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Intelligent Social Distancing Enforcement: A YOLOv3-Based Framework for Health Security

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Abstract

During the COVID-19 pandemic, individuals encountered numerous challenges due to the swift spread of the virus. Effective implementation of social distancing is crucial in halting the transmission of airborne, touch-based, and close-contact diseases such as Chickenpox, Influenza, Pertussis (whooping cough), and Respiratory Syncytial Virus (RSV), among others. Regrettably, many individuals are not adhering to these prescribed norms. This study aims to address the issue by introducing a system for close contact detection and assessing the proximity between individuals to mitigate the impact of contagious diseases. Our framework utilizes the YOLOv3 algorithm for human identification in video sequences, extracting information from detected bounding boxes. The pairwise distances are computed using the Euclidean distance formula. A tracking algorithm is then employed to monitor individuals throughout the video sequence. In gauging compliance with social distancing guidelines, we set a threshold for detecting violations and evaluating whether the distance between individuals falls below the minimum prescribed social distance. Additionally, a mailer function is being implemented to notify authorized personnel if any violations of social distancing norms occur, subject to certain predefined conditions being met.

***Keywords*:** Pedestrian detection, YOLOv3, alerts, Euclidean formula

1. Introduction

Coronavirus disease is an infectious disease which is caused by the SARS-COV-2 virus. The ongoing COVID-19 pandemic has inflicted a severe crisis due to its rapid and deadly spread. The major symptoms of COVID-19 disease are fever, dry cough, backpain, headache, runny nose, itchy throat. Nasal congestion, runny nose, diarrhoea, and other symptoms of the upper respiratory tract and digestive system are present in a small percentage of individuals. After a week, severe patients frequently experience respiratory problems, and they quickly advance to irreversible metabolic acidosis, coagulation malfunction, and multiple organ failure. Older people and those with basic medical conditions like heart disease, diabetes, respiratory disease or lung infection, cancer are majorly effected by corona virus disease. Most probably, anyone can get sick with COVID-19 and become seriously ill or die at any age. The virus can spread easily from an infected person's mouth or nose in the form of small liquid particles when they cough, sneeze, speak or sing. Moreover this can be spread while taking breathe too. The particles can be tiny aerosols or bigger respiratory droplets. The best way to prevent and slow down the transmission is by having awareness about the disease and how the virus spread. Protect yourself and others from infection by staying at least 1 metre apart from others, wearing a properly fitted mask, and washing your hands or using an alcohol-based sanitizer frequently.

Despite the existence of a vaccine for this disease, the number of infected individuals continues to rise. This persistent increase can be attributed to various variants, including Alpha, Beta, Gamma, and the recently discovered Omicron, each exhibiting distinct symptoms. The dynamic nature of these variants makes it challenging to anticipate the behaviour of the disease. Furthermore, subvariants such as BA.2 and BA.5 have

emerged, and a novel subvariant named JN.1 has been identified within the Omicron family. JN.1 differs from its counterparts with a singular mutation in the spike protein compared to Pirola. In response to these developments, the Union Health Ministry in India has called upon states to enhance their COVID surveillance efforts to curb the spread of the virus.

2. Literature Review

The current COVID 19 halo infection has caused a severe catastrophe with its deadly spread. Despite the implementation of the vaccine, the severity of the infection has not diminished, and it has become stronger and more destructive. So, the only solution to protect ourselves from infection is social-distancing [1]. Social Distancing is the best possible way to detain the spread of Covid-19. Even though vaccine has been found and working effectively in saving the lives of people, social distancing is necessary to reduce the spread of virus to maximum extent which not only saves people from being infected but also reduces the impact of spreading of the disease [2]. Since the start of the COVID-19 pandemic, social distancing (SD) has played an essential role in controlling and slowing down the spread of the virus in smart cities. To ensure the respect of SD in public areas, visual SD monitoring (VSDM) provides promising opportunities by (i) controlling and analyzing the physical distance between pedestrians in real-time, (ii) detecting SD violations among the crowds, and (iii) tracking and reporting individuals violating SD norms [3]. One research proposes real-time AI platform for people detection, and social distancing classification of individuals based on thermal camera. YOLOv4-tiny is proposed in this research for object detection. It is a simple neural network architecture, which makes it suitable for low-cost embedded devices. The proposed model is a better option compared to other approaches for real-time detection. An algorithm is also implemented to monitor social distancing using a bird's-eye perspective [4]. Face masks and social distancing were two of the most crucial practices for limiting the spread of novel viruses. With YOLOv5 and a pre-trained framework, we present a novel method of complex mask detection. The primary objective is to detect complex different face masks at higher rates and obtain accuracy of about 94% to 99% on real-time video feeds. The proposed methodology also aims to implement a structure to detect social distance based on a YOLOv5 architecture for controlling, monitoring, accomplishing, and reducing the interaction of physical communication among people in the day-to-day environment [5].

3. Proposed system

Our envisioned system seeks to establish a project that minimizes individual investigations' workforce and time required. The primary objective is to analyze social distancing in public spaces and promptly address individuals who violate these guidelines. The automated nature of this task ensures swift and practical actions.

The central emphasis of our proposed system lies in detecting individuals in videos or images and assessing whether social distancing is being upheld. This is accomplished by applying computer vision and object detection techniques, utilizing OpenCV and the YOLO algorithm

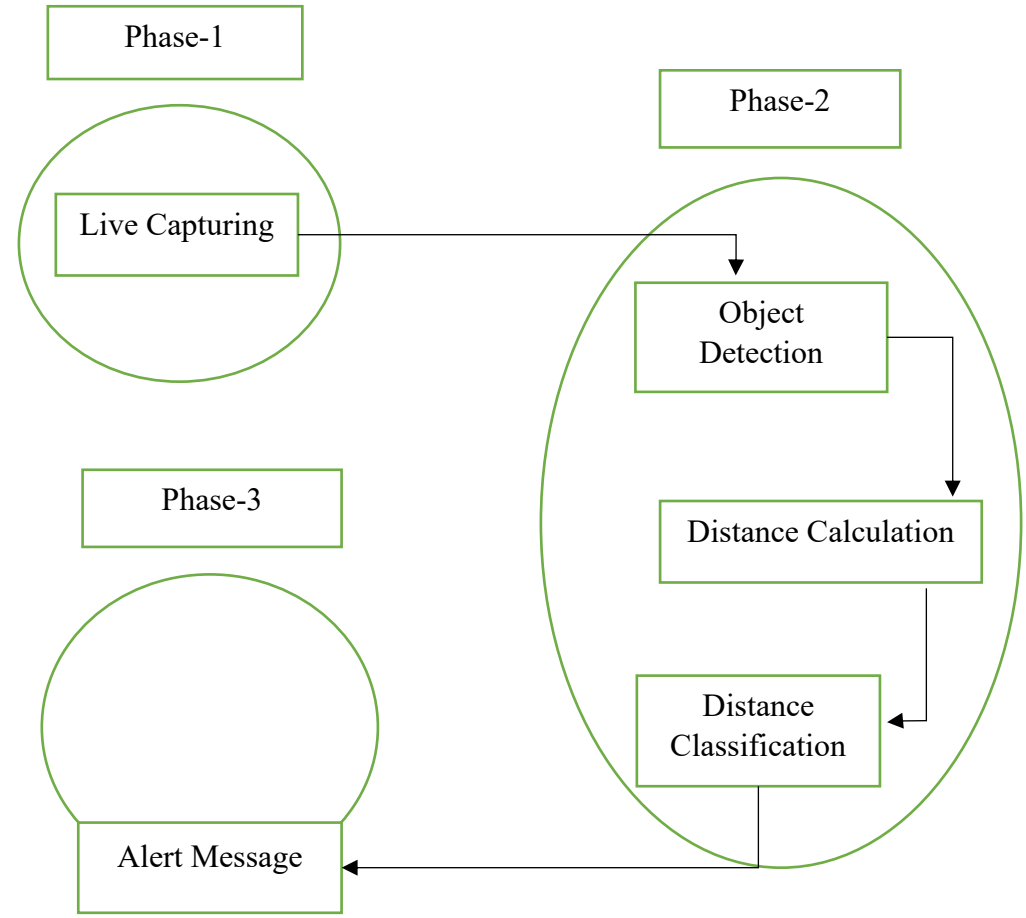

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Figure: Proposed System

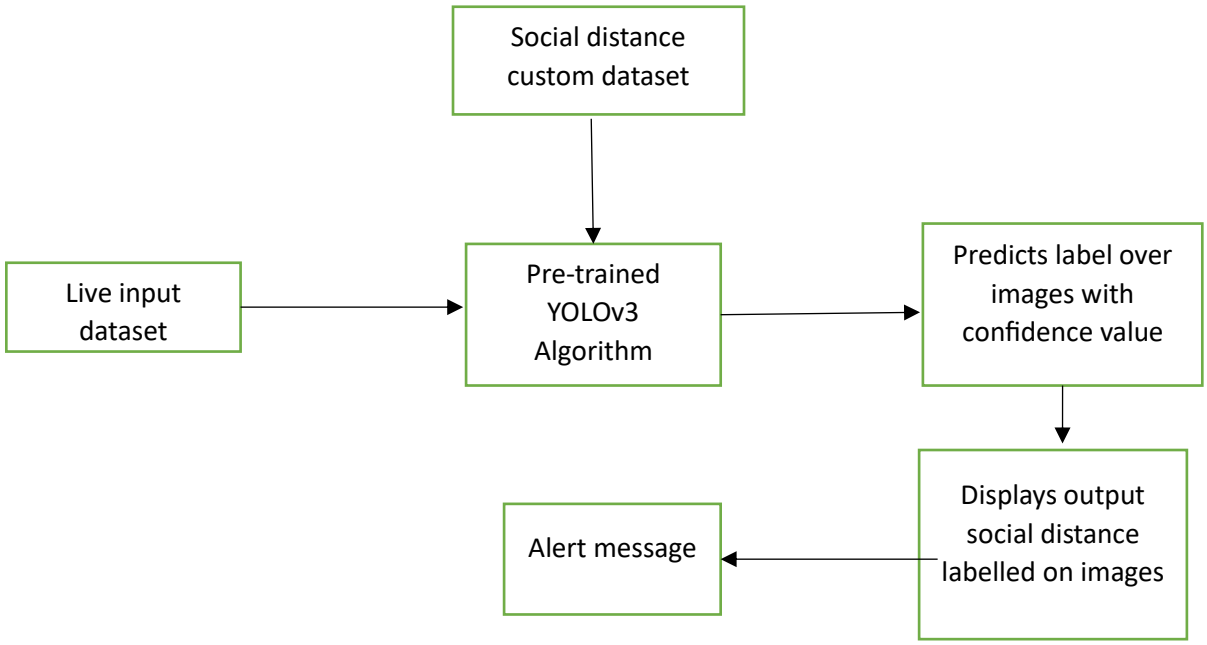

Figure: Architecture for Proposed system

4. Methodology

This section of the paper discusses the Design methodology of the project in a detailed manner of the necessities and working of the project.

The project's backbone is YOLOv3 (Version 3) algorithm YOLO – You Only Look Once. This model recognizes 80 different objects in images and videos, but most importantly it is super- fast and nearly as accurate as Single Shot MultiBox (SDD). The Object detection is tested and trained on COCO dataset, contains 80 different types of classes, out of which persons is the only class we are focusing. In this project the minimum safe distance limit between two people is 50 pixels and maximum safe distance limits between two people is 80 pixels. OpenCV, NumPy, SciPy, and Imutils are some of the libraries used in the project.

A. Live Capturing

The initial step involves feeding the model with image or video data, which is obtained from the Closed Circuit Television (CCTV). The camera is captured at fixed angle as the video frame, the video frame was treated as the perspective view and transformed into a two-dimensional top-down view for accurate estimation of measuring the distance. In this method, it is deduced that the pedestrians in the video frame are walking on the same flat plane. The camera tuning process is carried out with OpenCV. Now the view's transformation is achieved through a measuring function that takes four points within the input image or video frame. Then it maps them to the sides of a rectangular 2D image frame. This transformation makes the distance calculations between individuals easier.

B. Object detection and tracking

When it comes to the detection of pedestrians YOLO model is used. The YOLOv3 algorithm is considered as object detection. This model recognizes 80 different objects in images and videos, and it is very fast and nearly accurate as Single Shot MultiBox (SSD). First it divides the image into 13×13 grid of cells. The size of these 169 cells varies depending on the size of the input. For a 416×416 input size that we used in our experiments, the cell size was 32×32. Each cell is then responsible for predicting a number of bounding boxes in the image. For each bounding box, the network also predicts the confidence that the bounding box actually encloses an object, and the probability of the enclosed object being a particular class. Most of these bounding boxes are eliminated because their confidence is low or because they are enclosing the same object as another bounding box with very high confidence score. This technique is called non maximum suppression. In the given figure (tx, ty, tw, th) are bounding box coordinates. (P1, P2, …, Pc) are object confidence and corresponding class label probabilities. NMS (Non-Maxima Suppression) is also used to reduce overlapping bounding boxes to only a single bounding box, thus representing the true detection of the object. Having overlapping boxes is not exactly practical and ideal, especially if we need to count the number of objects in an image.

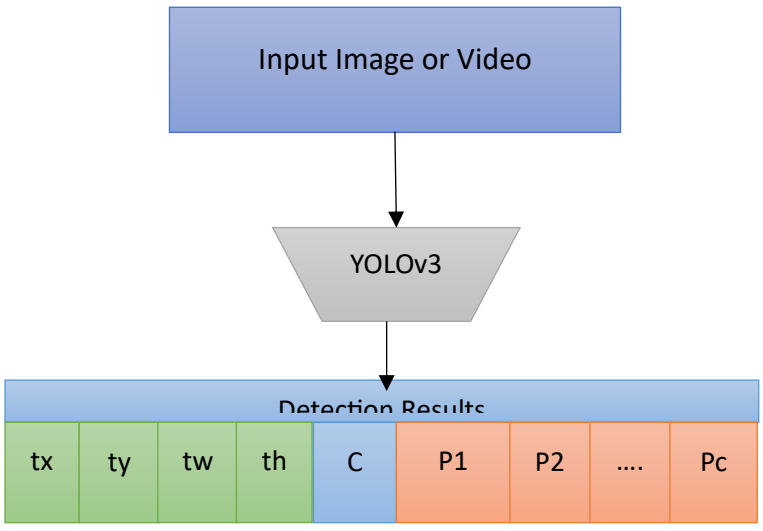

Figure: Pedestrians Detection using YOLOv3

C. Distance calculation

After detecting the persons in the frame supplied as input, the model will detect the pedestrian and draw various bounding boxes on the pedestrian. So several bounding boxes are created around each individual pedestrian. This is prevented by using an algorithm known as Non-maximum suppression (NMS). NMS will consider the box with the best probability of covering that individual, and just one box will be drawn around the person. Once the bounding box is detected then centroid is calculated. Centroid is calculated to get the centre position of all the bounding boxes. After getting the centroid of all the bounding boxes, we calculate the distance between the pedestrians. This distance is calculated by using Euclidean distance formula. This formula considers the two points in two dimensional plane. Let us assume (x_1, y_1) and (x_2, y_2) are the two points

$$d = \sqrt{[x_2 - x_1]^2 + [y_2 - y_1]^2}$$

where,

- (x_1, y_1) are the coordinates of one point.
- (x_2, y_2) are the coordinates of another point.
- d is the distance between (x_1, y_1) and (x_2, y_2).

D. Distance classification

After calculating the distance between two pedestrians we need to classify them by comparing with threshold value. The threshold value here is denoted with 't' pixels. If the distance between the pedestrians is greater then the threshold value t, marked as green, it means there is no violation of social distancing. But if the distance between two pedestrians is less than the threshold value t, then it is marked as red, it means there is a violation of social distancing between the pedestrians.

E. Alert message

After classifying the distance, we get to know the violation pairs. Then a mail is sent to the respective authority at that area using the mailer function. This will make the process easy instead of using the manpower that is manually informing the pedestrians by going to that place. This also reduces the risk of spreading the virus.

F. Flow chart of the Model

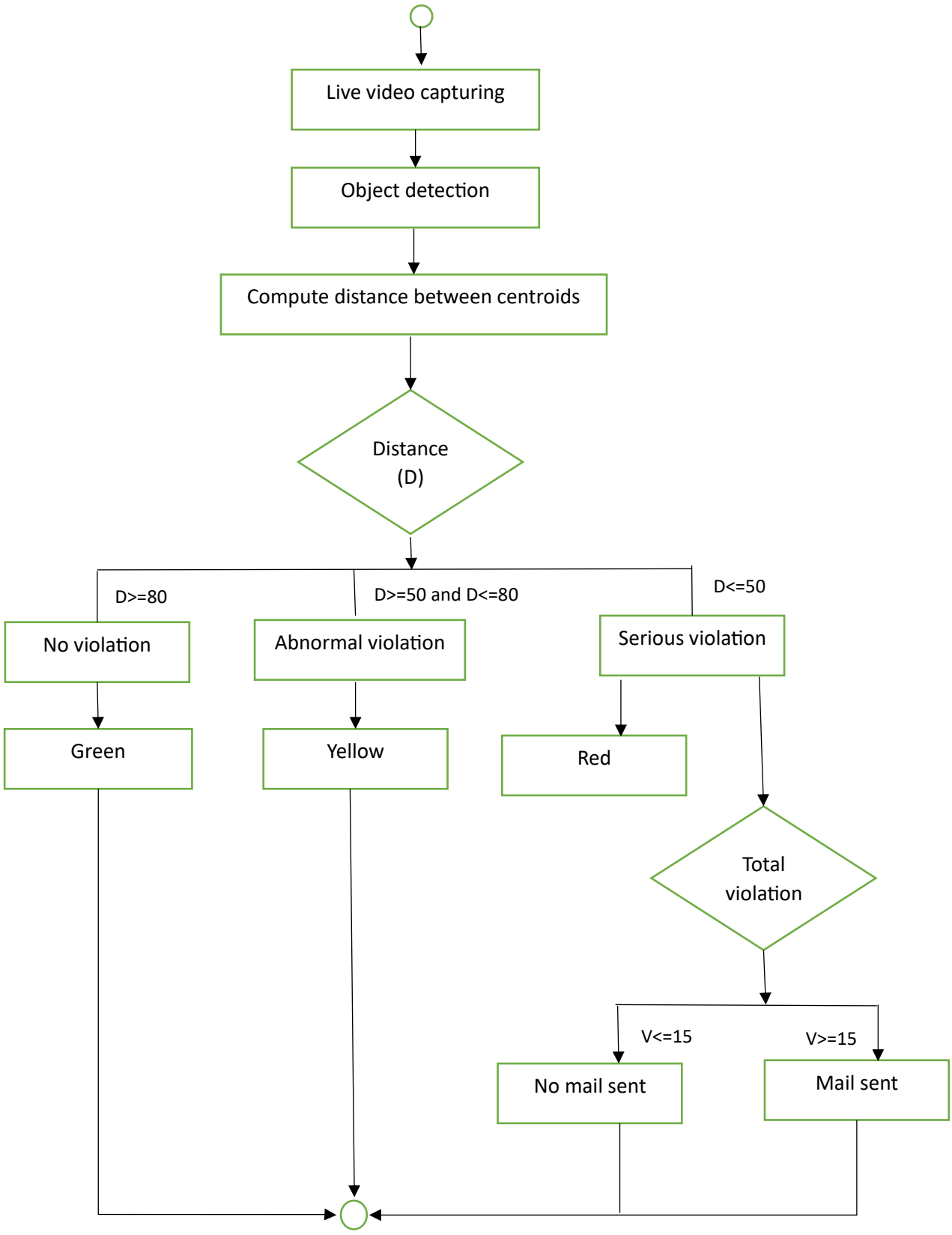

Figure: Flow chart of the model

5. Results and Discussions:

Test cases:

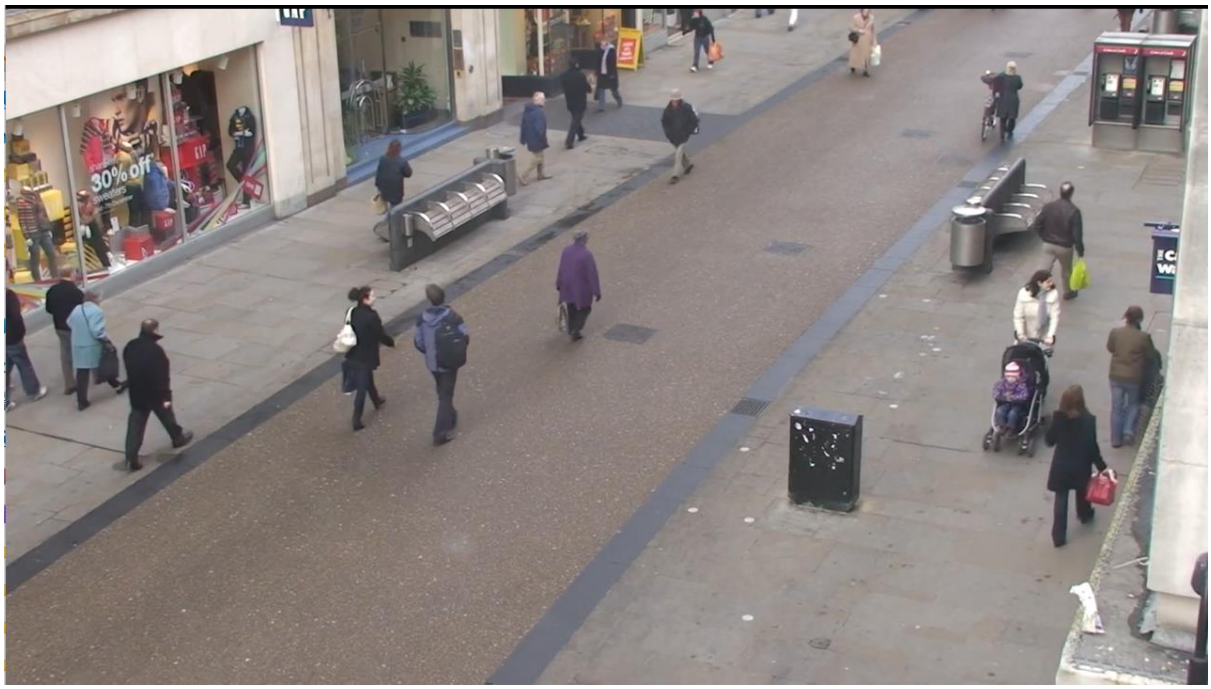

Figure: 5.1 Test case 1 input

Figure: 5.2 Test case 1 output

Figure: 5.3 Test case 2 input

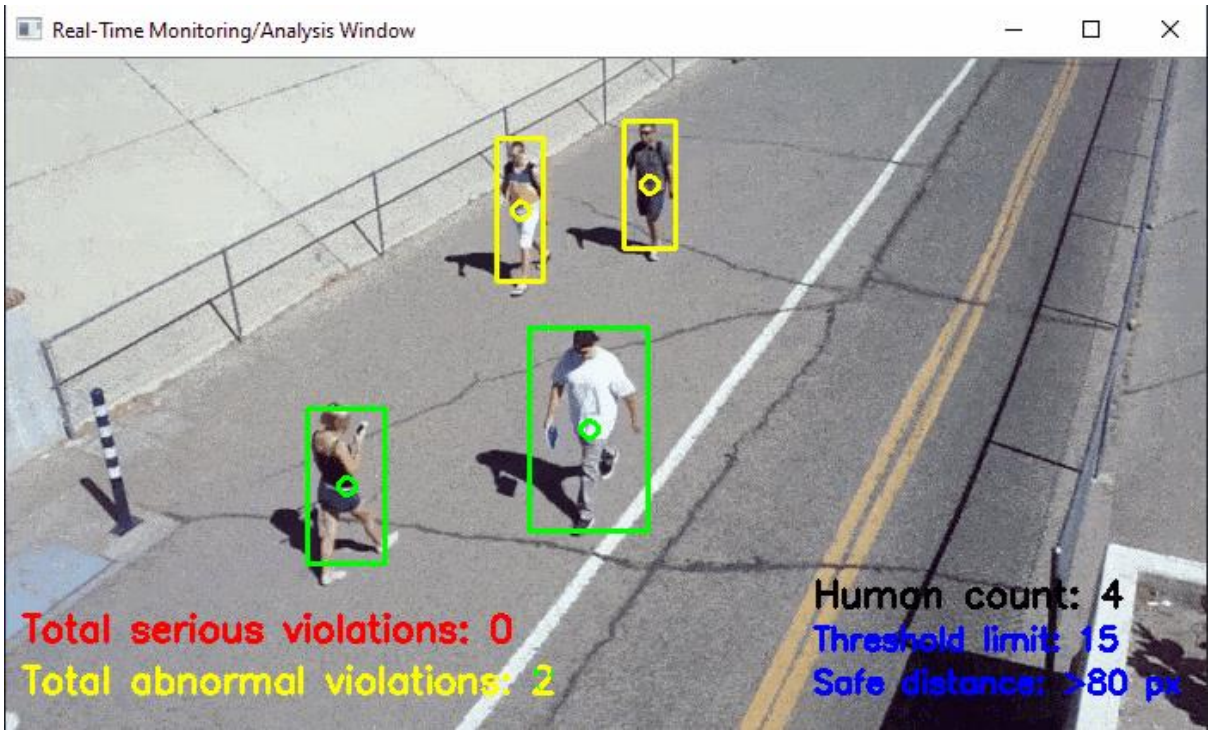

Figure: 5.4 Test case 2 output

Tables: Test case - 1

People Count	No. of violations	Alert mail
18	9	Sent
6	2	Not sent
21	14	Sent
17	5	Not sent

Table: 5.1 Sample test case 1

Test case - 2

People Count	No. of violations	Alert mail
4	0	Not Sent
13	5	Not sent
16	7	Not sent
8	4	Sent

Table: 5.2 Sample test case 2

6. Conclusion:

Social distancing is one of the important precautions in reducing physical or close contact that may lead to the spread of corona virus. Upon violating these guidelines, we will be increasing rates of virus transmission. We would be developing a system using Python and OpenCV library to implement our proposed features. One of the features is to detect the pedestrians and detecting a breach in violations of social distance. Another feature is that, it will be monitoring cam views over a wide area and to deliver an alert notification.

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