Real-time Social Distance Detection using YOLOv5 with Bird-eye View Perspective to Suppress the Spread of Covid-19

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Real-time Social Distance Detection using YOLO-v5 with Bird-eye View Perspective to Suppress the Spread of Covid-19

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***Abstract*— The Covid-19 virus outbreak has continued to spread since the end of 2019 worldwide. All people also implement health protocols not to contract this disease. One of the health protocols that must be implemented is to limit interactions between humans to a length of 1-2 meters or what is usually done with social distancing. To ensure that people do not violate social distancing, applying a social distancing detection system can be a solution to this problem. This system detects people who violate social distancing and then gives a voice warning to keep their distance to avoid spreading the Covid-19 virus by using the YOLO-v5 method, which is the latest version of the YOLO (You Only Look Once) method with a detection speed of up to 140 Frames Per Second (FPS) and 90% smaller than the previous version. The human detection rate in the detection system reaches 93,5%, and the accuracy for social distance detection reaches 95%. Based on the research that has been done, it can be said that this system can work well for detecting social distance, but the detection will start detecting the distance between the camera and the object exceeding 10 meters.**

Keywords—Artificial Intelligence, Computer Vision, Covid-19, Deep Learning, Social Distancing, YOLO

I. INTRODUCTION

The increasing number of active cases of the Coronavirus 2019 (Covid-19) outbreak which continues to increase, has caused the death toll to continue to fall due to this virus. As time goes on, medical care units are overwhelmed by the increasing number of active cases of the outbreak. The World Health Organization (WHO) reports that on December 14, 2021, cumulative active cases reached 268,934,575 people, with 5,297,850 deaths worldwide [1].

The virus that spreads worldwide was identified as first appearing in Wuhan, China, at the end of 2019 [2]. With many active cases worldwide, the World Health Organization (WHO) has constantly been warning the whole world to be aware of the Covid-19 virus.

The Covid-19 virus has a high level of infection so that it can be transmitted to people around it. It is known that the main route of the spread of this virus is through liquid droplets that attack the respiratory tract [3]. Therefore, the government, both in Indonesia and around the world, urges the public to implement health protocols, which include wearing masks when traveling, always washing hands, and implementing physical distancing and social distancing.

Social distancing is one of the steps that the government has taken to reduce the risk of the spread of the Covid-19 virus. The intended social restrictions are in the form of not shaking hands and limiting a distance of at least 1-2 meters when interacting with other people [4]. The goal is to avoid liquid droplets from someone who is at high risk of suffering from Covid-19 so as not to get infected. But in reality, not a few people do not obey the rules of this social distancing health protocol. Many people do not pay attention to their distance when interacting with each other. This has become a concern for both the government and other communities, because of course this has the potential to spread the Covid-19 virus.

Deep Learning has become a hot topic in recent years, some of which are used to create object, face, and other types of detection. Several popular detection methods used such as Fast-RCNN, Faster-RCNN, SSD (Single Shoot Multibox Detector) and You Only Look Once (YOLO) have become an evolution of detection methods that are precise but light in use in several aspects [5].

According to research that has been done in the form of human detection using the YOLO method used in the Smart Car system or Advanced Driver Assistance System (ADAS), the experimental results show that the accuracy of the human detection system can be relied on in Real Time using 7 layers of Convolutional Neural Network [6]. The next research that has been carried out is the detection of the use of masks using the improvised method of YOLO-v4. By improving the CSPDarkNet53 model, image scaling algorithm, PANet structure and data set based on mask wearing standards, it can solve the problem of low accuracy and low performance in real-time on the detection of people who wear masks or do not use masks [7].

Therefore, this study aims to design a social distance detection system that can detect people who commit violations if someone is near or interacts with other people less than 1-2 meters using the YOLO method. This research is not only original but also novel because this detection system adds a detection concept in the form of bird-view perspective measurements so that the resulting detection results are more accurate according to the perspective of the image captured by the camera. Then the detection system designed will use the YOLOv5 model with a real-time system. Using the fifth version or the latest method of YOLO, the system will detect more quickly and accurately at longer distances than the previous version of YOLO. Then the system will also calculate the distance of each person detected in real-time using the Euclidean distance algorithm. So if someone violates social distancing, the system will give a warning in the form of a warning sound so that person immediately stays away from other people. The results of this study can encourage the public to implement health protocols in the form of social distancing, especially in public places and crowds or all activities that have the potential to spread the Covid-19 virus so that it can suppress the spread of the Covid-19 outbreak virus both in Indonesia and in the world.

II. RESEARCH METHOD

A. You Only Look Once (YOLO)

YOLO is a deep learning method that aims to detect objects that unite the components of the detection object into a single neural network in the entire image. The system of the YOLO method itself, namely YOLO, divides the input image into regions or grids measuring S x S . If the center of an object falls into a grid cell, it is the grid cell that is responsible for detecting the object. Each grid cell predicts the bounding box and confidence. The value of this confidence represents how confident a model is in the box containing the object and how accurate the box is being predicted. The value of confidence is obtained through the equation :

$$Conf = \Pr(Object)\ x\ IOU_{pred}^{truth} \quad (1)$$

Pr(object) is the probability of an object appearing in a region. Meanwhile, IOU (Intercection Over Union) is the ratio of the overlap between the area in the ground truth and the area in the prediction box. So the higher the IOU (Intercection Over Union) value, the higher the detection accuracy. And if the confidence value shows the number 0, then it means that there are no objects in that cell.

Each bounding box consists of 5 predictions, namely x, y, w, h and confidence. The x and y values represent the coordinates of the midpoint relative to the grid cell boundaries. While the values of w and h represent the width and height relative to the whole image. Each grid also predicts the class probability value. Pr(Classi|Object). YOLO gets the class confidence value specifically for each bounding box by multiplying the class probability value with the confidence value from the bounding box. This value indicates the probability class that appears in the bounding box and shows how accurately the bounding box predicts an object [8].

B. YOLO-v5

As time goes by, technology is growing. Likewise with YOLO which has experienced many developments to be faster, stronger and better than the initial version. For now, the YOLO series includes YOLO-v1, YOLO-v2, YOLO-v3, YOLO-v4 and YOLO-v5.

YOLO-v5 is the latest version of the current YOLO development. developed based on YOLO-v4. The processing Speed of the YOLO-v5 is drastically increased with the fastest speed reaching 140 Frames Per Second (FPS). YOLO-v5 is small even 90% smaller than YOLO-v4, making it possible that YOLO-v5 can be deployed to an embedded device. And a higher level of accuracy and a better ability to recognize small objects.

With the development of YOLO, the YOLO-v5 detection system managed to cover the shortcomings with its initial version, namely YOLO-v1. YOLO-v1 was developed based on the R-CNN method. Region Based CNN method or commonly called R-CNN. The system of YOLO-v1 is that the input image is processed only once, hence it is called You Only Look Once. Then the different features are extracted through multiple convolution layers, and the convolution kernel parameters are shared each time. YOLO-v1 has a very fast image detection speed. It is faster than the previous detection model namely R-CNN and can meet real-time requirements. The speed can reach 45 frames per second, using the full image as environmental information. However, the disadvantage of YOLO-v1 is that its position detection accuracy is low and small objects cannot be detected [9].

C. Network Structure Model

The structure of YOLO-v5 is similar to that of other versions of YOLO. This structure is divided into 4 parts: Input, Backbone, Neck, and Prediction. Figure 1 will explain the Architecture of the YOLO-v5 model.

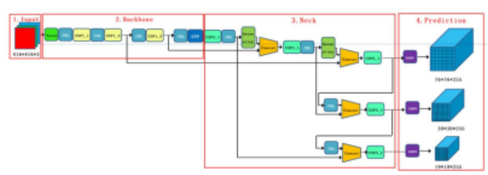

Figure 1. Architecture of YOLO-v5 model

The input part can realize data enhancement, adaptive anchor frame calculation, and adaptive image scaling. The feature extraction section of its main function is to adopt a focus structure which can complete the cutting and convolution operations and a CSP structure which enhances the learning capability of the feature network. Since the Focus and CBL of different networks have different numbers of convolution kernels, and the number of residual modules in the CSP is different, the model can show different performance by controlling the width and depth of the network. The Neck section uses both the FPN and PAN structures, using information extracted from the Backbone section to strengthen the combined capabilities of the network features. The output layer is divided into three convolution layer channels, which are calculated through the loss function, and the results are subjected to maximum value suppression processing to provide predictive results [10].

D. Dataset

YOLO-v5 has a built-in dataset that is pre-trained with the Common Objects in Context (COCO) dataset. COCO dataset is a dataset for object recognition, segmentation and labeling. This dataset contains more than 200,000 images labeled with 80 different classes, including the human class [11]. Therefore, YOLO-v5 can be used for social distancing detection, where the main system detects humans first. Because human detection has been previously trained in the COCO dataset and the COCO dataset is the default dataset of YOLO-v5, there is no need to do custom dataset training first.

E. Research Stage

To detect people who violate health protocols in the form of social distancing, where someone interacts with other people less than 1-2 meters, using the YOLO-v5 method, there are several stages in how this system works. Figure 2 is a flow of how the system will work.

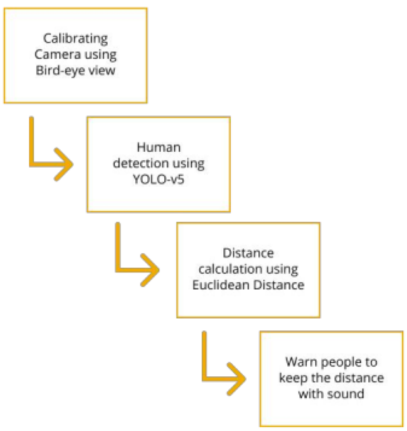

Figure 2. System core process

In Figure 2, it is explained that there are four core processes for this system. The first thing this system will do is calibrate the camera using a bird-eye view perspective. The system will capture the frame first, and then we need to set 4 coordinate points that will be used as a benchmark for changing the perspective to a bird-eye view. With these coordinate points, the system will perform image processing to change the image's perspective to a bird-eye view. The frame will be stretched into a full rectangular frame to be further marked with a regular circle. After that, the size and range of the image frame will be returned as all and the circle mark. So that the circle will follow the perspective according to the coordinates that have been set previously, as described in more detail in Figure 3 below.

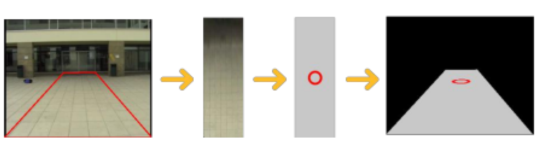

Figure 3. Bird-eye view perspective image processing

After the image is processed into a bird-eye view perspective, it will create a variable for a circular sign that will be used as a human detection sign. The mark will adjust to every object that has been detected as a human. Then the image will perform image processing to return the display to its original state by bringing the mark that has followed the bird-eye view perspective.

The next process is human detection using YOLO-v5. The camera will be turned on continuously to capture images in real-time. YOLO-v5 will process every frame captured by the camera to detect humans. Detected humans will be marked with a bounding box that has been converted into a circle in the previous process by adjusting the perspective of the bird-eye view.

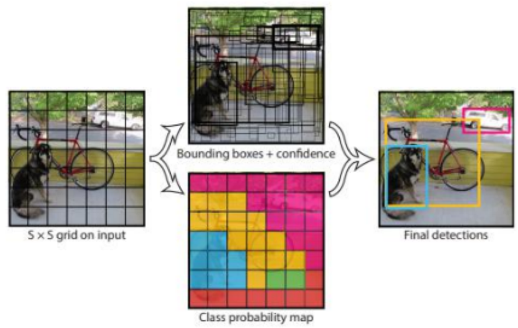

Figure 4. YOLO object detection system model

YOLO will divide the system into S x S grids on the input. Then each grid cell will be made up of bounding boxes, confidences for each box, and probability classes. So that in the end it will produce object detection predictions for each class.

After every human is detected in the system, the next step is to calculate the distance of each human using the Euclidean Distance formula. This formula is used to calculate the distance from two points in Euclidean space to study the relationship between angles and distances. Euclidean distance is the most common distance calculation formula used for numerical data, between two data points x and y in d-dimensional space [12]. For two-dimensional calculations at the coordinates (x1,y1) and (x2,y2), the Euclidean distance (d) can be determined using the equation::

$$d(P_1P_2) = \sqrt{(y_1 - x_1)^2 + (y_2 - x_2)^2} \quad (2)$$

Then the last process is the sound output that will be issued in the form of a warning if there are two or more humans adjacent to a distance of less than 1-2 meters so that the circle marks on the system clash. Collision signs will turn red as a sign that the system has caught a social distancing violation. The sound output is used to give warnings to violators of social distancing to keep their distance to reduce the possibility of contracting the Covid-19 virus.

III. RESEARCH AND DISCUSSION

In this study, testing and analysis will be carried out for the results of the social distancing detection system that has been developed. The test was carried out using an android smartphone camera that was connected to a laptop using the DroidCam application, the goal was to capture images in realtime more freely. Furthermore, the dataset used is the default dataset from YOLO-v5, namely COCO Dataset, so there is no need to do custom dataset training because COCO Dataset already has data for human detection that was previously trained as many as 200,000 images. By doing this test, it can be seen the level of success of this system in detecting social distancing violations.

The success rate of testing on this system is calculated using the following formula:

$$k = \frac{n}{m} x\ 100\ \% \tag{3}$$

Where :

k = percentage of test success
n = number of successful detections
m = number of observed data

The test results are carried out by calculating the percentage of 2 types of detection, namely the percentage of human detection using Yolo-v5 and the percentage of detection of social distancing whether it has been detected or not.

Figure 5. Test image 1

The first test was carried out with two interacting people, as shown in Figure 5. It appears that the two people interacted with a distance of less than 1-2 meters, so that they were violating social distancing. With a distance of 4 meters from the object to the camera, the system achieves an accuracy level of 100% for human detection using Yolo-v5 because it can detect the two people and give a circle mark on each object. The system also managed to reach a 100% level for social distancing detection accuracy because the system managed to detect that the two objects violated social distancing by changing the colour of the circle sign from green to red and issuing a warning sound to keep the distance..

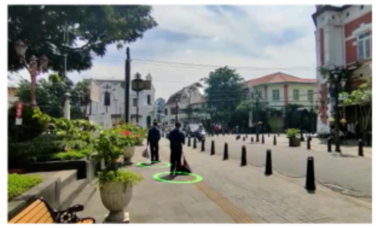

Figure 6. Test image 2

The second study, conducted on a highway with two human objects shown in Figure 5. It appears that two people are sweeping the road, but they keep their distance from each other. With a camera-to-object distance of 7 meters, the system achieved an accuracy rate of 100% for human detection using Yolo-v5. The accuracy rate for social distancing detection reaches 100% because it appears that the two people are keeping a distance from each other so that the system does not detect the two people violating social distancing by putting a green mark on the circle for each person..

Figure 7. Test image 3

. Then for the third study was carried out with many people, according to Figure 7. Here the distance from the camera to the object has various distances because there are many people. The furthest distance reaches 8 meters. The system succeeded in detecting six humans caught by the camera, so the accuracy for the human detection system using Yolo-v5 in the third study reached 100%. The level of accuracy for the social distancing detection system also reaches 100% because the system successfully detects that four people do not keep their distance by providing a red circle indicator.

Figure 8. Test image 4

The fourth study was carried out on the highway with several people, and the camera distance was quite far, as shown in Figure 8. The test was carried out with the camera a bit far from the object, which reached 10 meters with some people walking, and some did not keep their distance. The system detected six people, but seven people were caught on camera. That is because other objects somewhat covered that one person, so the camera did not catch it clearly, so the success rate in this third test, namely for human detection using Yolo-v5, reached 85.7%. For social distancing detection, it reaches 100% because the system has succeeded in detecting people who do not keep the distance caught by the camera.

Figure 9. Test image 5

The fifth study was carried out with a considerable distance because the camera used an angle from above, such as CCTV. The camera recorded many pedestrians, some of whom did not keep their distance. The distance for the camera to the farthest object is 15 meters. The accuracy rate for the human detection system using Yolo-v5 reaches 86.3% because some are not detected. For the accuracy of social distancing detection, it reaches 75% because the system fails to detect accurately, it seems that someone has kept their distance, but instead, it is detected that they are violating social distancing.

The comparison of all the results of the analysis on the tests that have been carried out is summarized into Table 1 as follows:

TABLE I
SYSTEM ANALYSIS PERCENTAGE RESULTS

Test Image	Farthest Object Distance	Human Detection	Social Distancing Detection
1	4 m	100%	100%
2	7 m	100%	100%
3	8 m	100%	100%
4	10 m	85,7%	100%
5	15 m	81,8%	75%
Average		93,5%	95%

Based on the data in Table 1 above, it can be seen that the system can detect human objects and detect social distancing violations with a camera distance of 4 to 15 meters to get an average accuracy for detecting humans of 93,5% and accuracy for detecting social distancing reaching 95%. This test shows that the accuracy of social distancing depends on the accuracy of human detection. If a human is detected, the detection of social distancing can only be measured. While the level of accuracy of human detection with Yolo-v5 is very accurate when the object is visible, but cannot detect when the object is too far away, so it looks tiny on the camera and cannot detect when human is stacked whit another object so the camera cannot see it clearly.

IV. CONCLUSION

After researching the social distancing detection system, it can be concluded that it can function properly to detect social distancing violations. The system does not need to be trained for human detection because it can detect humans well by default using the dataset from YOLO-v5, namely the Common Objects in Context (COCO) dataset. The level of accuracy obtained for human detection accuracy using YOLO-v5 reaches 93.5%. This happens because the human detection system using YOLO-v5 has a drawback, namely, if the distance from the camera to the object exceeds 10 meters, the accuracy level will decrease slowly. Otherwise, the object looks small in the camera, and the system cannot detect if another object is blocking the human. Euclidean Distance is used to calculate the distance from two human objects so that the system can detect social distancing violations. The accuracy of detecting social distancing violations has reached a high enough number, 95%. This research can help the government suppress the spread of the COVID-19 virus by detecting people closer than 1-2 meters. The system will inform that a social distancing violation has occurred so that people who violated will be aware and not too close to other people, thereby preventing the spread of the Covid-19 virus.

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