Implementation of social distancing for COVID 19 using YOLO

Mr. Mahesh G[#1], Dr. Chidananda Murthy M V[#2], Dr. M. Z. Kurian[#3]
Dept. of E & C, SSIT, Sri Siddhartha Academy of Higher Education, Tumakuru, India.

Abstract: **The contagious disease COVID 19 (Corona VIrus Disease 2019) which is caused by the novel CORONA virus has imposed lot of restrictions on the civilian movements within and between the countries. The WHO (World Health Organization) has passed a strict imposition to follow Social Distancing (SD) in order to prevent the spread of the disease. SD is nothing but keeping a least separation of 2 meters or 6 foot between the individuals in public places. Also, SD emphases on no contact or minimum contact between the people who are not from your household. The vaccination against COVID 19 disease might require a sufficient amount of time (few months to a year). Hence SD is the only current non pharmaceutical solution to curb the spread of this pandemic. On the other hand, the common people are not used to practice SD and maintain a safety bubble of 2m around them always. Hence there is a requirement of an automatic system that could help maintain the required SD without much difficulty.**

The object detection techniques are playing an important role in detecting various common objects that are seen in our day to day life. YOLO is the recent and real time object detection technology. In the field of computer vision, object identification is thought to be one of the most challenging tasks. In YOLO with a single evaluation, the bounding boxes and class probabilities are anticipated using only one neural network from the images directly. In the meantime, frame detection is treated as a regression problem. The intended scheme utilizes inverse perspective mapping and YOLOv3 based algorithm for detection of people accurately and to implement social distancing.

Keywords **– COVID-19, CORONA virus, Social Distancing, People Detection, YOLO, YOLOv3.**

I. INTRODUCTION

The new generation of the coronavirus disease (COVID-19) was reported in late December 2019 in Wuhan, China. Only after few months, the virus became a global outbreak in 2020. On May 2020 The World Health Organisation (WHO) announced the situation as pandemic [1],[2]. The statistics by WHO on 21st July, 2021 has confirmed cases of about 19,13,86,140 and a scary number of 41,05,450 deaths in more than 200 countries. India alone has encountered a total number of 3,12,15,142 infections with 4,18,511 deaths. With the growing trend of patients, there is still no effective cure or available treatment for the virus. Therefore, precautions are taken by the whole world to limit the spread of infection. These harsh conditions have forced the global communities to look for alternative ways to reduce the spread of the virus.

With the growing trend of patients, scientists from all over the world, medical organisations and researchers of pharmacy industry are continuously occupied and striving hard to produce suitable medicines or vaccines for the deadly virus. As a result, many countries have produced vaccines within a very short period of time. As the time required for vaccinating the whole population of the country may take few months and up to a year. And also, the newly invented vaccines are not yet proved to be secure and effective for people of all age groups. Still research and clinical trials are in progress for children and pregnant women. The clinical tests are under process and results awaited. As a result, necessary precautions are to be taken by all countries of the whole world to prevent the spread of this infectious disease [3],[4].

It has been proved that COVID-19 is a contagious disease. So the virus can be carried by the air through minute particles of saliva which may enter the air once infected people cough or sneeze without any respiratory etiquettes or speak without wearing face mask. The chances are more in poorly ventilated settings, crowded or closed areas. This is the main purpose of maintaining this minimum distance to avoid spread of virus from reaching the other person through air or wind [5].

The virus has spread to almost all countries of the world in spite of severe actions such as border closure, partial / complete lockdowns in their countries and simultaneously isolation and treatment of infected individuals is carried down to prevent the spread of disease. Adopting these measures for prolonged periods affects the economic condition of the country and its people. At the same time the people will also find it difficult to lead their lives during complete or partial lockdowns of the countries or cities as a lot of people have lost their jobs and other earning sources. The disease was under control till end of 2020 with stringent SD rules being imposed on citizens. Later, as the daily number of cases started decreasing, the government started easing the SD measures. Slowly, the restrictions on movement across the borders, re-opening of shopping complexes, public transport, restaurants, are eased down to boost the economy.

As a result many countries have faced severe second wave of the disease and few are in third wave. These tough conditions have forced the entire world's population to search for other substitute means to reduce the

spread of the virus. Hence, during this process of removing restrictions, the government and citizens should not forget to maintain SD measures. The only current feasible solution to lift the imposed lockdown in order to manage the economy is strictly following Physical distancing and minimizing human contacts. Social distancing helps prevention of multiplying of the contagious infection, by reducing the vicinity of personal interactions in enclosed or congested shared spaces such as offices or workplaces, gyms, cinema halls, schools or universities, party halls, temples, hotels etc., to slowdown the infection risk. Thus SD plays a pivotal role in prohibiting the spread of corona virus and thus helps in postponing or reducing the peak number of infected individuals.

The fig. 1 shows a general SD scenario where a minimum of 2 meters or 6 foot distance has to be maintained between the individuals.

Fig. 1 Social Distancing scenario [6]

WHO has confirmed that the COVID 19 infected people may show symptoms such as cold, cough and fever with increase in the body temperature. There are chances of taste and smell loss in addition. The researches have also established that, individuals with minor or no symptoms (asymptomatic) might too be the transporters of COVID virus, who are known as passive carriers. Therefore, it is very essential that every individual adopt disciplined behaviours and follow SD [6].

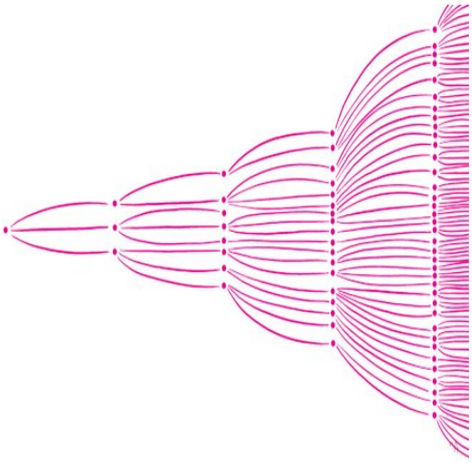

Fig. 2 A single person spreading virus with no SD measures

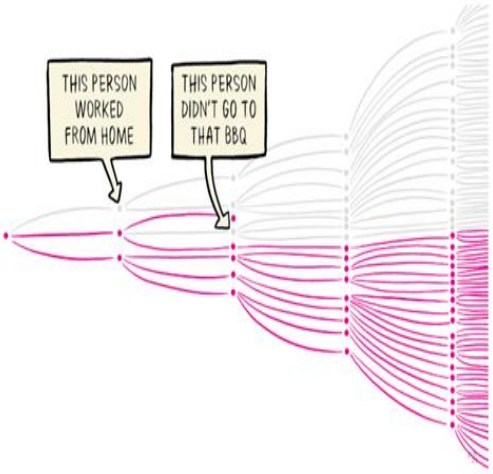

Fig. 3 Total number of cases reduced with few people following SD measures [6]

When no SD measures are adopted, the total number of cases is increasing exponentially by the spread of virus. The fig.2 depicts how, a single person can spread the virus to a large number of people group. It is clear that if the people are allowed to move freely without any SD restrictions, within a short period of time the infections increases to a large number.

With appropriate SD measures such as maintaining a distance of 2m between individuals, few of the people working from home or with closed restaurants, there is a considerable decrease in the total number of cases. In

fig. 3, the total number of people that are being infected is being reduced to approximately half of the previous cases.

A. Social Distancing Effect

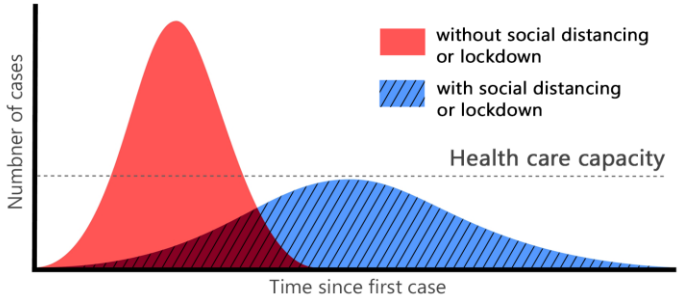

Fig. 4 Objective of SD measures to reduce and delay the peak of pandemic and healthcare capacity

With reference to the above fig. 4, which depicts the total number of infections are at peak within a very short period of time and at the same time exceeding the available healthcare capacity without any SD measures. With SD rules in place, the peak of the epidemic is postponed and the number of cases is matching with the available healthcare capacity. It also gives an extra buffer time for the governments to increase the facilities that are required for treating COVID 19 patients like increasing the beds, acquire sufficient stock of medicines and oxygen etc. [7].

In short, without SD the daily total number of cases will be large and exceed the present available healthcare capacities. And with SD measure, the peak of the pandemic is postponed and the total number of cases does not exceed the present healthcare capabilities.

B. SD monitoring with an automatic system

During the outburst of corona virus disease, with restrictions on people's movement, it is necessary that people will have to go out for procuring the essential goods which are basic for their daily living such as food, medicines, fuel, healthcare and other necessary works. In order to meet such demands, there is a requirement to develop an automatic system that is capable of simplifying social distancing. In India, the government is making use of the contact tracing application known as "Arogya setu" for tracing and tracking of infected persons with the help of internet, Bluetooth and GPS technologies [8].

With this motivation, the authors are making an effort to provide a general meaning of social distancing in the present context to COVID 19 situation. The paper is organised as follows. The system block diagram is presented in section II. Later, in Section III the YOLO object detection algorithm is discussed. Section IV gives the Algorithm for the SD monitoring system. Applications of the system are dealt in section V. Limitations and Future scope are discussed in Section VI and VII. At the end, the paper is concluded in section VIII.

II. SYSTEM BLOCK DIAGRAM

The system consists of 3 phases for SD monitoring, namely

1. Identification of pedestrians
2. Tracking of people and
3. Calculation of inter pedestrian's distance

With reference to fig. 5 which shows the proposed system's overview. Against this framework, we are proposing a non-intrusive, artificial intelligence based active observation scheme for directing audio visual cues whenever a violation of SD is detected. As a solution to the problem of monitoring SD, a 3 stage model is proposed. The system performs function of identification, their tracking and finally the distance between them is estimated.

The images or videos are captured with the help of pre-existing CCTV cameras. The videos or stream of images is then fed as input to our deep neural network model. Then the people are detected in the image with their localising bounding boxes. The proposed scheme has to identify the pedestrians with different postures, varying sizes, different cloth colours and with varying weather conditions such as poor light. With this planned system,

the persons are identified in the given image with bounding boxes utilising a pre trained deep CNN. Then, these findings in the image domain are converted into real-world bird's eye view (BEV) coordinates. Whenever a distance less than the prescribed SD are observed, the model initiates a warning signal. Concurrently, if the number of people in a particular area is over a predetermined value called critical threshold, the system gives an optional control signal to the admin and avoid congestion of people by controlling the number of people that are entering into premises.

This proposed work can be made use to accommodate SD in public areas like Railway stations, public transport systems, Offices or workplaces, Schools and colleges etc.

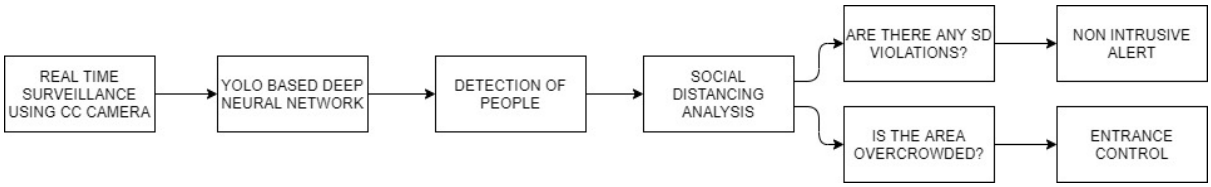

Fig. 5 proposed system's overview

The steps to build a social distancing detector include:

1. Apply **object detection** to detect all people (and *only* people) in a video stream
2. **Compute the pairwise distances** between all detected people
3. Based on these distances, **check to see if any two people are less than *N* pixels apart**

III. YOLO: THE OBJECT DETECTION ALGORITHM

YOLO stands for You Only Look Once. It is the recent and real time object detection technology. In the field of computer vision, object identification is thought to be one of the most challenging tasks. In YOLO with a single evaluation, the bounding boxes and class probabilities are anticipated using only one neural network from the images directly. In the meantime, frame detection is treated as a regression problem, a simple pipeline is enough. It will have an optimised performance i.e. YOLO is extremely fast with pipeline in detection and in one second, it can process 45 frames. Using YOLO it is possible to estimate which objects are present and where they are. Since we assume detection here as a regression problem, a complex pipelining is not necessary.

YOLO has several advantages over classifier-based systems. It looks at the whole image at test time so its predictions are informed by global context in the image. It also makes predictions with a single network evaluation unlike systems like R-CNN which require thousands for a single image. This makes it extremely fast, more than 1000x faster than R-CNN and 100x faster than Fast R-CNN.

A. How It Works?

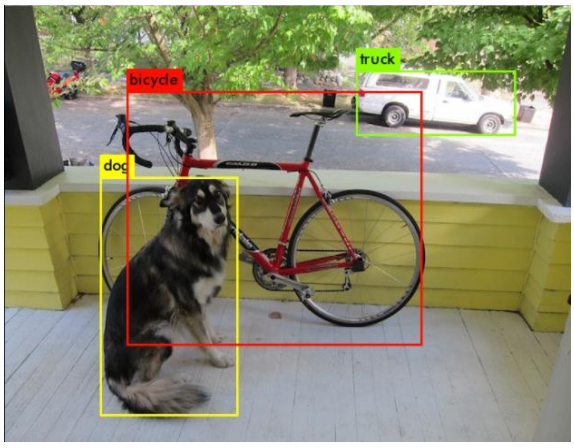

Fig. 6 The objects detected (A dog, bicycle and a truck) using YOLO [9]

Prior detection systems repurpose classifiers or localizers to perform detection. They apply the model to an image at multiple locations and scales. High scoring regions of the image are considered detections.

By default, YOLO only displays objects detected with a confidence of 0.25 or higher. One can change this threshold value by passing the required threshold.

YOLO uses a totally different approach. It applies a single neural network to the full image. This network divides the image into regions and predicts bounding boxes and probabilities for each region. These bounding boxes are weighted by the predicted probabilities. YOLO is pleasingly straightforward: With reference to figure several bounding boxes and their bounding boxes class probabilities are guessed simultaneously using a single convolutional network. YOLO's identification performance is enhanced by pre training it on full images.

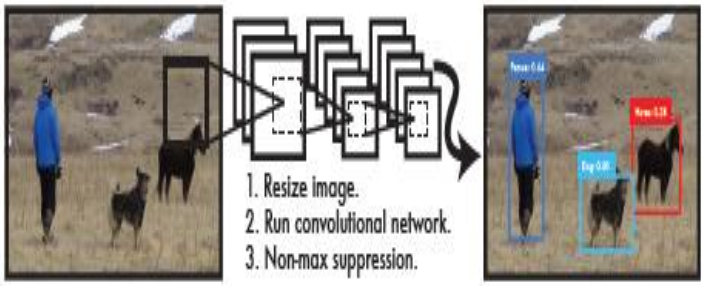

Fig. 7: The YOLO Detection System. The input image is resized to 448X448, then object detection along with their confidences are resulted using a single convolutional network

An image is divided into an SXS grid. Then an object is detected, if its centre stays in that bounding box. For the bounding boxes detected, the confidences are calculated. The confidence is a measure of how confident or accurate the system is about its prediction of the object that it detects. The bounding box confidence will be equal to zero whenever there is no object inside that bounding box. The confidence of the bounding box along with 4 coordinates x, y, w & h are predicted. The centre point of the bounding box is denoted by (x,y). The width and height of bounding box is denoted with x and y respectively [10],[11].

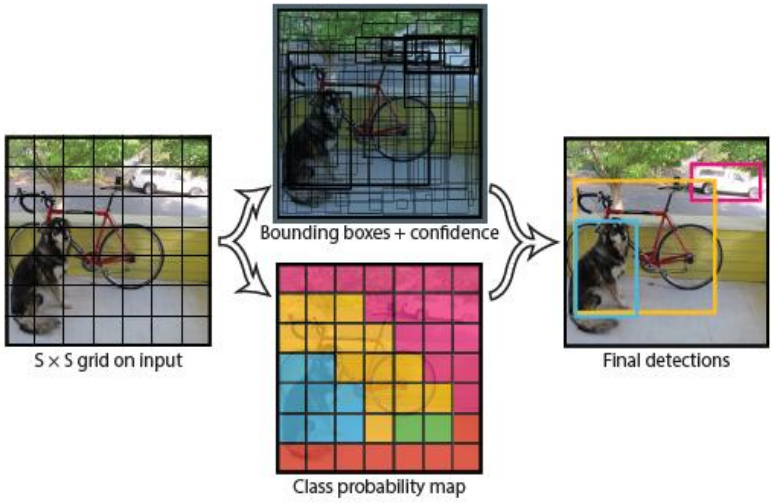

Fig. 8 YOLO object detection procedure

B. Advantages of YOLO

1. YOLO sees a very less number of background errors in comparison with Fast R-CNN

2. On training with natural images and YOLO can detect random images very accurately.

C. Limitations of YOLO

1. Not capable of detecting small objects in groups as it can only predict two boxes and only one class in each grid cell.

2. Incorrect localizations is another source of error

IV. OBJECT DETECTION ALGORITHM

Algorithm for SD monitoring with its steps are listed below:

1. Take the input video stream or directly from camera

2. The people class is detected from the frames and it returns the prediction probability for a person, bounding box co-ordinates and also the object's centroid.

3. The blobs are constructed to perform object detection with YOLO and Open CV

4. Based on the confidences of detection, the people object class is detected with confidence more than the threshold

5. The Euclidean distance between the centroid pairs are computed

6. The calculation of Euclidean distances is repeated until all the distance pairs are calculated

7. With the calculated distance between centroids, check if it is violating SD rules (To check whether the centroids are N pixels apart)

8. If the calculated distance is less than SD recommendations, then bound the object (people) with red bounding box

9. If the calculated distance is more than SD recommendation, then bound the object (people) with green bounding box

10. Determine the total number of SD violations at that time

11. Display the audio visual cue with total number of violations at that time

12. If the SD violations are in large number then send control messages to admin to check the inflow.

V. APPLICATIONS

1. The system might be used in public areas like Shopping Malls, metro & Railway stations, Roads, Cinema halls to maintain required SD

2. The employee's activity in a workplace like an office or a manufacturing plant can be monitored

VI. LIMITATIONS

1. Constraints of weather and in filter design

2. Speed and performance

3. A system with high computational capabilities is necessary

4. The distance here is approximated with the pixels in the image. Hence, the distance calculated will be 80% to 90% accurate.

VII. FUTURE IMPROVEMENTS

1. Using a SSD (Single Shot Detector) will result in faster results, instead of which is quite slow comparatively.

2. A GPU (Graphics Processing Unit) can be employed in the system to improve the throughput.

VIII. CONCLUSION

YOLO serves as an effective object detection technology for detecting people, which assists in implementing SD easily. As per the recommendations from WHO, State and Central government's health authorities, for current situation Social Distancing is the only best and temporary preventive solution to curb spread of infectious disease like COVID-19. Even though many vaccines are being available now, yet their effectiveness is to be experimented and it is not 100% effective. Also, it may take few months to a year to vaccinate the whole population in a country like India.

The proposed SD detector can detect people using YOLO and identify who are violating SD measures. An audio visual cue display shows the violations by bounding the people in red boxes. It is also capable of showing total number of violations at any instant helping the admin to control inflow and outflow.

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