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Social Distancing Detection with Deep Learning

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Abstract : Covid-19(sars-cov-2) has had a major global impact on the daily lives of billions of people living around the world. Social distancing has proven to be an effective measure to hamper the spread of the disease. The system presented is for analyzing social distancing by calculating the distance between people in order to slow down the spread of the virus. This system utilizes input from video frames to figure out the distance between individuals to alleviate the effect of this pandemic. This is done by evaluating a video feed obtained by a surveillance camera. The video is calibrated into bird's view and fed as an input to the YOLOv3 model which is an already trained object detection model. The YOLOv3 model is trained using the Common Object in Context (COCO). The proposed system was corroborated on a pre-filmed video. The results and outcomes obtained by the system show that evaluation of the distance between multiple individuals and determining if rules are violated or not. If the distance is less than the minimum threshold value, the individuals are represented by a red bounding box, if not then it is represented by a green bounding box. This system can be further developed to detect social distancing in real-time applications.

Keywords : social distancing, pedestrian detection, deep learning, convolutional neural network

I.INTRODUCTION

When the novel coronavirus (Covid-19) pandemic emerged, the spread of the virus left the public anxious if they did not have any effective cure. The World Health Organization (WHO) has declared Covid-19 as a pandemic due to the increase in the number of cases reported around the world [1]. To contain the pandemic, many countries have implemented a lockdown where the government forces the citizens to stay at home during this critical period. The public health bodies such as the Centers for Disease Control and Prevention (CDC) had to make it clear that the most effective way to slow down the spread of Covid-19 is by avoiding close contact with other people [2]. To flatten the curve on the Covid-19 pandemic, the citizens around the world are practicing physical distancing. To implement social distancing, group activities and congregations such as travel, meetings, gatherings, workshops, and praying had been banned during the quarantine period. The people are encouraged to use phone and email to manage and conduct events as much as possible to minimize the person-to-person contact. To further contain the spread of the virus, people are also informed to perform hygiene measures such as frequently washing hands, wearing masks and avoiding close contact with people who are ill. However, there is a difference between knowing what to do to reduce the transmission of the virus and putting them into practice. The world has not yet fully recovered from this pandemic and the vaccine that can effectively treat Covid-19 is yet to be discovered. However, to reduce the impact of the pandemic on the country's economy, several governments have allowed a limited number of economic activities to be resumed once the number of new cases of Covid-10 has dropped below a certain level. As these countries cautiously restart their economic activities, concerns have emerged regarding workplace safety in the new post-Covid-19 environment. To reduce the possibility of infection, it is advised that people should avoid any person-to-person contact such as shaking hands and they should maintain a distance of at least 1 meter from each other.

II. LITERATURE SURVEY

This section of the literature review finally shows the following facts based on a careful examination of several authors' work:

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[1] One of the most effective precautions in minimizing physical contact that could lead to the spread of coronavirus is social distancing. Viral transmission rates would be higher as a result of non-compliance with these guidelines. To implement two proposed features, a framework was created using Python and the OpenCV library. The first feature detects social distancing violations, while the second feature detects violations of entering restricted areas. The accuracy of both features has been checked. This thesis seems to have met all of its goals based on the overall findings. The obtained results, however, have some limitations. According to the results of the system's tests, the object detection model used for detecting people has trouble correctly detecting people in the outdoor environment and difficult scenes with distant scenes.

A stronger object detection model can be introduced in the future for further development.

[2] A deep learning model is used to propose a technique for detecting social distancing. The gap between people can be measured using computer vision, and any non-compliant pair of people will be marked with a red frame and a red line. A video of pedestrians walking down a street was used to validate the proposed process. The visualization results revealed that the proposed method is capable of determining social distancing measures between individuals and that it could be further adapted for use in other settings such as the workplace, restaurant, and school. Furthermore, by optimizing the pedestrian detection algorithm, incorporating other detection algorithms such as mask detection and human body temperature detection, increasing the computational power of the hardware, and calibrating the camera perspective view, the work can be improved even further.

[3] Social distancing has been suggested as a way to prevent the spread of infectious diseases like COVID-19. This article contains a thorough examination of how technology can allow, encourage, and enforce social distancing. To begin, we discussed social distancing in general. addressed the technology's role in the current COVID-19 pandemic, as well as a variety of practical social distancing situations in which it could be used. We then went through a range of wireless technologies that can be used to facilitate and encourage social distancing and discussed them. We gave a summary of each technology, looked at the state-of-the-art, and explored how it could be used in various social distancing scenarios.

III. RELATED WORKS

This section features and highlights some works related to object detection and person detection using deep learning. A heft of work recently focused on the classification of objects and detecting them involving deep learning are also discussed. Detection of humans done using computer vision is considered as a part of object detection. The detected objects are localized and classified based on their shape with the help of a predefined model [1]. The techniques that use convolutional neural networks (CNN) and deep learning have shown to achieve better performance on visual recognition benchmarks. It is a multilayered perceptron neural network that contains many fully connected layers, sub-sampling layers, and convolutional layers. It is powerful in detecting different objects from different inputs and it is a supervised feature learning method. Because of the outstanding performance in large datasets such as ImageNet, this model has achieved tremendous success in large-scale image classification tasks [2].

The object detection and recognition have achieved great success due to its neural network structure which is capable of constructing objects on its own with the help of descriptors and can learn distinguished features that are not primarily given in the dataset. But this has its own set of advantages and disadvantages as of speed and accuracy. The real-time object detection algorithms which use the CNN model such as Region-Based Convolutional Neural Networks (R-CNN) [3-5] and You Only Look Once (YOLO) are developed for the detection of multiple classes in various regions. YOLO (You Only Look Once) is a prominent technique as to speed and accuracy in deep CNN based object detection. Figure 1 shows how object detection is done based on the YOLO model.

Transforming the objective and interpretation from the work [6-8], this system which is proposed presents a method for detecting people using computer vision. Instead of using drone technology, the input is a stream of a video sequence from a CCTV camera installed. The camera’s range of view covers the pedestrians passing by in the range of the installed camera. The people in the frame are represented using a bounding box using the deep CNN models. The deep CNN based YOLO algorithm is used to detect the people in the sequence of video streams taken by the CCTV camera. The calculations are done by measuring the centroid distance between the pedestrians, this will represent whether the pedestrians in the video follow sufficient social distance Figure1

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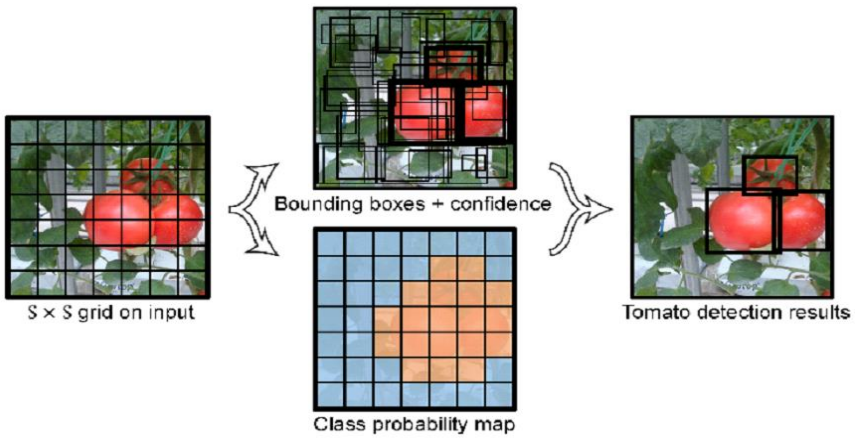

Figure 1. Object Detection using the YOLO model.

III. METHODOLOGY

This social distancing detection tool was developed to detect the safety distance between people in public spaces. The deep CNN method and computer vision techniques are employed in this work. Initially, an open-source object detection network based on the YOLOv3 algorithm was used to detect the pedestrian in the video frame. From the detection result, only the pedestrian class was used and other object classes are ignored in this application. Hence, the bounding box best fits for each detected pedestrian can be drawn in the image, and this data of detected pedestrians will be used for the distance measurement.

For camera setup, the camera is captured at fixed angle as the video frame, and the video frame was treated as a perspective view and transformed into a two-dimensional top-down view for more accurate estimation of distance measurement. In this methodology, it is assumed that the pedestrians in the video frame are walking on the same flat plane. Four filmed plane points are selected from the frame and then transformed into the top-down view. The location for each pedestrian can be estimated based on the top-down view. The distance between pedestrians can be measured and scaled. Depending on the preset minimum distance, any distance less than the acceptable distance between any two individuals will be indicated with red lines that serve as precautionary warnings. The work was implemented using the Python programming language. The pipeline of the methodology for the social distancing detection tool is shown in Figure 2.

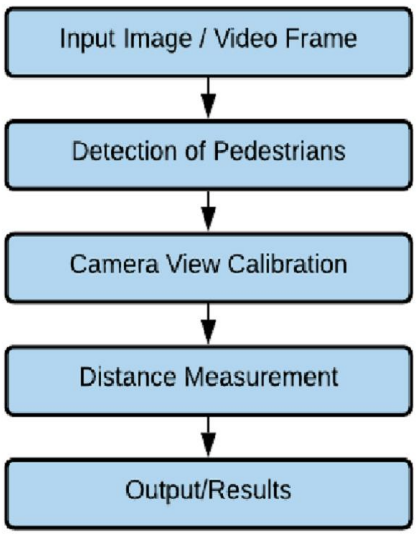

Figure 2. Pipeline for social distancing detection.

The working of the Social Distancing Analyzer is depicted using a flowchart shown in Figure 3.

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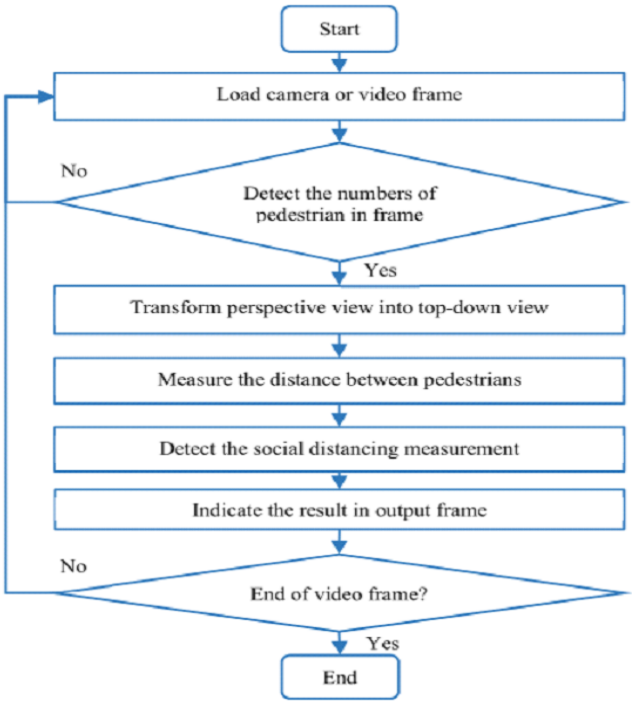

Figure 3. Program flowchart of social distancing detection for each video frame

A. *Input Collection*

The image captured and video recorded by the CCTV camera is given as the input as shown in Figure 4. The camera is set up in a way it captures at a fixed angle and the video frame's view was changed into a 2D bird's view to accurately estimate the distance between each person. It is taken that the people within the frame are leveled on the horizontal plane. Then, four points from the horizontal plane are chosen, then it is changed into the bird's view. Now the position of each person can be calculated based on the bird's view Figure 4.

Figure 4. Sample Image captured by CCTV camera.

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The interval between people is easily estimated, scaled, and measured by calculating the euclidean distance between the centroids. A threshold value or a preset minimum value for the distance is set. Depending upon this value, any distance lower than the preset minimum threshold value is found, then a warning is shown using red-colored bounding boxes.

B. *Calibrating the camera*

The region of interest (ROI) of an image or a video frame focused on the person who is walking was captured using a CCTV camera was then changed into a two-dimensional bird's view. The changed view's dimension is 480 pixels on all sides. The calibration is done by transforming the view frame captured into a two-dimensional bird's view. The camera calibration is done straightforwardly using OpenCV. The transformation of view is done using a calibration function that selects 4 points in the input image/video frame and then mapping each point to the edges of the rectangular two-dimensional image frame. On performing this transformation, every person in the image/frame is considered to be standing on a leveled horizontal plane. Now the interval of each person in the frame can be calculated easily as it corresponds to the total pixels present in between each person in the changed bird's view.

C. *Detection of pedestrians*

Deep CNN model was the object detection approach that mitigated the computational complexity issues by formulating the detection with a single regression problem. When it comes to deep learning-based object detection, the YOLO model is considered one of the state-of-the art object detectors which can be demonstrated to provide significant speed advantages suitable for real-time application. In this work, the YOLO model was adopted for pedestrian detection as shown in Figure 3. The YOLO algorithm was considered as an object detection taking a given input image and simultaneously learning bounding box coordinates (tx, ty, tw, th), object confidence and corresponding class label probabilities (P1, P2, …, Pc). The YOLO trained on the COCO dataset which consists of 80 labels including human or pedestrian class. In this work, the only box coordinates, object confidence and pedestrian object class from detection result in the YOLO model were used for pedestrian detection.

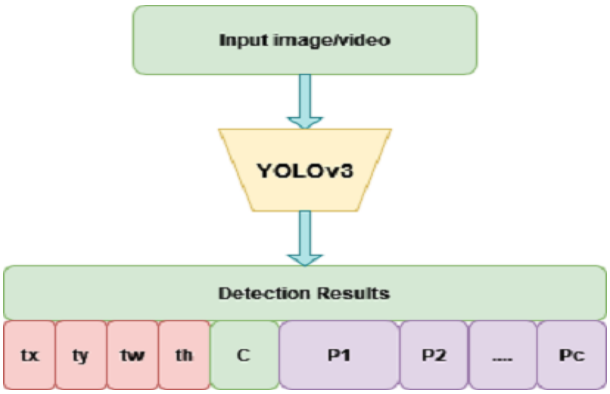

Figure 5. Detection of pedestrians using the YOLOv3 model.

IV. RESULTS AND DISCUSSION

The video shows the pedestrian walking on a public street. In this work, the video frame is fixed at a specified angle to the street. The perspective view of the video frame is transformed into a top-down view for a more accurate estimation of distance measurement. shows the social distancing detection in a video frame and the results of the top-down view. The sequences are depicted from top to bottom. The points represent each pedestrian for social distancing detection. The red points represent the pedestrians whose distance with another pedestrian is below the acceptable threshold and the green points represent the pedestrians who keep a safe distance from other pedestrians. However, there are also some detection errors shown. These errors are possibly due to the pedestrians walking too near to another pedestrian until they are overlaid on the camera view. The precision of the distance measurement between pedestrians is also

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affected by the pedestrian detection algorithm. The YOLO algorithm is also able to detect the half body of the pedestrian as an object by showing the bounding box, the position of the pedestrian corresponding to the middle-point of the bottom line is estimated based on the bounding box will be less precise. To overcome the detection errors, the proposed methodology had been improved by adding a quadrilateral box to observe the appointed region in an image as shown in. Hence, only the pedestrians walking within the specified space will be counted for people density measurement.

Figure 6 and 7. Here red boxes represent people who are too close (less than 6 feet) to one another

V. CONCLUSION AND FUTURE SCOPE

A methodology of social distancing detection tool using a deep learning model is proposed. By using computer vision, the distance between people can be estimated and any non-compliant pair of people will be indicated with a red frame and red line. The proposed method was validated using a video showing pedestrians walking on a street. The visualization results showed that the proposed method is capable of determining the social distancing measures between people. We can add on other algorithms such as face mask detection and human body temperature detection. In the future, we can use this methodology on mobile camera autonomous drones

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