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Estimating social distance in public places for COVID-19 protocol using region CNN

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Article Info	**ABSTRACT**
	The coronavirus disease has spread throughout the world and its fear has made people to be more cautious in public places. Since precautionary measures are the only reliable protocol to defend ourselves, social distancing is the only best approach to defend against the pandemic situation. The reproduction number i.e. R0 factor of COVID-19, can be slowed down only through the physical distancing norms. This research proposes a deep learning approach for maintaining the social distance by tracking and detecting the people present indoor and outdoor scenarios. Surveillance video is taken as the input and applied into you only look once (YOLO) V3 algorithm. The persons in the video are identified based on the segmentation algorithm present within the framework and then using Euclidean distance the image is evaluated. The bounding box algorithm helps to segregate the humans based on the minimum distance threshold. The proposed method is evaluated for images with peoples in the market, availing essential commodities and students entry inside a campus. Our proposed region-based convolutional neural network (RCNN) algorithm gives a better accuracy over the traditional models and hence the service can be implemented in general for places where social distancing is mandatory.

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1. INTRODUCTION

Detection of COVID-19 for the past 2 years with the basic symptoms is a challenge. In the city of Wuhan, there were a lot of pneumonia cases of COVID-19 found in December 2019. The entire world is under the grip of the fear caused by this latest digital age demon, it spread to almost all the countries and the numbers of new COVID-19 cases and deaths appear in day-to-day life with many new variants. Though the initial formation and spread of this menace is still a subject of suspicion, the devastating effects that have been caused by this invisible enemy to mankind is uncountable. The global COVID-19 pandemic has perhaps created first of a kind of universal teachable moment for humanity, exposing the fault lines of our societal and economic structures and institutions and how they serve us in a moment of acute crisis. It is mandated to self-isolate, limit external interactions through social distancing and follow protocols defined by the World Health Organization (WHO). Social distancing is the best practice that aims to minimize or interrupt more spread of COVID-19. It also reduces the physical contact between possibly infected individuals and normal persons. Figure 1 shows the picture depicting the people in the market who does not maintain social distancing in Figure 1(a) and people who maintain social distancing is presented in Figure 1(b).

The measures of social distancing are adopted to prevent the spread of this disease by reducing the occurrences of people coming into contact and maintaining a physical distance with individual persons. Most common symptoms were fever, cough, loss of taste and smell, headache, and red or irritated eyes. Transmission of the COVID-19 virus spreads more easily in crowded places, in close contact with persons, especially people who have communicated with each other in very near, enclosed, and confined spaces with less ventilation. Transmission can occur through the nose or mouth, if splashed or sprayed with contaminated fluids in the eyes, through droplets or aerosols, and rarely via contaminated surfaces. The most common transmission occurs when an infected person coughs, sneezes, or talks.

This proposed work identifies the distance between people standing in a crowd or in any queue where there is a possibility of spreading diseases. WHO has given instructions to adopt social distancing as an effective way to mitigate the spread of the COVID Coronavirus affects many people in different situations.

| (a) | (b) |

Figure 1. People in the market who (a) violate social distance and (b) maintain social distance

2. RELATED WORK

The paper of Das *et al.* [1], proposes a novel social distancing method and crowd identification with focus on density estimation, anomaly recognition and high-risk detection. Experimental results using the global nearest neighbor tracking algorithm suggest that it is providing a good accuracy. In the paper titled "Social distancing and face mask detection from CCTV camera," a mask detection using openCV was proposed. It suggests that the system will detect face masks in photos/images using real-time videos [2]. Shalini *et al.* [3] proposes a social distance analyzer using computer vision by evaluating a video feed obtained through a surveillance camera. The paper of Kumar *et al.* [4] proposes to detect social distancing with footage of people walking on the pedestrians and creates a red or green bounding box using a deep learning approach. Monitoring social distance under low light conditions using deep learning and motionless time of flight camera is proposed by Rahim *et al.* [5]. The work describes the risk factor involved based on the density of the violation. In the paper of Saponara *et al.* [6], implementing a real-time, AI-based, people detection and social distancing measuring system for COVID-19, it has been deployed with a low-cost embedded system (Jetson Nano) which has fixed cameras and no rotational cameras. A Fine-tuned you only look once (YOLO) v3 with deep sort techniques is proposed to track people who frequently violate the distancing norms. The paper proposes an improved regional convolutional neural network (RCNN) with feature amplification and oversampling for aerial images [7].

3. PROPOSED MODELLING

The Theme of the work is to examine whether the people keeps the perfect social distancing in a friendly manner, the proposed system checks using a CCTV camera. Using YOLO V4 algorithm, the detection of human is implemented. YOLO V4 is a tool that separates video into a number of image frames. These frames were used to compute region proposals using RCNN algorithm.

3.1. The YOLO V4 algorithm

One of the fastest object detection methods available is you only look once (YOLO). Though it is no longer the most accurate object detection algorithm, it is an excellent choice when real-time object detection is required without sacrificing too much precision. The third version of YOLO was released with the speed which has been traded off for boosts in accuracy in YOLO v4. It is the real-time object detection method that recognizes particular objects in Indian films, real-time feeds, or photos. YOLO v4 now classifies items seen in

photos using multiple labels. Some authors used to apply the class scores in the early versions of YOLO and consider the class with the highest score value to be the class of the image encompassed in the deducted object of the bounding box. This was altered in YOLO v4. Figure 2 shows the splitting frames of YOLO.

The Target detector of YOLO v4, which satisfies real-time needs for a particular issue, offers the benefits of detecting speed and precision. However, YOLO v4 demands high hardware performance and includes a lot of backbone network characteristics, which is not good for the spread of applications. In this proposal, the video is captured by a real-time CCTV camera, with video data acquisition the crowd is detected using artificial intelligence. The result is transferred to a one-stage detector which detects the people alone and finally, the images were split into a number of frames.
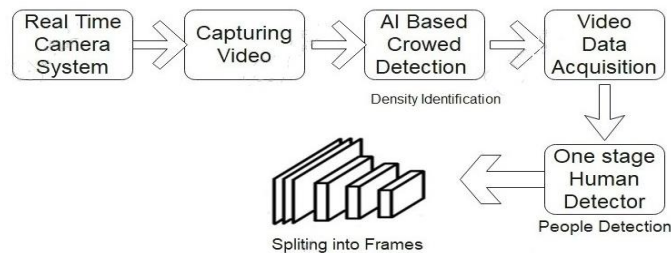

Figure 2. YOLO Architecture for splitting the frames

3.2. The region based convolutional neural network algorithm

The RCNN is central to deep learning and has impressive detection effects [8]. The RCNN method classifies the object area with trained CNNs and then determines whether it belongs to the object or background object area. The RCNN pipeline begins with the development of region proposals or regions in an image that potentially corresponds to a specific item. The selective search algorithm generates image subsegments that potentially belong to one object based on color, texture, size, and shape, and then repeatedly combines comparable regions to construct objects [9]. This generates object proposals at various scales in the images. The Figure 3 shows the Architecture for the detection of objects.
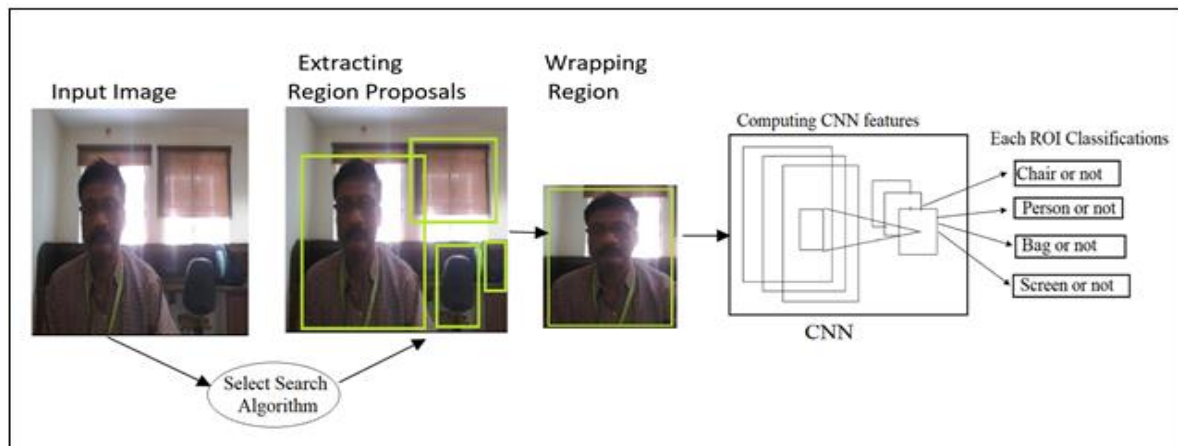

Figure 3. RCNN architecture for object detection

3.3. The overall architecture of the proposal

Classification and localization are two separate tasks in object detection. An RCNN is a region-based convolutional neural network. Region proposals are the key factor in the RCNN series. To locate objects within an image, the region proposals were used. The RCNN detection algorithm has two stages. The first stage selects a selection of image regions that may contain an object. The object is classified in each region in the second stage. The selective search technique is used in this RCNN architecture to create around 2,000 area ideas. These 2,000 region suggestions are then sent into the CNN architecture, which computes CNN features. Then these

features are fed into an support vector machine (SVM) model, which is used to classify the given object in the region proposal. Figure 4 shows the overall architecture of the proposed system.
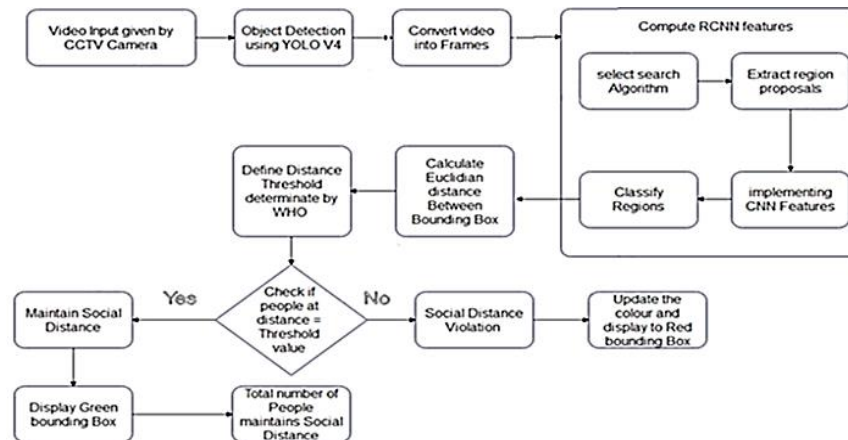

Figure 4. The architecture of detecting social distancing measurement using RCNN

3.4. Implementation

The crowd density, crowd counting, and flow estimation are some components that are focused on monitoring the crowd [10]. The video is captured and recorded by a CCTV camera which is given as an input. Using a CCTV camera the region of interest (ROI) of a video frame focused on the person who is walking is captured. By transforming the view frame captured into a bird's view environment the calibration is done. Each person in the frame performing this transformation is considered to be standing on the bounding box technique. The implementation of the work is presented in Figure 3. The major idea behind YOLO [11] is to divide the original image into an S x S grid cell. In this cell, only one object is predicted and a fixed number of boundary boxes, then for each grid cell it predicts B boundary boxes using a confidence score. Next, it detects one object only and it predicts C conditional class probabilities, one per class. The predicted class represents the highest score with a distance threshold of 1 meter. Figure 5 shows the individual person detection in the system.

Figure 5. Individual person detection with the bounding box

The final classification of the result get from RCNN is measured by the Euclidian classifier as presented in Figure 2 [12]. The most common World health organization value for accepting a valid social distance is 1 meter which is set to a threshold value. The model checks whether the threshold value matches the individual people [13]. If it matches the model decides that the distancing is maintained or else it decides social distance violation occurs and the model displays the bounding box with the color red as shown in Figures 6 and 7.

The deep learning algorithm can be implemented in automated systems which can be used in health centres [14]. Deep learning gets its name from the number of additional layers we utilize to learn from data. If we don't already know, when a deep learning model learns, it simply updates the weights using an optimization function. The process flow of our model starts with getting input from a camera as a video frame, detecting the crowded place, camera view calibration, distance measurement, and finally getting the result.

In this process, various sets of features like movements of arms, and movements the body are extracted in order to get effective results. The implementation of various images and videos suggests that our proposed method of using RCNN for the identification of social distancing is better when compared to CNN. In recent years computer vision is an interdisciplinary area of the field which has been gaining more amounts of object detection in recent years. The RCNN approach is similar to the CNN algorithm but the difference is that in the RCNN detection algorithms, we draw a bounding box around the desired object to locate it within the original image. Also, we might not necessarily draw just one bounding box in an object detection environment, there could be more bounding boxes representing various objects of interest in the same image very faster than CNN. Some of the limitations of the proposed work are the picture quality should be very high and the cameras should be used for the detection of people during night times in low lighting conditions. It is difficult to detect the person and calculate the distance in an uncontrolled background environment.

Figure 6. Individual person detection with social distance

Figure 7. Violation of social distance

4. RESULTS AND DISCUSSIONS

Distance measurement is the most important part of the work, and therefore to find out the distance between two points Euclidean distance measuring algorithm is used. Lets assume that (x_1, y_1) and (x_2, y_2) are any two points and the distance is evaluated as $d = \sqrt{[(x_2 - x_1)^2 + (y_2 - y_1)^2]}$. Based on this the research work takes up an area where there are 15 people. Table 1 summarizes the distance calculations and their adoption towards threshold value. It can be seen that among all the 15 people only 4 coordinates have violated the social distancing which is shown in Figure 8 and other coordinates have social distancing. Considering these two points P (x_1, y_1) and Q (x_2, y_2) that d is the distance between them joining P and Q by a line segment and constructing a right-angled triangle whose hypotenuse is PQ. For this, use horizontal and vertical lines from P and Q which meet at t1 as given in Figure 9.

Table 2, present the coordinates of PQC and I with their Euclidean distance to show that they have exceeded the threshold limit of 1 meter. The proposed work also evaluated around 10 different datasets as presented in Table 3, under different public places and found that the RCNN algorithm works better and detects violators. This study uses the framework to predict intentions of social distancing violation and past non-compliance during the COVID-19 pandemic. Figure 10 shows the total violated and non violated coordinates.

Table 1. Violation of social distance among 15 people

| People	X axis	Y axis	Social distancing
Person 1 (P)	**3**	**2**	**Violated**
Person 2 (A)	1	10	Non violated
Person 3 (B)	9	2	Non violated
Person 4 (Q)	**4**	**1**	**Violated**
Person 5 (C)	**4**	**3**	**Violated**
Person 6 (D)	7	7	Non violated
Person 7 (E)	9	6	Non violated
Person 8 (F)	12	1	Non violated
Person 9 (G)	3	8	Non violated
Person 10 (H)	1	6	Non violated
Person 11 (I)	**5**	**4**	**Violated**
Person 12 (J)	1	1	Non violated
Person 13 (K)	10	10	Non violated
Person 14 (L)	5	10	Non violated
Person 15 (M)	12	5	Non violated
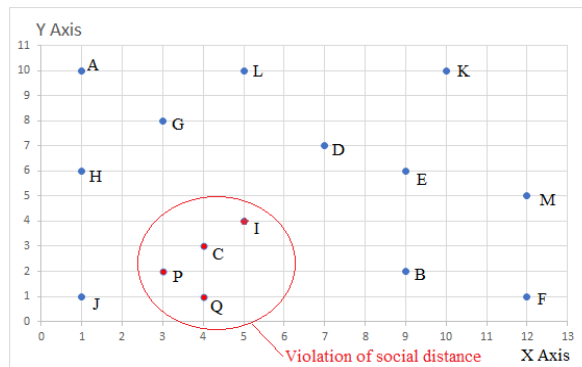
Figure 8. Coordinates of people standing in an area and violation of social distance
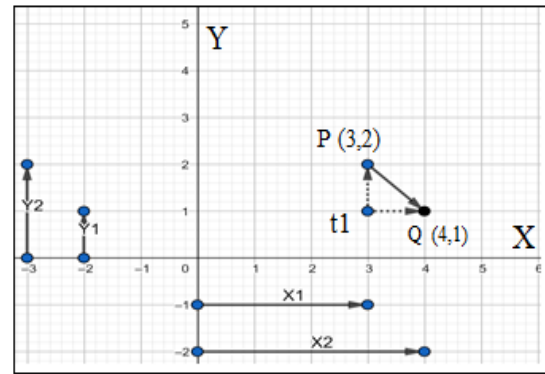

Figure 9. Graph showing the distance between the two coordinates of persons P and Q
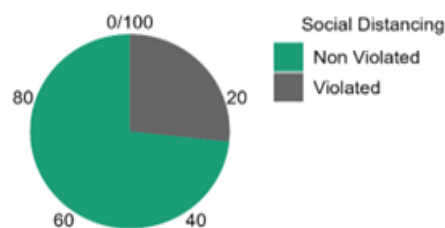

Figure 10. Total number of violated and non-violated coordinated

Table 2. The distance calculation of coordinates P, Q, C, and I

Coordinates which has no social distance	Meeting point	Euclidean distance (in units)
P, Q	t1	2
P, C	t2	1.41
C, I	t3	1.41
Q, C	t4	2

Table 3. Findings of violation of social distance from various video file formats

CCTV videos	Video file name	Total No. of persons detected	No. of persons following social distance	No. of persons violating social distance
1	group.mp4	14	6	8
2	crowd.vlc	16	10	6
3	people_walking.avi	8	5	3
4	walking.avi	12	8	4
5	people_stock.fly	8	4	4
6	people_video.mp3	7	4	3
7	school_students.mov	15	11	4
8	street.mp4	9	6	3
9	play_ground.mpeg	8	5	3
10	market.mp3	9	6	3

The quantile-quantile (Q-Q) plot [15], [16] implies a graphical representation of the quantiles of two distributions in relation to each other. It plots quantiles against quantiles to obtain the solution. When reading a Q-Q [17], [18] plot, 'y = x' line is considered. The Q-Q plot is a graphical approach for detecting whether two data sets are from the same population. For the data shown in Table 1, the below graphs shows the plots for X and Y quantities in Figures 11 and 12.

The research describes a deep learning-based system for detecting social distancing in order to reduce the impact of the coronavirus pandemic [19]–[21]. The detection tool was created to warn people [22]–[25] to keep a safe distance from each other by analyzing a video feed.
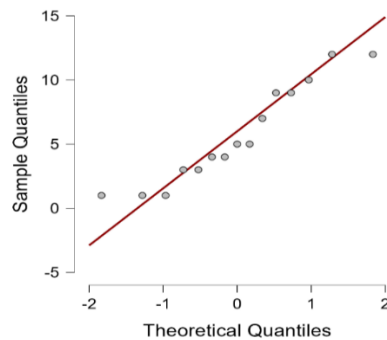
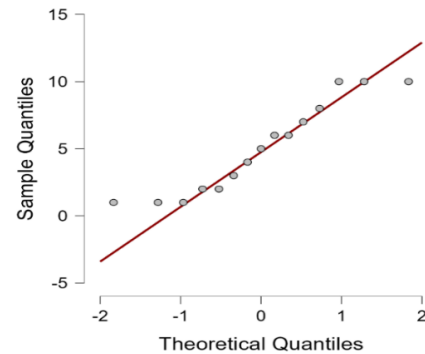Figure 11. Graph showing plots for X axis quantities

Figure 12. Graph showing plots for Y axis quantities

5.   CONCLUSION

The objective of this study is to analyze and classify the social distancing among groups of people gathered in a place. Analyzing the video footage of any public place and finding the distance between people is a challenging task that involves machine learning algorithms for searching the people present and calculating the distance between them. Our proposed work is a novel approach where it helps to monitor the distancing norms imposed during the COVID-19 protocols in public places. The algorithm uses region-based CNN which seems to be better than the traditional CNN algorithm. Our approach effectively detects and identifies the density of the crowd and tells whether the crowd is violating the norms or not. Also, the work was tested in different public places like schools, markets, railway stations, and found to be very effective. This method can be extended with the classification of videos where there are multiple violations that occur and where norms need to have strictly adhered. This will ensure that the public monitoring system to prevent COVID-19 will be digitally enhanced and will certainly benefit society. Depending on whether or not people are adhering to social distancing, this proposal creates red or green bounding boxes over it. It can also recognize persons in real-time on web cameras, and CCTV. This could aid in the development of public space layouts or the implementation of preventative measures to lessen high-risk areas. it may also be utilized in areas such as driverless vehicles, action recognition technology, and crowd analysis.

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