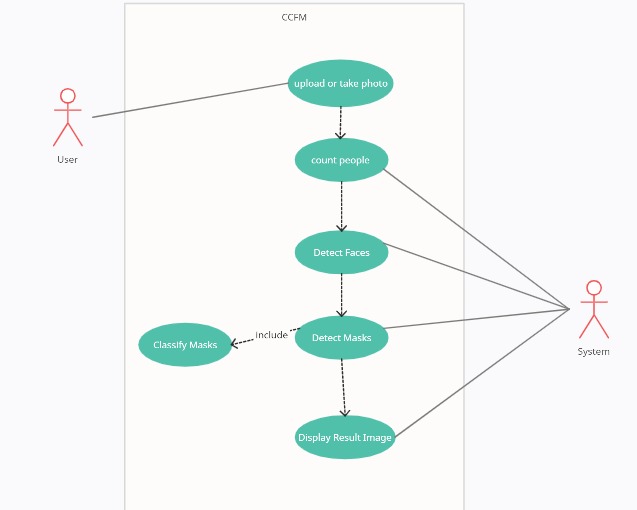


Figure 13 UseCase Diagram

Table 10 UseCase Description

|  |  |
| --- | --- |
| Case | Description |
| Upload or take Photo | user upload photo or capture image from camera |
| Count people | System count how many person in photo |
| Detect Faces | System detect faces from photo in boundary box |
| Detect Masks | System detect mask on faces |
| Classify Masks | System classify wear mask or not |
| Display Result image | System Show photo with number of people and faces wear mask with green bounding boxes and another with red bounding boxes |

### 3.2.2 Sequence DiagramChart Description automatically generated

Figure 14 Sequence Diagram For Counting Function

### Chart, box and whisker chart Description automatically generated

Figure 15 Sequence Diagram of Detect Face Function

### 

Figure 16 Sequence Diagram For Detect Mask

# Implementation and Testing

**1-Datasets:**

1. Crowd Counting Datasets

i-The ShanghaiTech

it is crowd counting dataset [14] is consisted of two parts: Part A and Part B. Part A includes 300 images for training and 182 for testing. This part represents highly congested scenes. Part B contains 716 images in relatively sparse scenes, where 400 images are used for training and 316 for testing as shown in figures 17,20 Part-A were collected from the Internet, while images from Part-B were collected on the busy streets of Shanghai.

**Part A:**

Chart, pie chart

Description automatically generated

Figure 17 Shanghai-Part A

Sample :

A picture containing person, tree, outdoor, people

Description automatically generatedA large crowd of people

Description automatically generated with medium confidence

Figure 19 sample of Shanghai Part A

Figure 18 sample of Shanghai Part A

**Part B:**

Chart, pie chart

Description automatically generated

Figure 20 Shanghai Part-B

Sample:

A group of people walking on a sidewalk

Description automatically generated with low confidenceA group of people sitting on the grass

Description automatically generated with medium confidence

Figure 21 Sample of Shanghai Part-B

Figure 21 Sample of Shanghai Part-B

Figure Sample of Shanghai Part-B

ii-UCF-QNRF

It is a large crowd counting dataset with 1535 high-resolution images and 1.25 million head annotations. There are 1201 training images and 334 test images as displayed in figure 23 a pie chart for the division of train and test Images. It contains extremely congested scenes where the maximum count of an image can

reach 12865.[15]

Chart, pie chart

Description automatically generated

Figure 23 UCF-QNRF dataset

Sample:

A picture containing text, person, different, people

Description automatically generated

Figure 24 Sample of QNRF dataset

2-Mask Datasets:

i- MaskDetection Dataset(sidgan22)[16]:

Face Mask Detection Dataset 3833 Images, This dataset is obtained by Labeled Faces dataset. dataset consists of famous people images that are collected from the website. The data was split in train model by 80% training and 20% testing that show in figure.

Chart, pie chart

Description automatically generated

Figure 25 MaskDetection Dataset(sidgan22):

Sample:

A person wearing a mask

Description automatically generated with medium confidence

A person smiling for the camera

Description automatically generated with medium confidence

Figure 27 Sample MaskDetection Dataset Figure 26 Sample MaskDetection Dataset

ii- Face Mask Detection - Kaggle (OMKAR GURAV, 2020)[17]:

This dataset, it is possible to create a model to detect people wearing masks, not wearing them or wearing masks improperly. This dataset contains 853 images belonging to the 3 classes. The classes are: With mask , Without mask , mask worn incorrectly.The figure represent data in train model by 80% training and 20% testing.

Chart, pie chart

Description automatically generated

Figure 28 Face Mask Detection (OMKAR GURAV)

Sample:

A group of people smiling

Description automatically generated with low confidence



Figure 30 Sample Mask Detection (OMKAR GURAV) Figure 29 sample Mask Detection (OMKAR GURAV)

**2-Description of Application phases:**

1-Preprocessing Functions:

Referring to figure 31 the preprocessing operation in the training phase is split into two main functions generating the ground truth and generating density maps.

* Generate the ground truth:

The main of this function is generating Ground truth Using MATLAB for those datasets that do not provide ground truth with its images, which use with its turn to generate a density map, by:

Selecting each head in the image to make a sparse matrix of annotated heads.

Then save this matrix as (.mat) format to use it later.

* Generate the density maps:

the main objective was to convert the ground truth (that Provided with the dataset or we generate it) into density maps.

In a provided image’s ground truth, a sparse matrix consisting of the head annotations in that image.

This sparse matrix was converted into a 2D density map by passing through a Gaussian Filter.

Build a kdtree which is a data structure that allows fast computation of K Nearest neighbors of the head annotations.

Find the average distances for each head with K (in this case 4) nearest heads in the head annotations.

Multiply this value by a (factor, 0.3 as suggested by the author of the paper.)

Put this value as sigma and convolve using the 2D Gaussian filter.

The sum of all the cells in the density map results in the actual count of people in that.

That’s because, we have unlabeled data so we use density mas a Target Count to compare it With a predicted count in training phase.

Diagram

Description automatically generated

Figure Preprocessing Flowchart

Figure 22 Preprocessing Flowchart

2-Counting

In the Counting function, as seen in figure 32 we receive the preprocessed image and send it to the SDC-net model. that uses standard SGD for the training. The encoder in SDC-net is directly adopted from convolutional

layers of VGG16 [18], that is a convolutional neural network model pretrained on ImageNet

the first stage is that SDC executes on the generated feature map that is divided and sent to the shared classifier to produce the division count, this classifier fetches the local features that correspond to spatially divided sub-regions, and predicts the first-level division counts, we keep dividing the feature map until reaching the output of the first convolutional block.

The division of the feature map is based on idea of considering the length of map as intervals and each 0.05 of interval is considered to be a partition so using this small partitions to count help to minimize the issue of repeatedly count same person more than one time in different partitions, otherwise by using more than 0.05 of interval falsely count people to much higher numbers.

Then we do evaluation to count in each sub region and sum them all to generate the total count of the image.

Finally, we add this count to the input image as label in the upper part of it.

A screenshot of a computer

Description automatically generated with low confidence

Figure Counting Flowchart

3-Face Detection

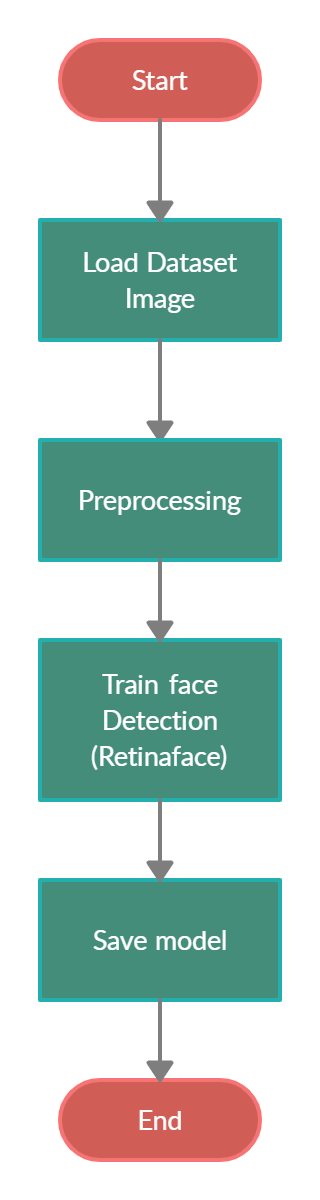


Figure 34Train Face Detection

Generate and train Retinaface model :

In train phase we detect face region from image. To extract face region we normalize the intensity of the image , then extract skin region and remove all the noisy data from image region. We now find skin color blocks from the image and then check face criterions of the image.

Height and width ratio is computed and minimal face dimension constraint is implemented. Crop the current region ,existence and localization of mouth then compute vertical mouth histogram.

4-Mask Detection

A picture containing text, sign, mounted

Description automatically generated

Figure 35 Train Mask Model Flowchart

Data Preprocessing in mask detection: applied to all the input images to convert them into specific versions, which could be fed to a neural network model.

1.Resizing the input image (224 x 224)  
2. Numpy array encoding a batch of images by nasnet.preprocess\_input  
3.one hot Encoding Labels “mask\_off” , “mask\_on”

Generate and train NasNet model :

In this model don’t include the fully-connected layer at the top of the network, used ImageNet For loading ImageNet weights, and used Average Pooling by size 7 X 7 that global average pooling will be applied to the output of the last convolutional layer, and thus the output of the model will be a 2D tensor.

Dropout by 0.5 ,its a regularization technique hat drops a unitat training time with a specified probability the neural network becomes too reliant on particular connections, as this could be symptomatic of overfitting

Apply ReLU activation function, and The final layer softmax function gives the result of two probabilities each one represents the classification of “mask” or “not mask”.The weights of each layer in the model are predefined based on the dataset.

Diagram

Description automatically generated

Figure 36 Mask Model FlowchA picture containing text, mounted, sign, gauge

Description automatically generatedart

Diagram

Description automatically generated5-The Whole Application

Figure Application flowchart

# 3-Results

# 1-Results of counting model:

The following graph show the results when training the SDC-net model on different datasets shanghai Part A,Part B and UCF-QNRF, we notice that Shanghai Part B gives the smallest mean square error of 50.6 relative to the other to datasets shanghai part A gives 100 and UCF-QNRF gives 195.3 .

Chart, bar chart

Description automatically generated

Figure 33 MSE of Counting

**2-results of mask model**

In this table show result of train NasNet model ,Precision That  ratio of correctly masked on to the total predicted of mask on test data is 1 that mean model can detect right all people wear masks in tested data , but in recall ratio of correctly masked on to the total predicted of all test data is 0.99 % and 0.01% false predicted as mask off.

accuracy performance after get average of Precision and recall get total accuracy 99%

|  |  |  |  |
| --- | --- | --- | --- |
|  | precision | recall | F1-score |
| Mask\_off | 0.99 | 1.00 | 0.99 |
| Mask\_on | 1.00 | 0.99 | 0.99 |
| accuracy |  |  | 0.99 |

Table 12 : Result of Nasnet Model

# 5-User Manual

* Before Running the Program the user's PC should Contain Pycharm and MATLAB then install all needed packages which are :

1. tkinter
2. pillow
3. cv2
4. python==3.6.2
5. pytorch>=0.4.0
6. numpy==1.14.0
7. scikit-image==0.13.1
8. scipy==1.0.0
9. pandas==0.22.0
10. h5py
11. tensorflow 2.5.0
12. retina-face

* After the user make sure that all packages are installed successfully, he needs to open the MATLAB program in the Background.
* After that run the program, the following window will appear as

shown in next Figure 36.

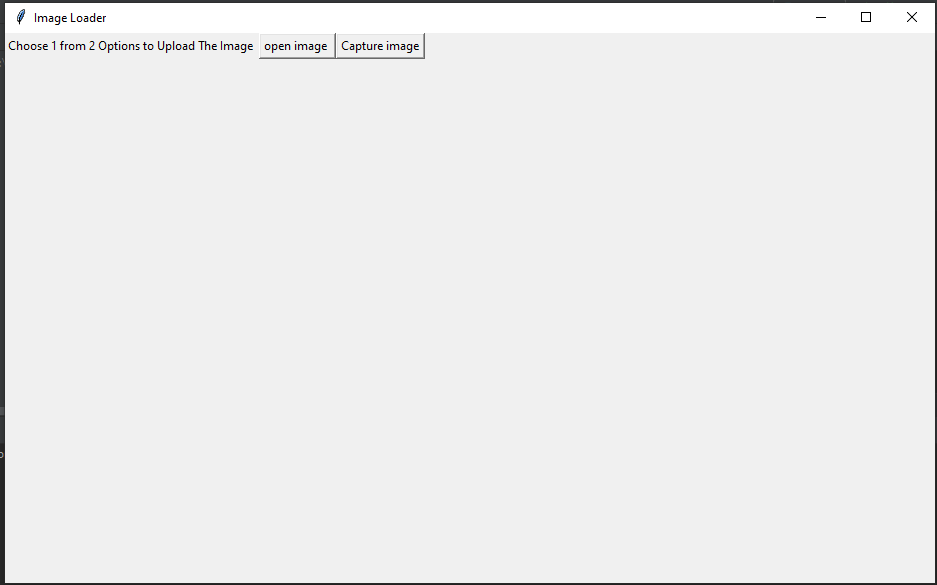


Figure 38 Start Window

* Uploading Image

1. Click on the open image button to browse the images as shown in Figure 37, and select the image that you want to know the number of people on it and detect wether wearing a mask or not and know if the mask was worn correctly or not, then press open.

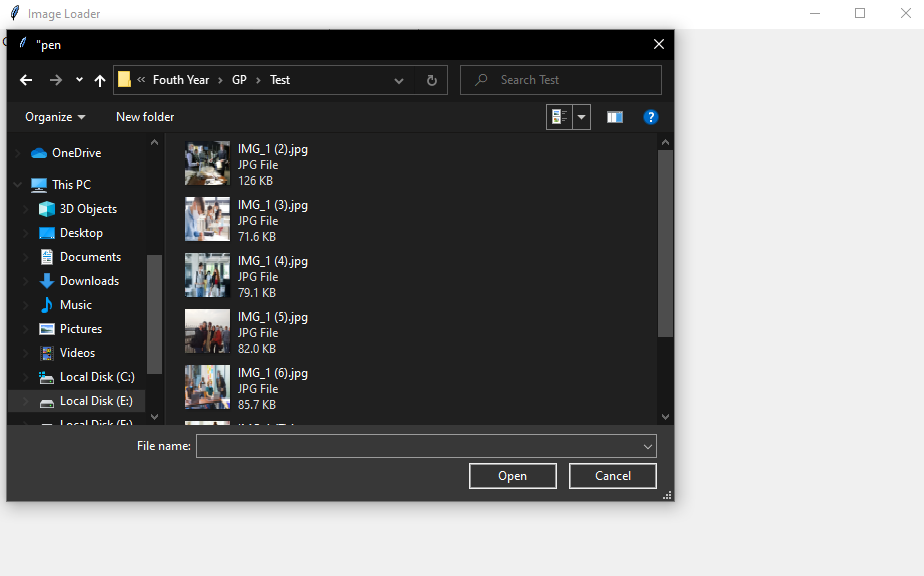


Figure 39

1. A Window Contain selected image will be opened as shown in Figure 38, the user just needs to double-click on the middle of this image ,after that it will close by itself after this click.

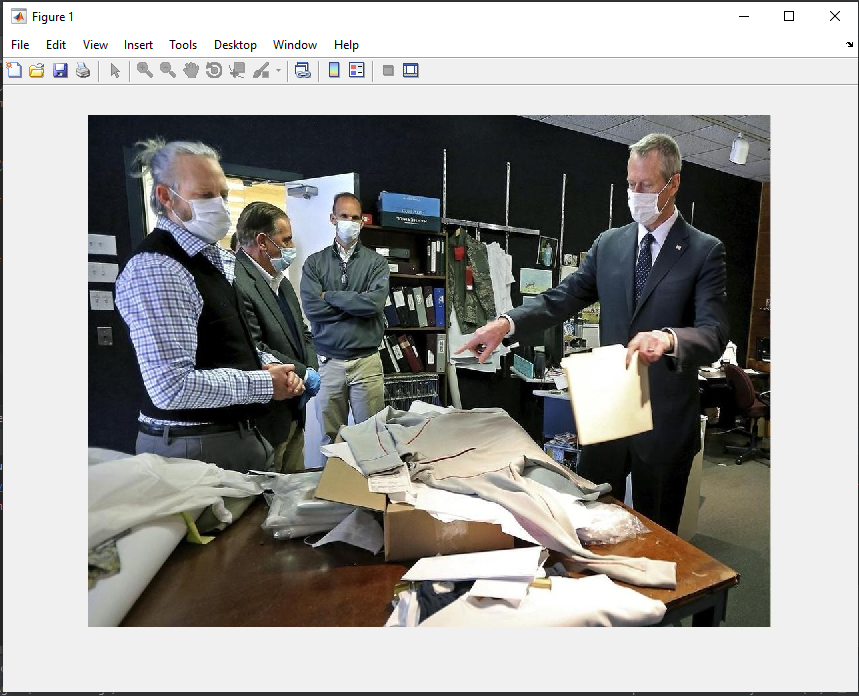


Figure 40

1. After a few seconds the user will find the input image appear on left side of the start window and a result image appear on the right side as shown in Figure 39.

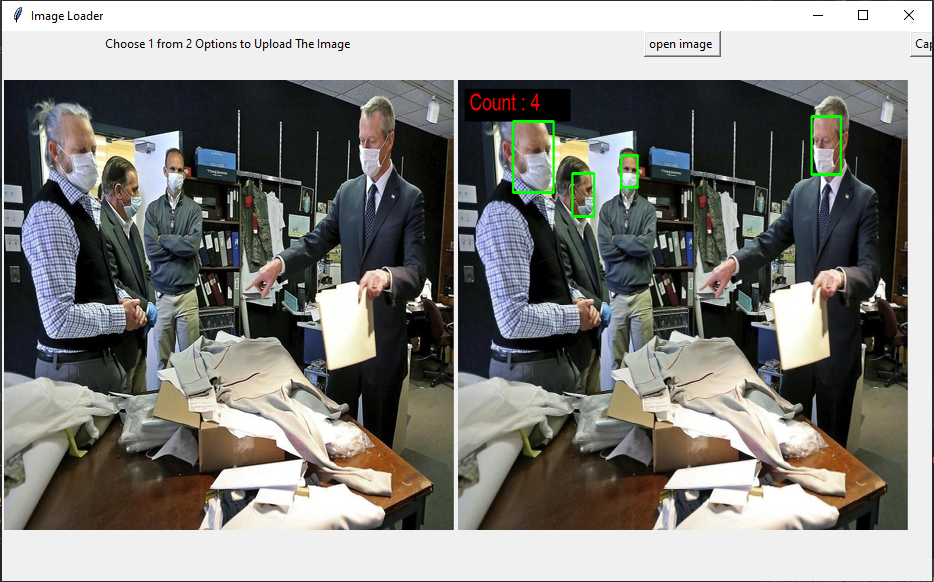


Figure 41

* Capturing image:

Click on the Capture Image button as shown in Figure 36, and

then press the (s button) to capture and save the image you want to know the number of people on it and detect if wearing a mask or not and know if the mask was worn correctly or not then repeat steps of Uploading Image Starting From Step 2.

# 6- Conclusion and Future Work

## 6.1 Conclusion

In this project, a two-stage Face Mask Detector and Crowed counting is implemented.

The First stage Crowed counting

Using SDC-net model for doing crowd counting that is model learned in closed set and can be generalized to open set. It first generate the ground truth of input image then the density map, the do feature extraction by VGG16 model the divide the maps to count each part separately then evaluate the count for all parts then we append this counter to input image.

The second stage uses a pretrained Retina Face model for face detection.

Then training Face Mask Classifier models trying NasNet Mobile and MobileNetV2 on dataset and based on performance, the NasNet model was selected for classifying faces as masked or non-masked with accuracy 99%.

The Crowd counting model is trained and tested using ShanghaiTech Part A , Part B datasets and UCF-QNRF dataset which contain extremely congested scenes more dense than images in Shanghaitech datasets, these are the most famous datasets for crowed counting.

Mask model is trained and tested using [16] and [17] datasets which contain various image of masks and image for person who wear mask in correct .

The result of crowd counting phase is input image but added to it label with count of number of people within it but this is not the final result as the other phase of mask detection also display result as image with boundary boxes on each face with red color if worn incorrectly and green one if worn correctly, so final result is image with merged results of both phases.

## 6.2 Future Work

The project performance can be improved by adding new helpful features that would help in the improvement of the software to be more supportive, useful and cooperative.

The feature that would cooperate in improving the project performance to the best are:

* making an alert when person is not wearing mask.
* User can add specific count for the room and alert will be fired when count exceeds this specific limit.
* make the model compatible with web application based and android.
* make a new classification for person who wear mask incorrectly with new boundary box color.

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