Monitoring of the Social Distance between Passengers in Real-time through Video Analytics and Deep Learning in Railway Stations for Developing the Highest Efficiency

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***Abstract*—Near the end of December 2019, the globe was hit with a major crisis, which is nothing but the coronavirus-based pandemic. The authorities at the train station should also keep in mind the need to limit the spread of the covid virus in the event of a global pandemic. When it comes to controlling the COVID-19 epidemic, public transportation facilities like train stations play a pivotal role because of the proximity of so many people who may be exposed to the virus. Using common place CCTV cameras and deep learning with simple online and real-time (DeepSORT) methods, this study develops social distance monitoring using a YOLOv4 identification of a Surveillance Object Model. Based on experiments conducted with a minicomputer equipped with an Intel 11th Gen Intel(R) Core(TM) i3-1115G4 at 3.00GHz, 2995 Mhz, two Core(s), four Logical processor, four gigabytes of random-access memory (RAM), this paper makes use of CCTV surveillance, which was put into practice at the Guindy railway station, Chennai, Tamilnadu in India in order to detect the violation of social distancing.**

Keywords— closed-circuit television, COVID-19, deep learning technology, crowd surveillance.

I. INTRODUCTION

In the year 2019, the globe was struck by the COVID-19 epidemic, which completely destabilized the situation on a global scale. On July 10, 2021, there were a total of 185 million instances of the virus affecting individuals throughout the world. As of may, 2022 total number of affected cases in India is 4.31 crores and in Tamilnadu, it was 34.5 lakhs People are affected by the epidemic.

According to the guidelines of the World Health Organization (WHO)[1], to maintain their distance and stay away from large groups. Some COVID patients who have been infected may develop symptoms like respiratory sickness if they do not seek medical care, which, if left untreated, can be fatal. If these patients do not seek medical treatment, they may die from their infection. These symptoms include In most cases, the illness is transmitted from person to person by the saliva that is produced by those who already have the infection. Everyone has to keep their hygiene in check, and they need to protect their health by adhering to the COVID-19 protocol, which includes things like washing their hands and covered up by masks, as well as maintaining a gap between person [2]. One preventative action that may be used to restrict the development of COVID-19 [3] is to create social distance. The risk of contracting and transmitting COVID may be reduced by using this method, which was designed to lessen the amount of close encounters that we have with other individuals who either have symptoms or are asymptomatic carriers.

To this problem, the government of India has released an update to the circular addressing foreign travel health protocol when the COVID-19 pandemic was at its height. This was done through a task group for the acceleration of managing COVID-19 in India. As a consequence of this, the Indian Railway Corporation[4], which acts in the capacity of a regulator for state-owned firms engaged in railway transportation in India, has published several protocol that refer to the provisions of the COVID Protocol which is stated in table 1. If we wish to utilise their services during the COVID-19 epidemic, we will need to adhere to this protocol. Passengers taking a train, for instance, are required to show proof of a negative rapid antigen result on a PCR test[5] completed no less than 24 hours before departure. Additionally, travellers are required to wear protective masks, such as cotton face masks or surgical masks, to lessen the likelihood that the illness may be transmitted. According to the protocol standards that have been published by the WHO and COVID-19 to reduce the risk of an infectious disease spreading through a crowded train car in India, the government has mandated a 6-foot safety zone between passengers. The control of the railway station is important to limit the danger of COVID-19 transmission, which is why this suggested paper is necessary. Maintaining numerous measures that may play an important part in decreasing and avoiding visitors in optimum circumstances is a goal for public transportation, which is why these measures are so important.

There are strategies available to lessen or get rid of the COVID-19 high risk. This article was crafted with the assistance of a CCTV footage [6] analytical system that was developed with the help of IoT and artificial intelligence (AI), and it can fulfill the following demands by the following priority points:

i) This system can count the number of crowds and categorize them into high-risk categories based on the sorts of persons in the crowds.

ii) If the system module detects anything out of the ordinary, this component will notify the server and provide a warning.

iii) The throng of people at the station may be monitored with the help of the social distance monitoring system generated by this technology. CCTV cameras[7] are used by the system to record persons in a crowded area and the associated social distance.

vi) This study has the potential to give the stakeholders an informative dashboard that is capable of providing descriptive analytics, predictive analytics, and prescriptive analytics. High-level executives are provided with a dashboard that displays data in real-time to reduce infractions.

The format for this proposed piece of research methodology is designed as object tracking , image acquisition, social distance checker, object detection, and data visualization. The below table from the Indian railways shows the protocols published during covid 19 pandemic.

TABLE I. PROTOCOLS AND THE GOVERNMENT ORDER OF INDIAN RAILWAYS

Date	Protocol / Govt Order Number	Establishment of Indian Railway Circulars
06.06.2022	E(Govt) 2021/CL-4/3	Novel Coronavirus prevention (Covid-19) for Central Government Officials .
02.02.2022	E(Govt) 2021/CL-4/3	Novel Coronavirus prevention (Covid-19) Central Government Officials Attending.
03.11.2021	E(Govt) 2021/CL-4/3	Novel Coronavirus prevention (Covid-19) Central Government Officials Attending– Resumption of Biometric Attendance regarding
18.06.2021	E(Govt) 2021/CL-4/3	Novel Coronavirus prevention (Covid-19) Central Government Officials Attending- Attendance of Government officials regarding.
14.06.2021	E(Govt) 2020/LE2/1/Pt.2	COVID-19/pandemic hospitalization/quarantine treatment/regularization
02.06.2021	E(Govt) 2021/CL-4/3 02/06/2021	Novel Coronavirus prevention (Covid-19) Central Government Officials Attending- Attendance of Government officials regarding.
05.05.2021	E(Govt) 2021 / CL-4/3	Preventive measures to contain the spread of COVID-19- Attendance of Central Government officials – regarding.
18.03.2020	E(Govt) 2020 / CL 4-2	Novel Coronavirus prevention (COVID-19)

Using CCTV analytics and deep learning techniques, in convolutional neural networks (CNN),[7] this study presented a method to address the social distance maintaining problem in public spaces; this idea is bolstered by the integration of previously processed data. Specifically, the research focused on the use of CNNs.[8] This system is captured by the CCTV, which then uses this captured data to identify the pattern required for video analytics. The analyses that have been performed may be utilized to get a better understanding of the situation at the station and provide information that can assist those who are in charge of managing the station in ensuring that all safety regulations have been adhered to. The proposed solution was tested in a CCTV system that is fixed at the Guindy train station and has a protected local connection.

Using the YOLO v4 [9] deep learning algorithm, the proposed prototype has the capability of identifying individuals who can monitor social distancing. This system is also capable of achieving real-time visitor counts with violation detection on a Mini PC. Health authorities and governments merely need to check the dashboard visualisation to release high-risk categories and follow people's movements..

II. PROPOSED METHOD

This section provides an overview of the most recent studies on object detection and social distance, One of the things that may be done to slow the progression of COVID-19's growth and stop it from becoming more widespread is to create social distance. In the year 2020, several researchers around the world used various techniques in their investigation of the detection of social distance. This research makes use of hardware that includes liquid crystal display (LCD) modules. When combined, these components can become a device that can detect objects surrounding the user, allowing for the determination of the distance between the user and other humans.

When the distance between users and other individuals is less than one metre, the results of this study will be shared with the relevant authority. The apparatus will make a noise to alert the user that it is required to maintain a social distance. These past efforts have shown how to improve railway technology like CCTV surveillance with AI. Prior study examined algorithms, concepts, ideas, and implementations for social distance monitoring standards. They proposed using the YOLO[10] architecture with apache, Hadoop, Spark, or a SQL database for the CCTV monitoring system. Each CCTV picture is turned into semi-structured data and shown in real time to count things, monitor them, and spot unexpected occurrences.

DeepSort, a neural network architecture with a huge dataset, detects and tracks individuals using social distance indicators and works effectively in a range of contexts in this research. Intelligent surveillance systems for social distancing monitoring are now in use. The top model is designed as YOLOv3 to identify numerous objects, while in the bottom module offered a spatial attention module for parameter optimization. Both of these modules were located in the neck module. Deep learning was also employed to detect items by Euclidian distance which was utilized to estimate the distances between objects. The region for object identification is square in shape, and it will identify anything that moves across its confines. This study used faster R-CNN and YOLOv4 techniques. however, it has not yet

implemented in the original railway station location. The system scaled or used YOLO and the YOLO tracks people's movements using DeepSORT, which stands for Deep Learning with Simple Online and Real-Time. This system identifies social distance breaches by previously observed persons.. Using YOLOv3, Punn et al. [11] devised the DeepSORT tracking methodology to locate and locate objects. The results of the experiment were analyzed and contrasted with those obtained from a quicker RCNN and a single-shot detector (SSD)[12] model. As a result of this study, it was discovered that YOLOv3 performs better with higher performance. In addition to this, it uses DeepSORT to monitor persons with a 2-meter minimum distance requirement. Several researchers have explored preventative strategies using technology-based solutions like AI-related studies to help the health and medical community overcome social COVID-19 distant practise issues. Previous research includes a variety of applications, such as patient location and tracking using GPS technology as well as crowd segmentation and estimate. This study approach has a flaw in that its reliability is contingent on the robustness of the global positioning system (GPS) network and satellites.

Ahmad et al. [13] developed a YOLOv3-based deep learning social distance monitoring system for COVID-19. This approach contrasts YOLOv3 with and without transfer learning. This study uses Euclidean distance to describe a people-tracking system and review its bounding box[14]. People's movement determines the bounding box centroid pair's Euclidean distance[15]. The authors assess social distance violations between passengers using a physical space-to-pixel approach, a threshold, and the number of violations. 5G infrastructure transfers high-speed bandwidth recorded video streams to enable deep learning[16], which requires considerable processing to offer near-real-time top-view multiple-person tracking solutions. Deep learning improves. This method necessitates substantial prices as well as an extremely intricate and dependable underlying infrastructure. The previous study has primarily focused on implementing how social distance monitoring can function, rather than developing an end-to-end solution. This is a drawback of the research. In this work, the module establishes social distance monitoring as a platform by integrating data from many technological sources, beginning with picture collecting and ending with dashboards. Theis module also provides recommendations for various authorised persons. The YOLOv4 object identification model and the DeepSORT[17] tracking method are utilized in the operation of this system. Both of these methods are based on the Kalman filter methodology. The Euclidean distance and the Hungarian[18] method both fall short when compared to the precision of our technique. This strategy is also employed at the Guindy train station by developing a real-time system with a dashboard that enables authorised persons to monitor this socially distant condition. This system module is tested at the Guindy railway station. The below Figure 1 illustrates the social distance technique. The use of closed-circuit television as an image sensor is proposed and analyzed here as part of an investigation into the behavior of passengers in a train station.

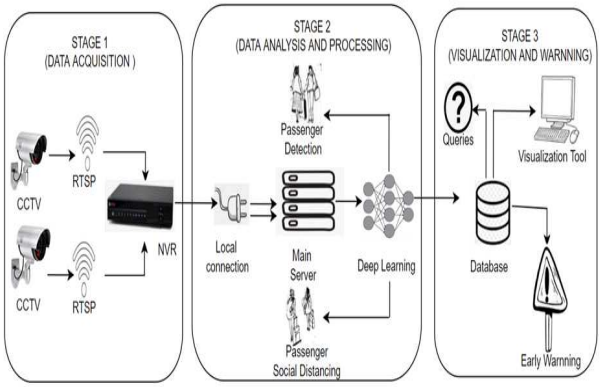


Fig. 1. The architecture of the social distance analyzer platform

To begin, this system describe about how the sensor works and what it is made of. Then, it explain why we chose to communicate with Internet protocols and software components that combine a detection algorithm with a counting algorithm and how to put it all together into an end-to-end solution that can collect, store, and analyse data using a platform architecture. In Figure 1 states a platform architecture which will be make us to help with this research. This is made possible by the use of IP cameras in the train station. In Figure 1 the architecture of the platform that will be built to help with this research. The plan that has been made is set up so that it goes from sensing to doing or visualizing .

III. THE METHOD

In this section, we find the most current findings from researchers working in the fields of image capture, object identification, object tracking, social distance analysis, and data visualization. The following are the stages that make up the method that came before. Capturing images using the RTSP protocol, identifying objects with the YOLO v4 detector model, following objects in real time with simple online and real-time (DeepSORT) tracking methods based on the Kalman filter approach, and measuring social distance with the help of the Euclidean distance.

A. Acquiring an Image

The process of social distance analysis begins with the collection of images at the beginning of the process. Here, CCTV footage will be taken of the evaluation area so that information may be extracted from the footage. This will allow the data to be used in subsequent stages. Within the scope of this investigation, the setting that serves as the point of interest for the research is the Guindy train station.

The passenger entry of the train will go through the station after accessing the counter at the entrance. The station's platform is one of the sites that travellers frequently walk through when they are there. This location serves as the point of connection between the main link building and the train, as well as the location where people board and alight from the train. It is possible

to monitor the movement of people on the platform using CCTV cameras there. When it comes to the installation of picture capture, closed-circuit television (CCTV) will serve as the principal source, rather than other devices. In addition, CCTV may be set to run continuously for a whole day, allowing for a more streamlined analysis of the data collected during the investigation process. Real-time streaming protocol (RTSP)[19], real-time messaging protocol (RTMP), and hypertext transfer protocol (HTTP) are all examples of video stream protocols that may be used to push the CCTV feed from the NVR in this setup (HTTP). The module chooses Real Time Streaming Protocol (RTSP[20]) as the video stream protocol because it is suitable for both local and wide area network (WAN) video access, does not need a media server, and is supported by the vast majority of CCTV systems.. Figure 2 will illustrate this paradigm.

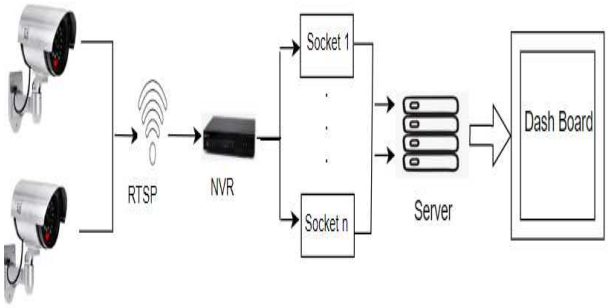


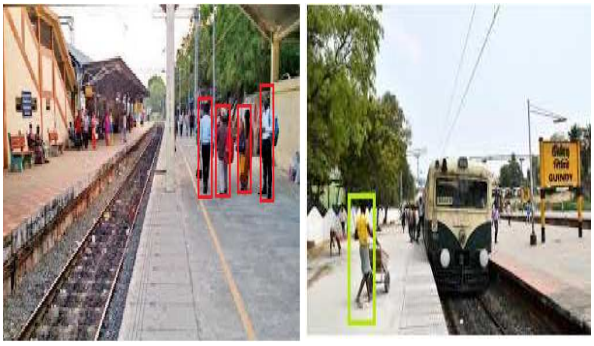
Fig. 2. Image acquisition schema flow

B. *Object detection*

Object detection[21] is made so that CCTV images of things in the environment can be used to find them. In this research, train passengers are most significant since they bring social distance into railway systems. At this stage, object detection can be done with the help of deep learning. YOLOv4 is one of the best detection objects on the market right now. YOLOv4 is one of the methods for finding objects that can be used in real-time and can find several objects in a single image. Using bounding boxes, the technique finds objects in the image and sorts them into groups. Figure 3 shows how objects in an image can be named so that they can be found when needed. It is how an object detection model is built from the ground up.

C. *Object tracking and Bounding Box*

Object tracking[22] is a process with several steps. The first step is to find objects in the scenario. The next step is to give each object that has been seen an identity. Tracking system-identified objects is the final step. Simple online and real-time tracking (SORT) was used in recent research and can track objects accurately and quickly. This method predicts and links frames. Then, the most present method for detecting objects was used to give it the best speed and accuracy in tracking objects. Object tracking is built into this system so that it can keep track of things in the environment. In this case, the focus is on train passengers, so that every person who walks across a CCTV camera will be captured by the camera and their movements will be tracked for further study. DeepSORT uses a CNN to find objects using the YOLOv4 model. Objects in the system are tracked using the Kalman filter and the Hungarian algorithm.



(a) No Social distance (b) with social distance

Fig. 3. People tracking illustration

D. *Social distance analyzer*

This study will examine social distance. To avoid illness transmission, the idea is to regulate passenger spacing to social distances. The CCTV system with a social distancing analyzer system alerts the railway station autorities to violating the train passengers. CCTV will locate and track each train traveller. Each monitored passenger will be allowed to go after all the necessary procedures have been performed, and a radius will be assigned to the region surrounding them. The purpose of this step is to establish how far apart each passenger is from one another and if a person is less than a particular distance from another, the system will indicate that they are too near to other people. This social distance method measures how far apart two objects are. To get the the coordinates of every individual object, you need to know the coordinates of the other objects.

The part of the video frame where the object was found is used. Figure 3 shows the area of the object that was identified as with social distance and with out social distance found. The 0 ᶜ center, of the object's lower bounding box, or 0 ᶜ center, is located in equaltion (1).

$$O^{c} = \left(\frac{x' - x^{0}}{2} + x^{0}, y'\right) \tag{1}$$

The real x and y coordinates of the object can then be found, and Calculate each object's distance. We use the Euclidean distance formula to figure out how far things are from each other. Using the person-to-person distance calculation formula, which is the two-dimensional Euclidean distance formula, to measure the distance between two objects is (2).

$$d = \sqrt{(x_d - x_e)^2 + (y_d - y_e)^2} \tag{2}$$

As can be seen in Figure 3, the distance of (d) is more than the threshold value of one metre, which indicates that the condition is safe. As a consequence of this, If the distance (d) is less than that of the threshold value then , the system will show a high risk displaying a red bounding box around the area of concern. similar to the

one shown in Figure 4 between a person and another person.

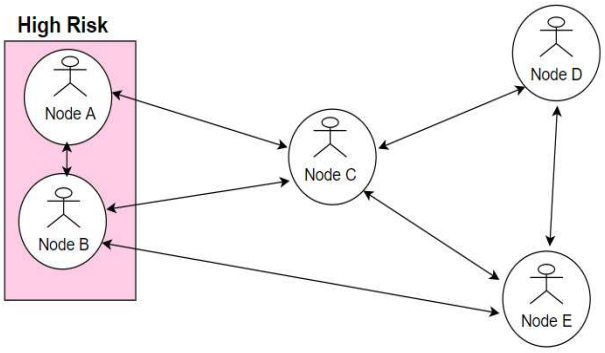


Fig. 4. Social distance analyzer schema

E. *Data visualization*

videos or Pictures of each object of interest, like train passengers who pass through the view of Object detection, will be produced as a result of the analysis done at each stage, and a social distance analyser will be used to process the CCTV so that each detected passenger will be assigned a bounding box[23] on each frame so that each passenger can be tracked. As a first step, the RTSP protocol will be used to transfer the CCTV feed to the centralised storage system. After then, the information will be examined for further applications. charts and graphs to help authorities make sense of the data collected by surveillance cameras. Actual video without YOLO and with YOLO description is shown in Figure 5.

IV. RESULTS AND DISCUSSION

Python is utilized for this implementation, namely the YOLOv4 darknet module for object detection and the SORT tracking[24] module for tracking discovered objects. OpenCV, Pillow Numpy, and Matplotlib some of the libraries used in this research. Mini-computer with 11th Gen Intel(R) Core(TM) i3-1115G4 @ 3.00GHz, 2995 Mhz, 2 Core(s), 4 Logical is the hardware equipment utilized to do image processing from input to output social distance at the time of implementation.

A. *Assessment of Passenger-Tracking Systems*

Figure 8 depicts the testing of the passenger tracking results. Figure 8 represents the raw footage without any post-processing effects. The analyzed outcome of object tracking is shown in Figure 8. The figure shows that certain video data may be retrieved without further processing. This recorded video simply displays video streams and some tasks that will be saved on the hard drive for later viewing to detect anomalous occurrences such as breaches of social distance or the buildup of the total passengers caught by the CCTV. Unfortunately, automated alerts are not a feature of previous research of video streaming. Figure 7 and 8 shows the outcome of object tracking of passengers performed on the platform using CCTV at the Guindy Railway station.

(a) Actual video footage without further analysis (b) showing the passenger tracking results analysis

Fig. 5. Social distance analyzer schema

The system's output is this conclusion, which is sent to the monitor screen so that it may be used as a factor in policymaking and spatial redesign. Furthermore, the system examines the position and density of individuals who violate social distancing norms whereby it may be viewed as a interference with social space in addition to the movement and people monitoring. The value of the crisis will be sent to the monitoring system in this way.

B. *Implementation evaluation*

This system's assessment obtained social distance monitoring which results high-risk that is the person who violates the social distancing and total persons detected. Figure 6 displays the findings after testing the system for 5 days and using it regular intervals.

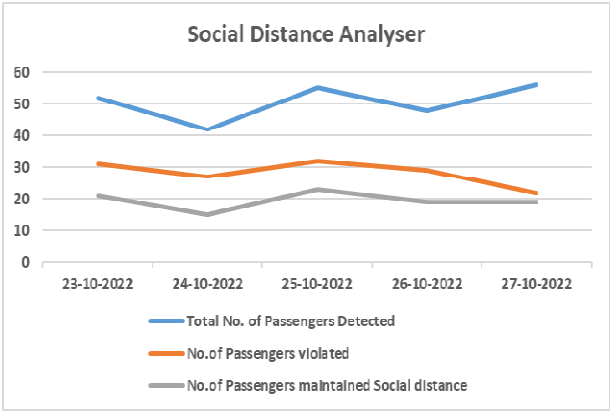


Fig. 6. Overall Social distance analyzer

This module is tested on a PC with Intel(R) Core(TM) i3-1115G4 at 3.00GHz, 2995 Mhz, two Core(s), four Logical processors SMBIOS Version 3.2, and Microsoft Windows 10.

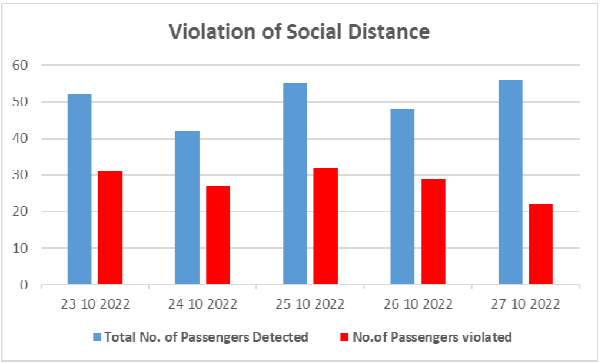


Fig. 7. Violation of Social Distance analyzing

This system notifies when monitored persons breach distance regulations. All rulebreakers will be considered high-risk. The algorithm's outputs may be used differently by higher authorities monitoring the area's distance rule safety procedure. The Figures 7 show the effects of social distancing violations.

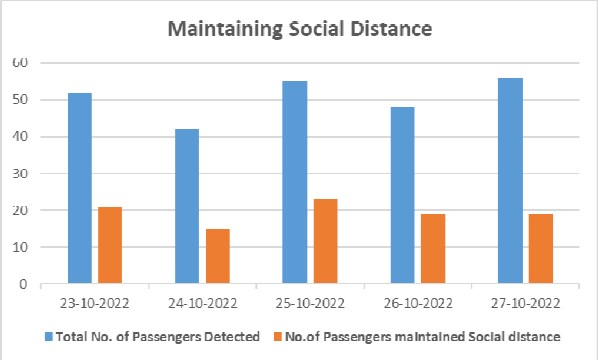


Fig. 8. Social Distance analyzing

. Figure 8 shows data visualization from social distancing for individuals from one CCTV in Guindy railway station and Line graph in figure 6 depicting total number of persons in each frame, status of people who do not adhere to social distancing norms, and number of people who do not violate coupled group regulations[25] .

V. CONCLUSION

A system that makes use of CCTV video analytics with deep learning algorithms (particularly CNN) to make public spaces safer and more convenient hospitable for everyone has been proposed as a result of this research. The CCTV cameras observe this system and identify the behavior required for the video analytics. The analytics that has been done can help us understand what's going on at the railway station and give the people in charge of the station information they can use to make sure all the safety rules should be followed. This proposed method was tested on a single CCTV system with a secure connection at the Guindy railway station. This system was able to work in a variety of situations, such as when objects were in the way or when the lighting changed. Using the YOLOv4 deep learning algorithm, the proposed prototype can find people who can monitor social distance. Health authorities and governments can benefit from this system's real-time visitor counts with violation detection on a Mini Personal Computer to release a high-risk and track moving objects like passengers, infection risk assessment, and analysis. A single camera on a mini PC was used to test this solution in the Guindy train station. This method may drastically decrease breaches by adjusting in real-time to minimize or eliminate the possibility of COVID-19 in all situations. This work needs to be enhanced for use in future studies by adding more cameras so that social distance monitoring can be implemented in many areas. This research also needs to get better by using Tesla, DGX 100, or more powerful GPUs (Graphic Processing Unit) to enhance the efficiency of detection, computation, and analysing of video frames.Models such as YOLO R and YOLO V5 may be used by this algorithm or technique to find objects.

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