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Crowd Management System

(Implementing Face Mask Detector and Real time Human Counter Using Computer Vision)

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Abstract **- The recent covid-19 virus has raised an alarming demand for crowd analytics and crowd management according to different situations and tackle the threats related to them, and it can be done with the help of modern technology. This paper is intended to explore how computer vision help to manage a number of people and develop a solution that suggests the required restriction on them. These pre-cautious steps can save a large number of resources.**

1. INTRODUCTION

A large number of people lose their lives every year because of the poor organzation of crowded events. Recently thousands of people have lost their lives due to overcrowding and mismanagement of the crowd. Overcrowding can be controlleid and managed, and hence catastrophes can be obstructed, by applying efficient crowd management techniques using modern technology [1]. The recent spread of many diseases like swine flu, and the major issue of the current situation of covid-19, and ongoing security issues have made the management of crowded events more critical than ever before. Managing a large number of people is a very complex, challenging, and costly exercise. Crowd phenomena related to mass events are mostly observed in urban areas, which attract even hundreds of thousands of people in addition to normal local inhabitants. Pedestrian and crowd modeling research context regards events in which a large number of people may be gathered or bound to move in a limited area it can lead to serious safety issues for the participants. This project aims to provide a set of tools that could be used and applied to the events for crowd management.

2. PROBLEM STATEMENT

As shown in the introduction part, overcrowding can be contained and managed, and hence catastrophes can be prevented, by efficient crowd management using modern technology. So, the objective of this project is to provide a set of tools that could provide ease and help in the process of management of the crowd. As part of the solution, our project aims to provide a set of tools using computer vision that could help in crowd management.

These tools will be used to manage the people in the crowd by detecting, counting, and tracking methods in which we will try to count the number of people in a particular region and restrict the total number of people in that region.

As a solution to the problem statement, the project aims to develop two basic modules for the prevention of the spread of the covid-19 virus which helps to implement the general guidelines suggested by major health organizations. The two modules are as follows:

a. Face Mask Detector.
b. Real-time Human Counter

The Face Mask detector will help different event organizers to keep track of the people whether they are following the guidelines and wearing the masks or not with the help of a CCTV camera on the entrance of the event premises. Based on the status of persons wearing or not wearing the face mask they could be restricted to enter the event premises and the entry is only allowed for the people wearing the face mask. In this module, the basic idea is to use the concept of face recognition and to modify and train it to detect faces with face masks with the help of CCTV cameras.

The other module, Real-time human counter aims to develop a solution that works based on object detection and tracking. It will count the number of people passing through a specified boundary and based on that it would count the number of people who entered the left the premises and according to it keep track of the total number of people present in the premises.

3. RELATED WORK

In the meantime, there were many different solutions were proposed to deal with the issue of covid-19.

A Face Mask detector called "The RetinaFaceMask " was introduced, which is a very high-accuracy and efficient face mask detector. The RetinaFaceMask used a one-stage detector, consisting of a feature pyramid network to fuse high-level semantic information with multiple feature maps, and a novel context attention module to focus on detecting face masks [2]. It applies the Region-based Convolutional neural network (R-CNN) for the detection of face masks. Experimental results show that RetinaFaceMask achieved state-of-the-art results on the public face mask dataset with 2.3% and 1.5% higher than the baseline result in the face and mask detection precision, and 11.0% and 5.9% higher than baseline for recall.

4. PROPOSED METHODOLOGY

The proposed methodology for each of the modules are discussed below:

4.1 Libraries Used

Most of the project solution is developed with python, some specific libraries which were used to ease the development task are:

- Python OpenCV
- C++ Dlib
- Tensorflow
- Keras
- numpy
- Scikit-learn

4.2 Face Mask Detector

The module for the face mask detector has been divided into two phases.

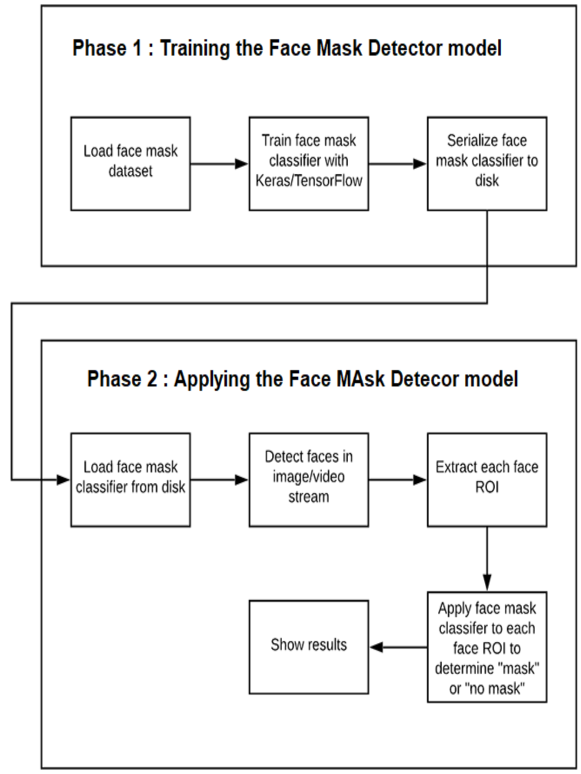

Figure 1. Face Mask Detector Module structure.

The first phase is focused on training a custom deep learning model to detect whether any person is wearing or not wearing a face mask with the help of our custom face mask detection dataset. The face mask detector model is trained with the help of a Convolutional neural network by using the tensorflow library, In this project, we have applied the concept of transfer learning i.e rather than training a complete fully connected CNN, a pre-trained classification model is used in this project a lightweight pre-trained model known as MobileNet is used, and it is modified by changing the output head with a custom fully connect head, this reduces the training time and cost and helps to achieve the required goal.

The second phase of this module focuses on applying the trained model in the previous phase. In this phase a very important task is to detect the faces in the input image/video stream on the basis of object/face detection technique. The different face detection techniques are as follows:

a. Haarcascading frontal face detector.
b. Dlib HOG based Frontal face detector.
c. Multi-Task Cascaded Convolutional Neural Networks(MTCNN)
d. Opencv DNN Face detector.

Table 1 . General frame rate observation for face detection techniques.

Face detection technique	Frame Rate
Haarcascades	9.25 fps
Dlib	5.41 fps
MTCNN	7.92 fps
DNN of opencv	12.95 fps

By comparing different face detection techniques based on frame rate, accuracy for face detection, etc., it was observed that OpenCV's DNN is the best fit for the specified role. Once a face is detected by using the deep neural network of the further OpenCV functions are used on the selected ROI (Region of interest) of the image and the other parts of the image are discarded.
The model trained in phase 1 is applied on the selected ROI of the face and the basis of the output from the model the user is provided an alert if the face is not detected with a face mask or its status as face mask detected and the person is allowed.

4.3 Transfer Learning

Transfer Learning is defined as a machine learning approach in which a model developed in past for some different tasks is reused as the starting point for a model on a second task. The deep learning neural systems and models are used as layered architecture that learns different features related to a given task at different layers. These layers are then connected to the last layer to get the final output. The idea behind the concept of transfer learning is to use the outputs of one or more layers of a deep neural network that is trained on a different task as a generic feature detector. The layered architecture of a neural network provides a way to utilize any pre-trained network by modifying the final layer for another task.

The figure 2. shows that how some final layers of a pre-trained model could be reused, the weights of certain layers which are used for detecting the generic features are kept unchanged or freezed and fine tuning of the rest of the modified layers is done.

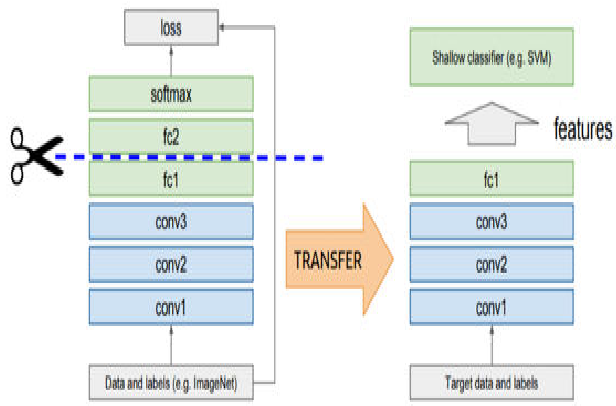

Figure 2. Transfer Learning with Pre-trained Deep Learning Models as Feature Extractors

Figure 3. shows a Convolutional layered architecture comparison between a pre-trained neural network and how it has been modified by replacing the final layers with customized final layers to provide corresponding output.

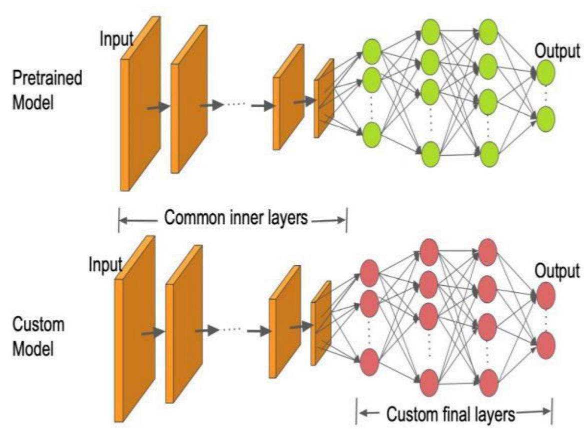

Figure 3. Example for custom model tarining using pre-trained model.

4.4 Real-time Human Counter

The Real-time human counter uses the concept of object detection and object tracking. While using object detection actually the position of an is detected in an image/frame, it is also computationally more expensive i.e slower as compared to object tracking.

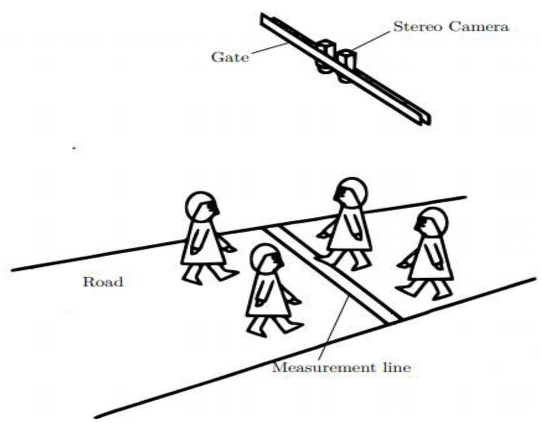

Figure 4. Real-time human counter implementation idea

The idea is to apply the concept of object detection and tracking with the help of CCTV cameras at different angles.

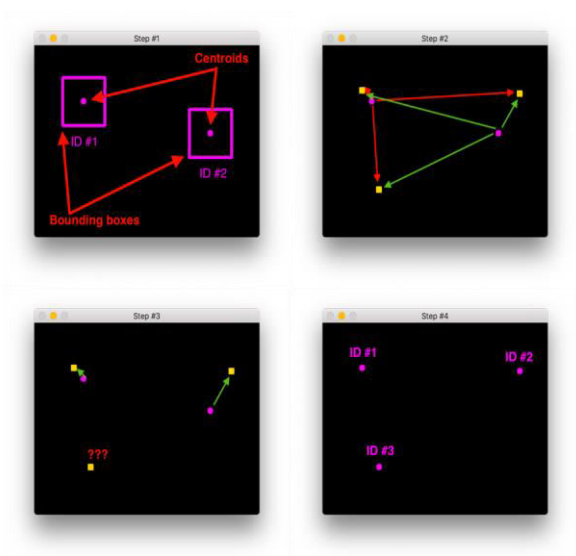

Figure 5. Steps for object tracking

It will accept the input coordinates of an object in an image and assign a unique ID to that object and then track the object's location in further frames.

In the first phase, we detect the object by using OpenCV SSDs, then accept a set of bounding boxes and compute centroids corresponding to each object by using the concept of Euclidean distances. Once the object is detected based on the detected object's centroid IDs are assigned to each object.

In the second phase, a decision boundary is declared on the frame according to the location requirement, and the object's ID and location of its centroid in the previous frames are analyzed on the basis of its location around the decision boundary. If it is found that an object had crossed the decision boundary the total count of the counter is adjusted according to and on the basis of total count we could keep track of the total number of people in a region.

To perform the task of object tracking the concept of correlation tracking is used. [3] The idea of area correlation tracking is an effective technique for tracking targets that have neither prominent features nor have high contrast with the background and the 'target' can even be an area or a scene of interest. Even using the technique is robust under varying conditions of target background and light conditions. It has some problems like target drift and false registration. When the tracker or target is moving, the registration point drifts due to the discrete pixel size and aspect angle change.

For correlation tracking, the correlation tracker of Dlib. The Dlib is an open-source C++ library that implements a variety of machine learning algorithms, including classification, regression, clustering, data transformation, and structured prediction. It also supports functionalities like threading and networking.

5. CONCLUSION

It is well said that Modern technology aims not only to make people's life easier but also safer. To ensure the safety of people in public places the developed solution known as the crowd management system the models developed for the face mask detector was able to classify faces wearing or not wearing a mask with very good accuracy and the real-time human counter plays a very major role to keep track of the movement of the crowd at specified public areas. And the real-time human counter provided a way to effectively deal with the task of keeping track of the crowd and managing it. In the below figure, it is shown that the different guidelines

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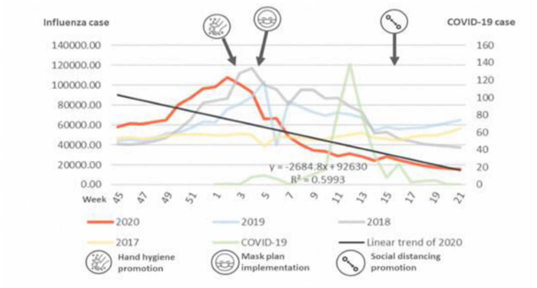

Figure 6. incidences of influenza in 2017-2020. COVID-19: coronavirus disease.

play a very important role to restrict the spread of the covid-19 virus after their implementations.The solution provided in the project gives an alternative to implement these guidelines and ensure the safety of the public to some extent.

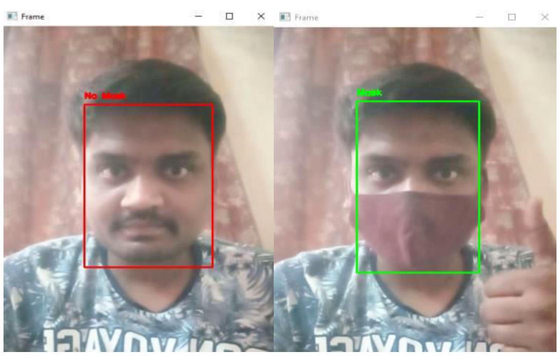

Figure 7 . output of face-mask detector

The above figure shows the output of the face-mask detector, and it is clear how efficiently it is able to classify the faces with or without face-mask and generate alerts if a face is found without wearing a face mask.

Figure 8. output of human detector

Figure 8. shows the output of the people counter and it is clearly shown in the figure that how people counter is increased when a person moves down the prediction border or specifically the entrance. The human counter module is based on the concept of object detection and object tracking. It uses the more computationally expensive part that is the human detection and assigning an id to each object in the frame, and then it runs the computationally less expensive task to detect the location or the specific coordinates of that object with respect to the prediction border and on the basis of that the total human counter is increased and decreased vice-versa.

The solution also has some limitations as the solution only provides a software implementation which is built focusing on developing awareness among the people to follow the suggestions given health organizations, and it provides alerts and insights for the effective management of the crowd but to implement it the proposed solution should be used in combination with different IOT based hardware to implement restrictions.

As the future advances, more modules that may be beneficial for the effective management of the crowd like social distancing monitoring, crowd behavior analysis based on crowd density and its movement are suggested as an addition to the current solution.

6. REFERENCES

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