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Monitoring Social Distancing Compliance Using Image Processing Algorithm

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Abstract

Since the outbreak in December 2019, Malaysia has been in the throes of the Covid-19 pandemic, which has had a particularly enormous impact on both the country and the people. Although the government has actively constructed a set of effective standard operating procedures (SOP) to ease the epidemic, such as wearing masks, washing hands often, and maintaining social distance, these have had little effect, and the pandemic continues to grow. As a result, many people have been unable to maintain social distance, allowing the disease to spread to others. According to this viewpoint, a social distancing monitoring system could be a useful tool for monitoring and reminding people to maintain adequate social distance in real time. This system allows for real-time video and CCTV surveillance, as well as effective distance analysis to determine whether the effective social distance has been attained. This strategy can also be used in a variety of venues, including school cafeterias, malls, public spaces, and so on. Otherwise, because shopping malls have a lot of CCTV cameras, the technology can also be deployed there. When a site has a significant number of people but no social distance between them, the system will warn management to improve the location's security measures.

Keywords

Social Distancing, Image Processing, Convolutional Neural Network, Surveillance

Introduction

The World Health Organization (WHO) recommends social distance as a way to keep COVID-19 from spreading in public areas. In shopping malls, schools, and other enclosed locations, the majority of countries and national health authorities have made a 2-meter physical separation an obligatory safety measure. As a result, in addition to wearing face masks, social distancing now claims to be even more crucial than previously assumed, and one of the greatest ways to inhibit the spread of the disease (Liu, H. et al., 2021). People with moderate or no symptoms may also be carriers of the novel coronavirus illness, according to recent research. As a result, it's critical that everyone maintains self-control and maintains social distance (Anon, 2020). Many studies have

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shown that social distancing is an effective non-pharmacological method and a key inhibitor in slowing the spread of contagious diseases like H1N1, SARS, and COVID-19.

Figure 1 shows how adhering to proper social distancing standards might lower the rate of infection transmission among individuals. Patients can better resist the virus by obtaining continuous and timely help from health care organizations with a larger Gaussian curve with a shorter spike within the range of the health system's service capabilities. Any unanticipated dramatic jump in infection rate (as seen in Figure 1) will result in service failure and, as a result, exponential growth in the number of fatalities.

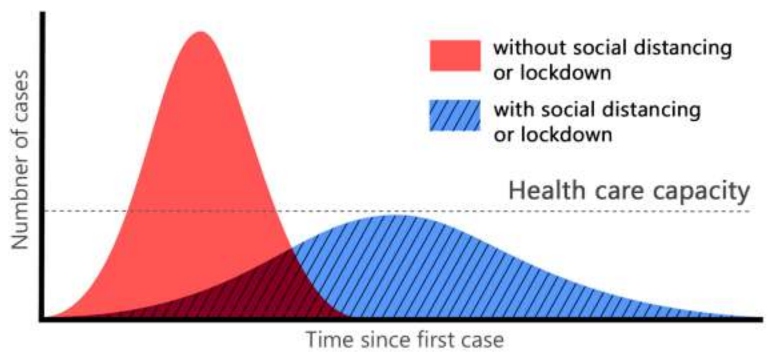

Figure 1. The impact of social distancing on the number of cases

In such situations, the Image Processing algorithm as part of Artificial Intelligence can play an important role in facilitating social distancing monitoring (Rosebrock, A., 2021). In this study, we use ordinary CCTV security cameras to construct a system that supports automatic people detection in crowds in both indoor and outdoor contexts (Ahmed, I. et al., 2021). In this paper, we propose a YOLO image processing algorithm to identify people in real time through CNN (Convolutional Neural Network). The neural networks allow us to extract complicated aspects from data so that we may analyze and classify the objects' features to provide a more accurate comprehension of the images (Gupta, A., 2021; Karimi, G., 2021).

The research work in this paper intends to assist in the decrease of coronavirus spread and associated economic expenses by developing an AI-based method (Image Processing) to automatically monitor and detect social distance compliance among individuals. One of the most important sub-branches of the study of object detection and computer vision is people detection in image sequences (video). Even though many studies have been conducted on human detection and action recognition, most are either limited to indoor applications or suffer from accuracy concerns when exposed to tough lighting conditions outdoors. Other studies use manual tuning approaches to identify people's actions, but restricted functionality has always been a problem (Mehla, S., 2021).

In this view, CNNs have played a critical role in feature extraction and complex object categorization, including human detection. In comparison to traditional models, CNNs allow researchers to construct accurate and quick detectors due to the advent of faster CPUs, GPUs and expanded memory capacities.

Methodology

As a solution for social distancing monitoring, we present a three-stage approach as methodology carried out in this study that includes people detection, tracking, and inter-distance calculation. Similar method has been proposed by Rezaei, M., & Azarmi, M in year 2020. Figure 2 depicts the methodology carried out in this paper.

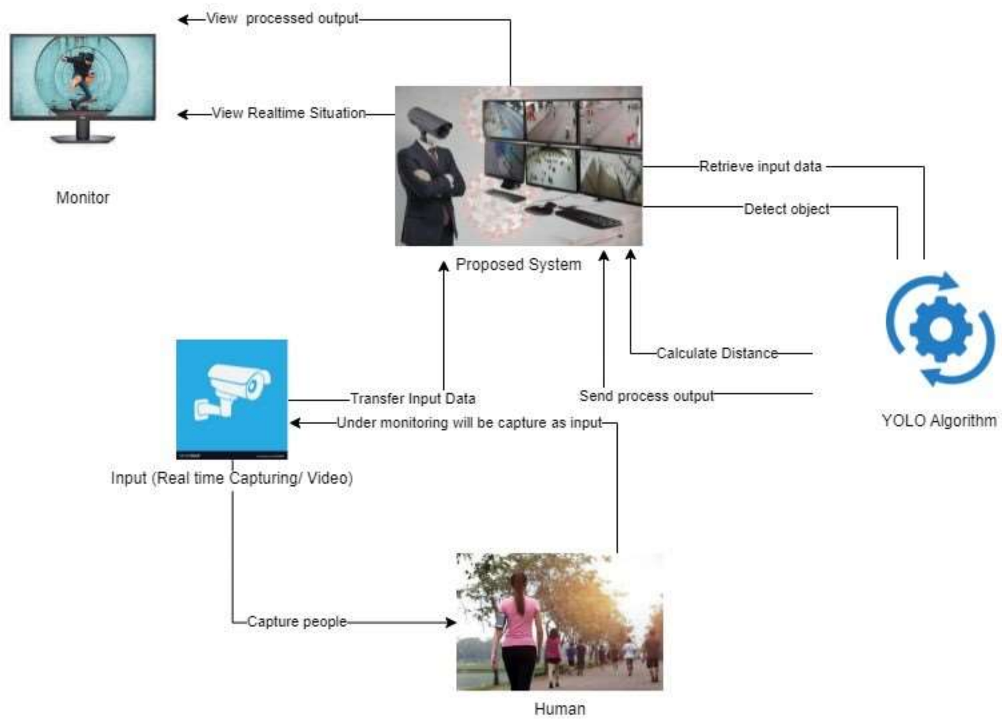

Figure 2. The overall methodology based on YOLO Neural Network Algorithm

1. First stage: people detection. The system retrieves input from the CCTV/Camera. Pre-condition: CCTV/Camera needs turn on as working. The system needs to work properly. Post-condition: Recorded file can successfully transfer to the system.

2. Second stage: tracking, using three approaches: Residual Block, Bounding Box Regression, and IOU (Intersection over union).
   The Residual Block technique will divide the image into various grids. After being divided, every grid has a dimension such as S * S. From figure 3 below is show how to divide the grid into the image. In the image can see many grid cells have been divided into equal dimensions, and each cell has a proper dimension. Objects appearing within grid cells will be detected by every grid cell. When an object appears within a certain grid cell, a grid cell will determine the center of the object (Rosebrock, A., 2021)

Figure 3. Grid Image in Residual Block

In bounding boxes technique, it highlights objects within an image. It is consisting of several attributes such as width, height, class (detect object), bounding box center

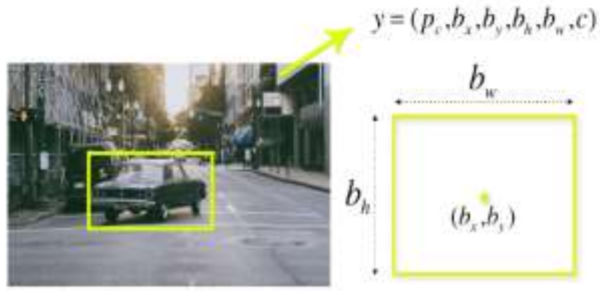

Figure 4. Bounding box technique

In object detection, IOU describes how boxes overlap. It's also providing YOLO with a perfectly round output box. The bounding boxes and confidence scores are predicted by each grid cell. Whenever the predicted bounding box and the real bounding box match, the IOU is equal to 1. In figure 5 below, they have one green bounding box and one blue bounding box. The meaning of the blue box is to predict the green box is the real box. The algorithm is to ensure that the two boxes are equal (Rosebrock, A., 2021).

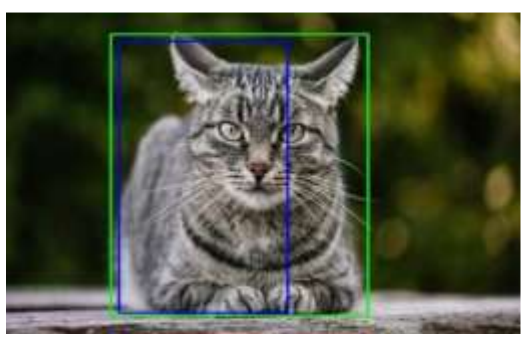

Figure 5. The IOU technique

The following figure 6 was created by combining the three techniques. The image is divided into grid cells. Grid cells exchange confidence scores and predict B bounding boxes. The cells forecast the class probabilities to determine the class of each object. Afterwards, the figure can distinguish between at least three object classes, including a car, a dog, and a bicycle. All predictions are made simultaneously using a single convolutional neural network. IOU ensures that the objects' expected bounding boxes match their actual bounding boxes. When bounding boxes do not fit the shape or dimensions of an item, they are removed. This will be done by determining the bounding boxes that are specific to each object. (Rosebrock, A., 2021; Karimi, G., 2021).

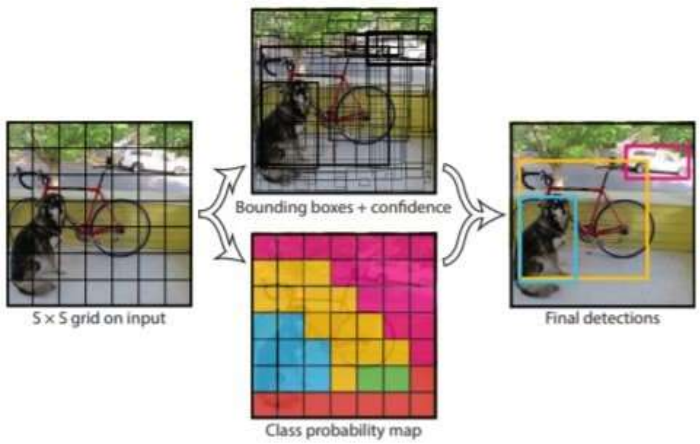

Figure 6. Combining three techniques to detect objects

3. Third stage: inter-distance calculation.
   Steps:
   - Measure the distance of object detection.
   - Measure between two objects distancing
   - If less than 1.5 meters turn green to the red grid.
   - Other more than 1.5 meters will keep green.
   - Generate the output to the monitor

Results and Discussion

This section discusses the steps we took to train datasets followed by experimental findings on people detection, social distance measures, and results visualization. There are five datasets that we include in this paper to show how the YOLO algorithm performs in detecting objects on the five datasets. The five datasets are videos on the hospital (figure 8), indoor room (figure 9), outdoor street (figure 10), downtown area (figure 11), and sightseeing spot (figure 12). To dynamically store and link dataset to the system, we develop a user friendly interface that is simple enough to operate and activate variety of dataset as depicted in figure 7.

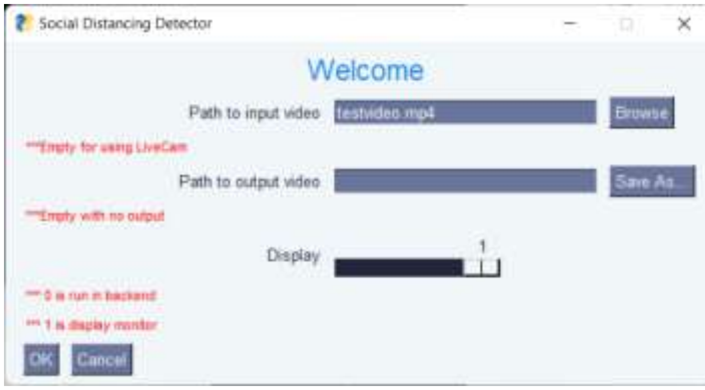

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Figure 7. The user interface to link variety of datasets

Figure 8. Detection performance against hospital dataset

Figure 9. Detection performance against indoor room dataset

Figure 10. Detection performance against outdoor street dataset

Figure 11. Detection performance against downtown area dataset

Figure 12. Detection performance against sightseeing spot dataset

When peoples are not obstructed, the YOLO algorithm performs best. This is where the YOLO identification algorithm poorly perform in the hospital dataset, as a large number of people are obstructing each other and YOLO can only recognize those who are not obstructed.

Figures 9, 10, 11, and 12 show how YOLO can detect people movement and determine the number of people on the screen, social distancing violation, and percentage of violation. When a violation exceeds a specific threshold, the authorities are notified and further action is taken. The threshold can be set automatically in the system based on rules that are applied to different situations.

In terms of visualization, as shown in Figures 13, 14, 15, 16, and 17, the system may examine object detection patterns and compare social distancing compliance across many datasets. The graph depicts the peak phase, which contributes linearly to the increase in social distancing violation.

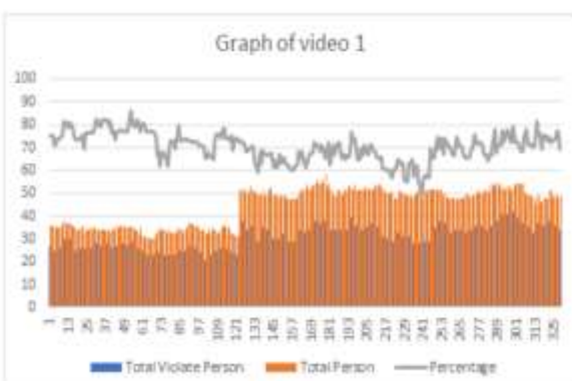

Figure 13. Visualization of hospital dataset

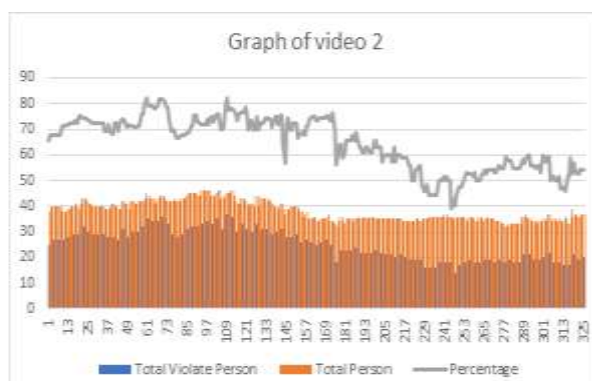

Figure 14. Visualization of indoor room dataset

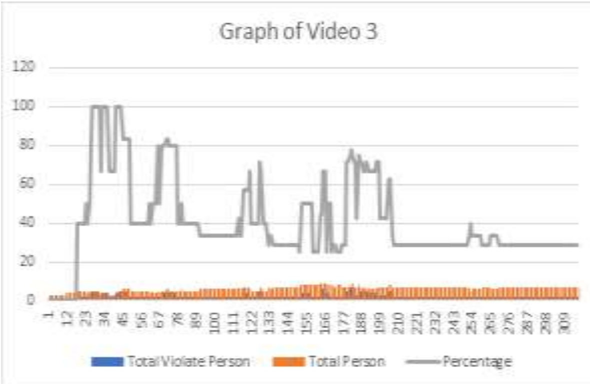

Figure 15. Visualization of outdoor street dataset

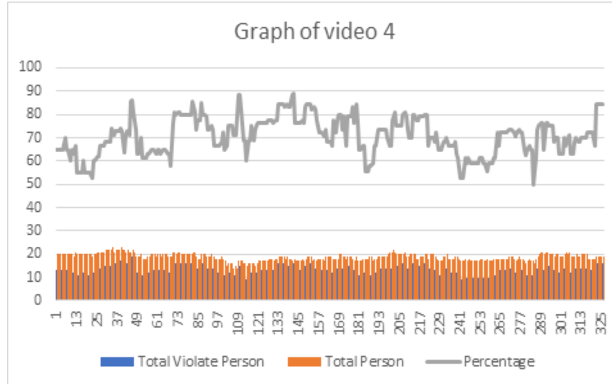

Figure 16. Visualization of downtown area dataset

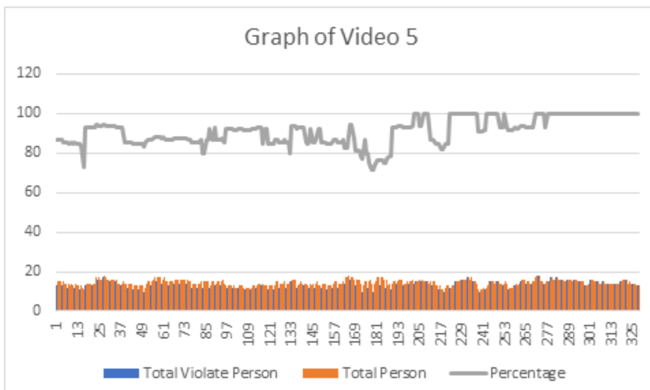

Figure 17. Visualization of sightseeing spot dataset

Conclusion

We proposed YOLO image processing algorithm to solve social distancing compliance monitoring for indoor and outdoor datasets. Although YOLO perform poorly for occluded objects, but the performance good in term of speed, accuracy and learning capabilities. The findings of this study are directly applicable to a broader community of researchers, not only in the computer vision, AI, and health sectors, but also in other industrial applications such as pedestrian detection for driver assistance systems, autonomous vehicles, anomaly behavior detection in public and crowd, surveillance security systems, action recognition in sports, shopping malls, and public places.

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