



Real-Time Surveillance System for Detection of Social Distancing

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ABSTRACT

As the corona virus can mutate and due to other scientific factor associated to it, experts believe that COVID-19 will remain with us for decades. Therefore, one has to keep social distancing measures. Accepting the pandemic situation, the paper presents a mechanism for detecting violations of social distancing using deep learning to estimate the distance between individuals to diminish the influence of COVID-19. The focus of this paper is to understand the effect of social distancing on the spread of COVID-19 by using YOLOv3 and Faster-RCNN and proposes IFRCNN (improved faster region – convolution neural network). The proposed method IFRCNN is checked on a live streaming video of pedestrians walking on the street. This paper keeps the live updates of the recorded video along with social distancing violation records on a location, so how many people in a location are maintaining social distancing. Updates will be stored in a cloud-based storage system and any organization or firm can get live updates of that location in their digital devices.

KEYWORDS

COVID-19, IFRCNN, Real-Time Surveillance System, Social Distancing, YOLO

INTRODUCTION

The aftermath that COVID-19 gave to the human race is going to stay forever. This manner of life has been forced upon us by covid-19, the fastest-growing pandemic the world has ever seen. According to the World Health Organization (WHO), covid-19 has infected approximately 2500 million individuals worldwide and killed over 4.5 million people. More than 221 countries and territories have been affected by the fatal virus thus far. The main cause of the problem is that covid-19 transmits from individual to individual via contact or being in near vicinity to an inflamed person. Given how densely

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populated some of the places are now, this has been a major undertaking. One of the important manners to save you the unfold of covid-19 is social distancing. Social Distancing oneself from others has become an important practice all around the world, transcending languages and cultures.

Eventually the virus could become a much milder illness but for now vaccination and surveillance, physical distancing and masking are critical and important to end this pandemic phase. Also, there are many unanswered scientific questions like how long vaccinations would be effective, how long this vaccination will be effective for individual with chronic diseases etc. Also, still 100% vaccination is not completed in many developed countries and still accessibility and availability are an issue to many under developed countries due to various reasons. So ultimately, we want to maintain a situation in which the damage is less severe to the mankind. For now, monitoring social distancing is the best option and we have to make sure that this happens on global scale.

So, in order to answer this issue about covid-19 infections, there is need to develop a system, in which everyone is within real time, and returns a bounding container that goes red if the distance between two persons is extremely vulnerable. Government will utilize this to track people's movements.

Figure 1. Social distancing



Realtime surveillance system is an application which provides realtime social distancing updates following by the people in an area. It is based on object detection using YOLO and SSD model, Euclidean algorithm for finding distance between the objects, persist realtime data in cloud(D. S. Rajput, Basha, et al., 2021; D. S. Rajput, Somula, & Poluru, 2021) and different technology stack for implementation of this application. This application helps the people, markets and government to get updates about the social distancing violation.

Social distancing is one of the key protection from being affected by COVID-19 (Corona Virus). In nowadays there is so many vaccination is launched by different Healthcare Organization in different countries but they are not going to provide 100% protection from corona virus (according to WHO), every health organization has announced that vaccination provides the capability to human being to fight against corona virus from being affected. Still healthcare(Kumar Rai, Sharma, Kumar, & Goyal, 2021; Rai & Srivastava, 2014, 2016, 2017) unit continuously doing research on this disease and trying to provide a complete solution for this disease but till the time people need to follow the social distancing to avoid the spread among the people.

In so many areas we can see that after knowing the spread effects of the corona virus among the people while they are moving in a crowd area or in market after all people are not following social distancing. In this technology era we have several technology involved in our daily life in different cases so to provide the protection to the people an idea came which can help the people as well as several organization to avoid the spread of corona virus and it can be said at least we can detect those people who are not following the social distancing when they are moving outside.

So our approach is to propose a model which will be able to find the distance between the objects and give the real time updates about the suspected people or if any cases is found to be as positive case then we can have a database where we can persist the details of those people. So this application

will provide the Realtime detection among the people that they are following social distancing or not. This application is going to use the Object detection methodology, which includes different modeling technique like CNN, R-CNN, Faster R-CNN, YOLO, SSD etc.

LITERATURE REVIEW

In 2017 (Ranjan, Patel, & Chellappa, 2017) suggested Face Detection algorithm that focuses at diagnosing human faces in a photograph. Due to illumination and resolution variation and extreme poses, face detection is still a complex goal. Numerous implementations pay attention on accurate detector designing. To uplift the performance of distinct task, discover corresponding work (gender identification, face detection, facial landmarks localization and head pose evaluation).

In 2020 (Hou, Baharuddin, Yussof, & Dzulkifly, 2020) has suggested method to prove on a pre-recorded video that the individuals are following social distancing or not. Yolov3 was used to employ the algorithm and further the video was modified into top-down view for accurate distance computation in 2D plane.

In 2020 (Andersen, 2020) posted a piece of writing on social distancing detector that's primarily based on OpenCV, pc vision and deep studying concept. The item throws a mild on social distancing at some stage in the pandemic length and it focuses on social distance monitoring through CCTV cameras established across streets. The digital camera facts the distance between humans in pixels and compares it with the same old size and thus behave as a social distancing detector. This social distance detector software good judgment resides inside the report of Py Script. The scripting file assists for looping over frame of a video stream and assure that people are maintaining a healthy distance from one another. It's far well suited with both video files and webcam streams.

In 2020 (Andersen, 2020) presented the social separation facts in response to COVID-19, in which he discussed about the importance of social distancing in absence of vaccines or effective treatment. He mentioned that there is substantial growth in social distancing since start of the COVID-19 spreading. Since his data showing an emerge for to reduce the spread of COVID-19 by following social distancing and by wearing mask, which is mandate but he also suggested that, it is better if people are stay at home and try to avoid the external object or people. So, his results show the impact of social distancing among the people to reduce the COVID-19 spread among them.

In 2020 (Kissler, Tedijanto, Lipsitch, & Grad, 2020) suggested towards social distancing that is related to providing social distancing policies for curbing the COVID-19 pandemic. In the setting of seasonally variable transmission, the usefulness of social separation in containing the SARS-COV-2 epidemic is questionable. In this paper they have provided the information that in summer intrinsic amount of people affected by in autumn the scene is different so what are the others need to keep the people safe using a mathematical model.

In 2020 (Chaudhary, 2020) introduced an deep learning, OpenCV, face recognition based application that uses Multi-task Cascaded Convolution Neural Networks to capture individual's faces from an image and later a face recognizer is used to identify the names of people in the frame. The application developed then logs the instance into a databased from the frame and alerts every single individual that broke the social distancing rule. The application utilizes cv2 for every frame to generate an edited image from the original that displays the individual that broke the social distancing rule, by their names on uppermost corner of their bounding box and drawing red lines between the individuals who broke it. Finally, the application outputs an edited video clip of the original, which in actuality is an assembly of all the edited frames.

In 2020 (Ahamad, Zaini, & Latip, 2020) has suggested using MobileNet Single Shot Multibox Detector (SSD) object tracking model and OpenCV library for identify individuals in areas of interest. The distance is measured using midpoint equation. As the unsafe distances between individual is detected, signals or warnings can be communicated to maintain safe distance. From the outcomes acquired, the distance chasing system attains among 56.5% to 68% correctness for testing executed

on outdoor and challenging input videos, while 100% precision was obtained for the supervised environment on indoor testing. On the other hand for the safety contravention alert characteristics build on segmented ROI, 95.8% to 100% accuracy for every single tested input videos is obtained.

In 2021 (Shukla, Kundu, Arivarasi, & Alagiri, 2021) proposed a simulated conceptual model that utilizes deep learning algorithms along with OpenCV library to evaluate distance among the individual in the frame, along with YOLO model trained on COCO dataset to recognize individual in the frame. The system has to be properly and efficiently shaped as per the location it is being installed at on the set threshold number of violation is revealed and the violations are displayed in red box along with the distance.

(Bari, Qamar, & Khalid, 2021) discuss how by using blockchain social distancing could be monitored and traced. The aim of the proposed system is to reduce the impact of pandemic, by implementing's merger of the blockchains and the Contact tracing app. By incorporating a symmetric key cryptographic mechanism & use of blockchain authors ensures to achieves user privacy and avoid data misuse.

(Marbough et al., 2020) reviews various blockchain applications and opportunities in combating the COVID-19 pandemic and develop a tracking system for the COVID-19 data collected from various external sources. Author proposes, implements, and evaluates a blockchain-based system using Ethereum smart contracts and oracles to track reported data related to the number of new cases, deaths, and recovered cases obtained from trusted sources.

DESCRIPTION OF THE PROPOSED FRAMEWORK

WHO officials in a press conference held in March 2020, said that “on account that human beings can unfold the virus earlier than they feel that they get inflamed, it’s miles better to live far from others whilst possible, even if you— or they—don’t have any signs and symptoms”. Due to the fact that social distancing is critical to prevent the unfold of covid-19, but it was found that social distancing was being violated at public locations and subsequently the concept of “social distancing detector” is added. In this paper we’re using object detection to display safe distance among human beings.

CCTVs were used since last many decades, but till now it has been used for limited purpose like recording etc. But keep in view COVID-19, CCTV with other supporting devices like raspberry kit can be better used for social distancing monitoring.

OpenCV, pc imaginative and deep gaining knowledge are used to display social distancing across the area. First of all, object detection is carried out to come across pedestrians in a video flow. Inside the subsequent step, the pairwise distances between all detected human beings are calculated and finally, these distances are displayed as a comparison to the normal distance that must be maintained (6 toes or 2 meters), with the aid of red bounding box if they’re violated and green bounding box frame otherwise. Currently, after the outbreak of this virus, the police authorities need to patrol across the metropolis and are bound to invest time unnecessarily. If the above said (6 toes or 2 meter) rule is violated, the local authorities or the neighborhood police stations will be without delay notified. The usage of this concept of social distancing detection, the police may be capable of screen and reach the exact place and manipulate the scenario immediately. For this reason, social distancing can be controlled and circuitously the unfold of covid-19 be avoided (Chen, Seff, Kornhauser, & Xiao, 2015).

METHODOLOGY

This Real time surveillance system will help monitor and detect safety distance among persons in public places utilizing computer vision as well as deep CNN strategies. To begin with, a YOLOv3 based open-source object detection network-based algorithm is adapted to find out the pedestrian in the video frame. For this purpose, pedestrian class is utilized and additional object class is omitted from the video captured for the purpose of this application. Thus, the bounding box outstandingly fits

for every identified pedestrian can be marked in the photo. After this distance is measured between bounding boxes for social distancing.

The Figure 2 shows the physical implementation and internal working of proposed model IFRCNN (Improved Faster Region-Convolutional Neural Network).

After detection of any human being that live updates, record will be stored in the cloud-based storage system from where we can access those records through the API and with proper networking (Babulal & Tewari, 2011) live updates for different place at the same time can be provided to the related organization or firm. For this we have used Application development tool such as database, Restful web services for API consuming, Native web application development technology which can run on any type of devices as a platform independent resource. Work Flow of the proposed framework IFRCNN is displayed in Figure 3.

Figure 2. Physical implementation and internal working of proposed model

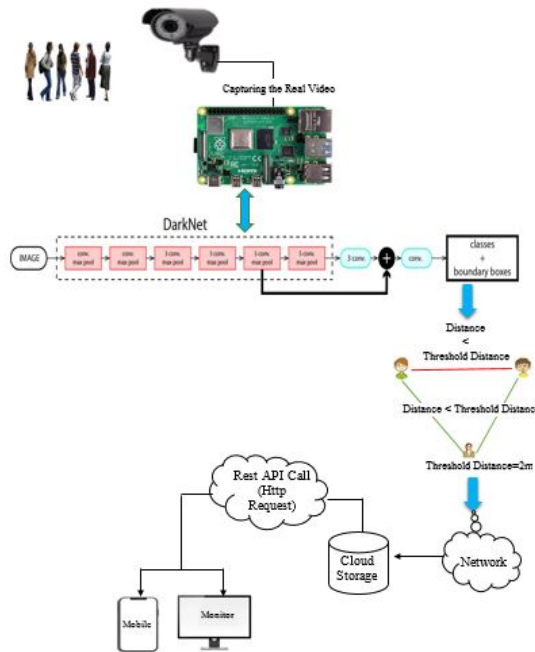
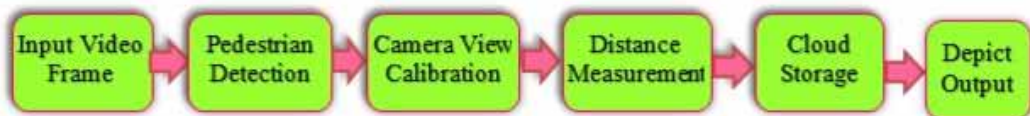


Figure 3. Flow of the proposed framework IFRCNN



Input Video Frame

For capturing video frames as a perspective view camera is placed at a specific angle. The images presented here are taken from the video processed using the system.

Pedestrian Detection

In object detection techniques Deep CNN model assists to diminish the computational complexity matter by comprising the detection escorted by single regression issue(Lowe, 2004). YOLO model is believed to be the best cutting edge object detectors which can be used to exemplify to produce outstanding speed benefit that will be appropriate for real-time application for deep learning(Basha & Rajput, 2018; Gadekallu et al., 2021)-based object detection. In order to construct this task, the YOLO model is chosen for pedestrian spotting. YOLOv3 uses Darknet-53 as a feature extractor. Darknet-53 has 53 convolution layers and therefore is more efficient and also offers speed to the whole process. The YOLO algorithm used for object detection takes a specific input image moreover generates bounding box coordinates (t_x, t_y, t_w, t_h) , object confidence and corresponding class label probabilities (P_1, P_2, \dots, P_c) . The object detection Algorithm (YOLOv3) is trained on COCO dataset that comprises of 80 other labels incorporating pedestrian or human. The proposed work obtains detection results in YOLO model only object confidence, box coordinate and pedestrian object class is utilized for pedestrian detection.

Camera View Calibration

From the pedestrian walking on street, a top-down 2D view which comprises of 480*480 pixels is obtained from the region of interest (ROI) of an image. Calculating the modification of the top-down view from perspective view is done by camera view calibration. Four points in perspective view are chosen in OpenCV and further mapped with corners of rectangle in 2D view. Therefore, it is presumed, every individual is standing on the same level flat plane. With the number of pixels in top-down view the actual distance among pedestrian can be determined.

Distance Measure

Distance among pedestrians can be calculated and scaled, once we obtain the bounding boxes. If the calculated distance is less than the acceptable distance between any individual on the preset minimum distance, that both persons will be connote by red lines that will act as cautionary alert. For calculating distance Euclidean distance is used.

Euclidean Distance

Euclidean distance computes the distance among two real-valued vectors. We are very probable to utilize Euclidean distance while computing the distance among two rows of data that have numerical values, such a floating point or integer values. Euclidean distance is calculated as the square root of the sum of the squared differences between the two vectors:

$$Euclidean_Distance = \sqrt{\sum_{i=1}^n (v_1[i] - v_2[i])^2}$$

To speed the calculation, when the distance calculation is executed a few thousands or millions of times it is normal to discard square root operation. After this modification the resulting score that will be obtained will have the same relative proportions and can be still used efficaciously inside machine learning. (Kumar & Thakur, 2019, 2021a, 2021b) (D. Rajput, Thakur, Thakur, & Sahu, 2012) algorithm for finding the most similar examples:

$$Euclidean_Distance = \sum_{i=1}^n (v_1[i] - v_2[i])^2$$

Cloud Storage

After finding the distance between the object at different localities where the camera is placed, the resultant (count of object (those violating social distancing), GPS coordinates)) is stored on the Cloud. For the purpose of data security and to make the cloud environment more secure and robust, the concept of blockchain technology is used. With the use of blockchain technology the chance of data tampering can be avoided without depending on any third-party entity. With the sandwiching of cloud along with blockchain, if any users wants to do any transaction over the stored data they have to first verify that whether the user is authoritarian or not, if yes common approval required from all the verified users. Once the changes have been made, the block with the adequate information like who performs the changes, time of the transaction, gas value, etc. is kept in a block and added to the blockchain to make it robust.

Depict Output

Now this information can be sent to authorities/or applications where it could be updated and further action could be taken in order to prevent the spread of COVID-19.

RESULTS AND DISCUSSION

The input videos are fed to the system using OpenCV. The video is processed and the object i.e., human is being detected and it is observed that the desired object is captured in the RED/GREEN bounding boxes while handling changes in environment and conditions like number of different objects present, color etc. The huge variation in the video demographic and the presence of different objects and constantly changing conditions, object (human) detection is a challenge and the system is expected to handle this diversity efficiently and therefore proper training is required.

In the Fig 4 result we are getting different objects but our RoI(Region of Interest) is only human beings so those objects only get extracted and bounding boxes applied on only those objects. In the Fig 4 three human being got detected and among them the distance is found greater than 2m that's why those all 3 human beings are appears in green bounding boxes. So here none of them are violating social distancing.

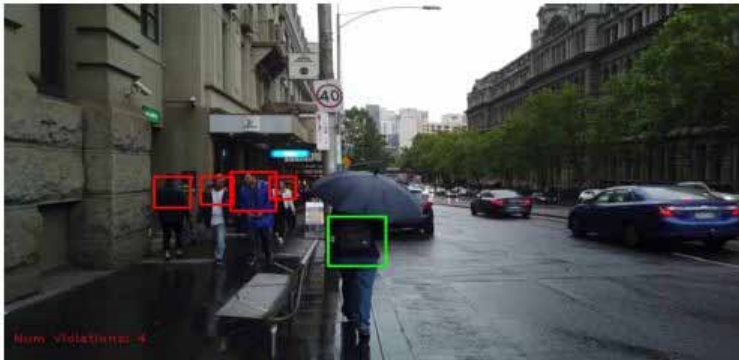
After applying the Euclidean distance algorithm on the bounding boxes, it is getting distance between those bounding boxes, so if any distance found to be less than 2m then the bounding box appears of those objects in RED color whereas if the distance is greater than 2m then bounding boxes appears in GREEN color.

Figure 4. Social distance monitoring among people



In the Figure 5 Video frame we are getting several different objects like Human Being, Car, Umbrella, Trees, Speed Marks etc. As our RoI is human being so with usage of the YOLO Model, only human beings are considered and RED/GREEN the bounding boxes are created accordingly. From the Figure 5 it can be observed that 5 different human being who are walking on street among them one object has greater than 2m distance from others who is appearing in green bounding box whereas 4 different human being are very close to each other and their distance w.r.t others is less than 2m that's why they all are appearing in RED bounding boxes.

Figure 5. Social distance monitoring among people



In initial days of COVID-19, people are not following social distancing as they are not much aware cause of spread of covid-19, so at that time spread factor is 100% but day by day as people are knowing the advantage of social distancing to avoid spread of covid-19 and when people started following the social distancing, it is decreasing day by day and the spread factor also got reduces as shown in the above resultant. Range of spread factor is between (0-1). We have considered 10000 people on Y-axis and 200 days (approx.) on X-axis. Figure 6 indicates that if 0% or non-followed social distancing, then within 20-25 days near about 100% population will be infected by COVID-19. Figure 7 indicates when social distancing is set to 0.5 or 50% i.e., half of the population follows social distancing, then within 50-55 days near about 80% population will be infected by COVID-19. Figure 8 indicates when social distancing is set to 0.25 or 75% i.e., $\frac{3}{4}$ of population followed social distancing, then within 85-90 days near about 30% population will be infected by COVID-19. Figure 9 indicates when social distancing is set to 0.20 or 80% population followed social distancing, then within 120-125 days near about 20% population will be infected by COVID-19.

Figure 6. COVID spread analysis graph when 0% social distancing is followed

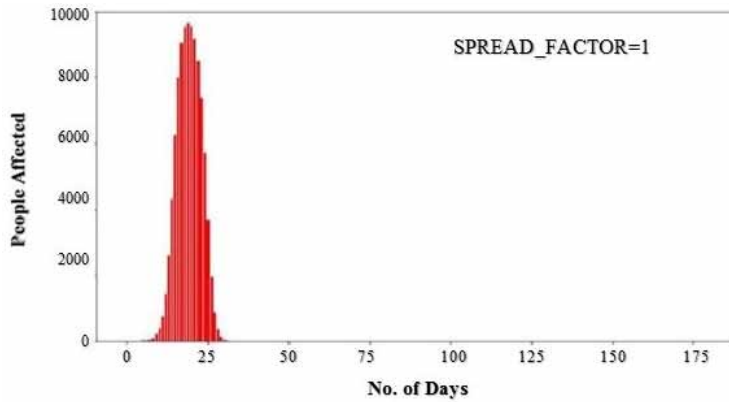


Figure 7. COVID Spread Analysis Graph when 50% population follow social distancing

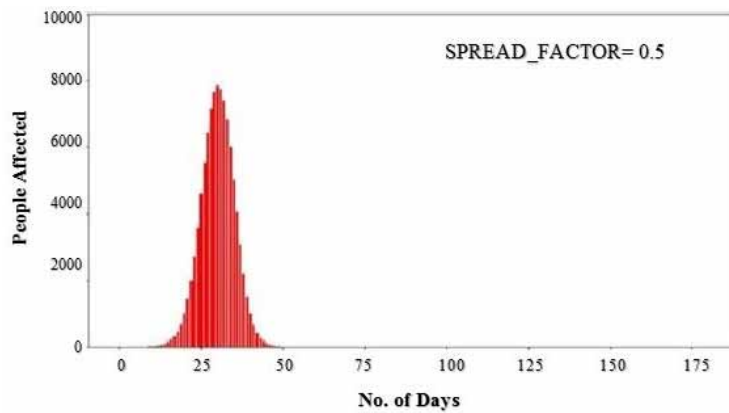


Figure 8. COVID spread analysis graph when 75% population follow social distancing

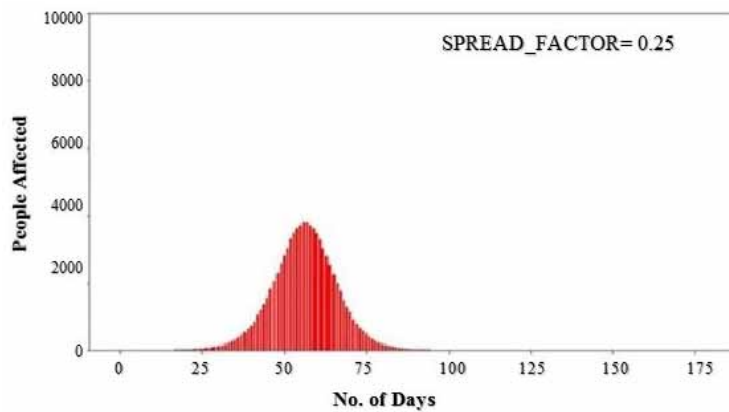
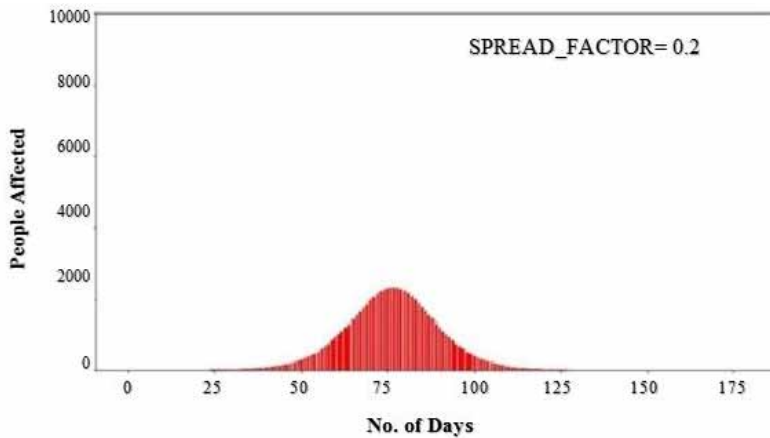


Figure 9. COVID Spread Analysis Graph when 80% population follow social distancing



With the decline in the cases of infected individuals, authorities can ensure decline in deceased individuals and as less individuals are infected authorities can ensure better hospitalization and medical facilities to the infected individual. With better medical facilities the survival rate would definitely increase. We can observe from the results that as the number of cases drops, this leads to decrease in death rate by following proper social distancing. From the resultant we can observe that by following social distancing the spread of COVID-19 can be reduced and at the same time one should keep in mind that as the Corona Virus has characteristic to mutate, even if a single individual is infected there will be risk of spread of COVID-19.

Table 1. Comparative analysis of different approach

Authors	Input	Tools/Software	Distance Calculation	Live	Accuracy
(Chaudhary, 2020)	CCTV	Keras-RetinaNet + Multitask Cascaded CNN	Law of Similar Triangle	No	85%
(Ahamad et al., 2020)	Self-Taken Video	MobileNet Single Shot Multibox Detector (SSD) + Open CV + COCO dataset	Mid-point Equation	No	68%
(Shukla et al., 2021)	CCTV	OpenCV + Yolo + COCO dataset	Not provided	No [Conceptual Model]	85%
[IFRCNN] Our Proposed Framework	CCTV + Raspberry Pi Kit	Faster R-CNN + OpenCV + YOLOv3 + COCO dataset + Cloud Storage	Euclidean Method	Yes	89%

Table 1 shows the accuracy of the IFRCNN model is 89% which is higher accuracy as compared to (Chaudhary, 2020), (Ahamad et al., 2020), (Shukla et al., 2021).

CONCLUSION

IFRCNN framework is proposed for a real time surveillance system for detection of social distancing using Yolo model of Faster RCNN. The proposed framework shows that the goal of social distancing can be completely monitored automatically and better preventive measures (rules) could be implemented time to time till risk of COVID-19 persists. This system automatically monitors the social distance which reduces the manual workload of the disaster management department. The accuracy of the IFRCNN model is 89% which is higher accuracy when compared to the existing models. This model IFRCNN can be implemented at various crowded places in-order to detect the violation of social distancing and better levels of social distancing policy could be executed. This approach can be implemented in any organization like industry/firm, educational places, market places etc. to erect stringent guidelines and course of action for social distancing. Social separation is and will remain the primary hygienic measures, as the new variant of Covid-19 will keep coming frequently for several years. With this mass screening with CCTV for surveillance will be possible throughout the pandemic. In future using blockchain technology penalty can be laid down on the individual not following appropriate social distancing and also the work can be additionally enhanced by improving object detection algorithms and by constructing hybrid algorithms which can assist in mask detection, coughing and sneezing detection. Accuracy and precision can also be further improved as this application is intended to perform in real-time as wrong information may create confusion among individuals.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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Not Applicable

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