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Implementation of YOLO-v5 for a real-time Social Distancing Detection

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ABSTRACT

The world is in an uproar with the Covid-19 pandemic, which has impacted society. Governments have made various efforts worldwide to suppress the spread of the Covid-19 virus. One of the health protocols that the government has appealed is social distancing or social restrictions, namely limiting interactions between human beings as long as 1-2 meters. However, in reality, many people still ignore social distancing policies. The application of a social distancing detection system can solve this problem. This system aims to detect people who are violating health protocols in the form of social distancing and then issue a voice warning to keep their distance from others to avoid the spread of the Covid-19 virus by using the YOLO-v5 method, which is the latest version of YOLO (You Only Look Once). The processing speed of YOLO-v5 has increased drastically, with the fastest speed reaching 140 Frames Per Second (FPS). It has a small size, even having a size of 90% compared to the previous version. The accuracy of human detection using YOLO-v5 from this system reaches 83.28%, and the accuracy of social distancing detection reaches 90.8%. From the results of the percentage analysis carried out, it can be concluded that the system created can function well for social distancing detection. However, it is not easy to detect if humans are too far from the camera.

I. INTRODUCTION

The Coronavirus disease 2019 (Covid-19) outbreak is a phenomenon of a deadly disease outbreak that has spread throughout the world, including in Indonesia. Health workers around the world are currently making efforts to control the outbreak of this disease which was emerged first in Wuhan, China, at the end of 2019 [1]. To date, the World Health Organization (WHO) on August 31, 2021, reported that this virus infected 215,714,824 people, with 4,490,753 deaths worldwide [2].

The Covid-19 virus has a high level of infection to 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, both in Indonesia and worldwide, the government urges the public to implement health protocols, including wearing masks when travelling, constantly 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 spreading the Covid-19 virus. The intended social restrictions are 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 at high risk of suffering from Covid-19 to avoid getting infected. However, in reality, not a few people do not obey the rules of this social distancing health protocol. Many people ignore 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 objects, faces, and other types of detection. Several popular detection methods used, such as Fast-RCNN, Faster-RCNN, SSD (Single Shot Multibox Detector), and You Only Look Once (YOLO), have become an evolution of precise detection methods 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 seven layers of Convolutional Neural Network [6]. The following research has been carried out to detect 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 research aims to design a social distancing detection system that can detect people who commit violations if someone is close to or interacts with other people less than 1-2 meters using the YOLO method. This detection system adds a detection concept in a bird-view perspective measurement. The accurate detection results produced are according to the image's perspective captured by the camera. Then the detection system designed will use the YOLOv5 model with a real-time system. So when there are people who violate social distancing, the system will warn with a voice. It is hoped that this research will encourage the public to apply more health protocols in the form of social distancing to avoid activities that can potentially 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. 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 centre 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:

$$Conf = \Pr(Object)\ x\ IOU^{truth}_{pred}$$

Pr(object) is the probability of an object appearing in a region. Meanwhile, IOU (Intersection 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 (Intersection Over Union) value, the higher the detection accuracy. Furthermore, 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: x, y, w, h and confidence. The x and y values represent the midpoint coordinates relative to the grid cell boundaries. At the same time, 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].

YOLO-v5 is the latest version of the current YOLO development, 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. Furthermore, a higher level of accuracy and a better ability to recognize small objects [9].

B. Dataset

YOLO-v5 has a built-in dataset pre-trained with the Common Objects in Context (COCO) dataset. COCO dataset is a dataset for object recognition, segmentation and labelling. This dataset contains more than 200,000 images labelled with 80 different classes, including the human class [10]. Therefore, YOLO-v5 can be used for social distancing detection, where the primary 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.

C. Research Stage

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

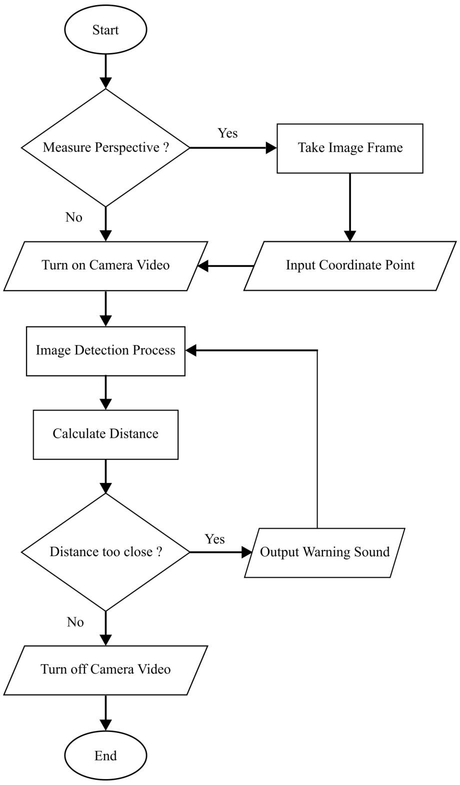

Figure 2. *Flowchart* work of application

In the flowchart of how the application works in Figure 2, the research stages can be detailed as follows:

1) Measuring Object Distance: The first thing to do is measure perspective. Because this system uses a bird-view perspective model, the detection process will be executed as if the image capture on the detection system is above as if it was taken with a bird's eye view. The process is carried out by determining four coordinate points in the current perspective of the image, then with these coordinate points, the perspective of the image frame will be changed to match the coordinate points taken. Figure 3 will explain the system from this perspective change.

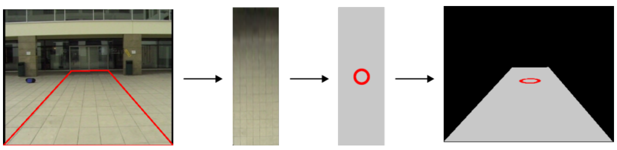

Figure 3. Work of application detection with bird-view perspective

After becoming a frame, the detection system will be carried out by giving a sign in a circle if the system detects humans. Then the system will return the display shape of the image frame to its original shape so that the image can be appropriately seen, as well as the circle mark will follow the perspective shape that has been set previously. By using this bird-view perspective model, it will get more accurate detection results than without using a perspective system like this.

2) Human Detection: Next, the system will turn on the camera to capture images to detect humans in real-time and perform the human detection process using the YOLO-v5 method. With COCO Dataset, the original dataset of YOLO-v5, we do not have to train the dataset ourselves. Humans who are detected will be marked with a bounding box that has been converted into a circle shape according to the perspective that has been measured previously by marking it using a circle mark.

3) *Distance Detection:* The distance of each human will be calculated using the Euclidian distance equation using 2 points. Euclidean distance is the calculation of the distance from two points in Euclidean space to study the relationship between angles and distances. The Euclidian distance is the most common distance used for numerical data, for two data points x and y in d-dimensional space. For two-dimensional calculations at the coordinates (x1,y1) and (x2,y2) [11]. The Euclidean distance (d) can be determined by using the equation:

$$d(P_1 P_2) = \sqrt{(y_1 - x_1)^2 + (y_2 - x_2)^2}$$

4) Social Distancing Violation Warning: If two or more people close together so that the circle marks collide with each other, the system will detect that it is a social distancing violation. Furthermore, if detected, the circle that was originally green will turn red, and the system will issue a sound output containing a warning to keep the loot.

III. RESULT AND DISCUSSION

In this study, testing and analysis will be carried out for the results of the social distancing detection system developed. The test was conducted using an android smartphone camera connected to a laptop using the DroidCam application. The goal was to capture images in real-time 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 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:

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

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 4. Test image 1

The first digital test results were carried out with a few people first, as shown in Figure 4. This test was carried out with a small number of people, and the standard camera position was parallel to humans. The distance between the camera and the object is 3 to 4 meters. The success rate in the first test for human detection using Yolo-v5 reached 100%. Judging by this success rate, the Yolo-v5 can accurately detect tiny and precise humans, as well as standard camera positions. Then the accuracy of social distancing detection reaches 100%. Judging from the picture, that two people violate social distancing, then detected by the system by showing an indicator that turns red.

Figure 5. Test image 2

The second test was carried out inside the mall shown in Figure 5, with several people walking. The standard camera position was parallel to the average human view but carried out at a distance. The level of accuracy of human detection in this second test with the average distance of the camera to the object is 6 meters reached 100%, meaning that Yolo-v5 can detect several humans from a relatively far distance. Then the accuracy of social distancing detection reaches 100% because, in Figure 5, it can be seen that there are two people who are embracing so that social distancing is detected.

Figure 6. Test image 3

The third test was carried out with several people walking, as shown in Figure 6. The test was carried out with the camera position a bit far away with an average distance of the camera to object from 1 meter to 10 meters but with a legal perspective with a human view. The success rate in this third test, namely for human detection, reached 88.9%. Judging from this success rate, Yolo-v5 can accurately detect humans from a sufficient distance, but some humans are not detected because they are too far away. For the accuracy of social distancing detection to reach 100%, according to Figure 6, there are two people who look too close so that they violate social distancing.

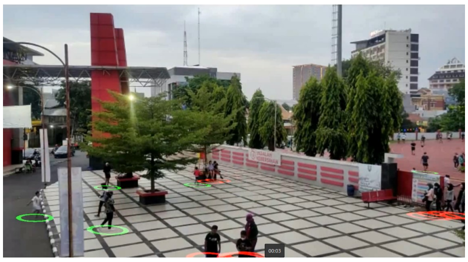

Figure 7. Test image 4

Furthermore, the fourth study was carried out at a considerable distance, and the camera position was located above to obtain a perspective in such a way, as shown in Figure 7. At this considerable distance, human detection using Yolo-v5 obtained an accuracy rate of 65%. This time, the system for human detection has decreased because human objects are too far away, with camera distance to the farthest object is 13 meters so that they appear small on the camera, can not be detected by Yolo-v5. For social distancing detection, it reaches an accuracy of 83%. This shows that the accuracy of the YOLO-v5 will decrease slowly if the distance from the camera to the object exceeds 10 meters and above. As in this 4th test, the accuracy of human detection on YOLO-v5 with a camera to object distance of 13 meters, resulting in a decrease in accuracy to 65%. So it can be concluded that the maximum limit for a human detection system if you want to achieve a high level of accuracy is a maximum of 10 meters. Then for social distancing detection was reduced because someone was violating social distancing, but the human object was not detected because it was too far away and too close to other people.

Figure 8. Test image 5

The following fifth test can be seen in Figure 8. This time the test was carried out with a longer distance, which is the distance of the farthest object is 15 meters. The camera angle was taken from above, and there were a lot of human objects playing sports. With the crowding level shown in Figure 8, the test for human detection only reached 62.5%. Of course, this is also because many human objects are too far away to look tiny on the camera, so that Yolo-v5 cannot detect the object. Human objects covered by other humans so that the camera does not capture them are also not detected by the system. Because many human objects are not detected, this has an impact on the detection of social distancing violations which only reached 71.4%.

The comparison of all the results of the analysis on the tests that have been carried out is summarized in 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	6 m	100%	100%
3	10 m	88,9%	100%
4	13 m	65%	83%
5	15 m	62,5%	71,4%
Average		83,28%	90,8%

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 83.28% and accuracy for detecting social distancing reaching 90.8%. 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.

IV. CONCLUSION

From the research results that have been done, it can be concluded that the system created can function well for social distancing detection. However, it is difficult to detect if humans are too far from the camera, where the system uses the YOLO-v5 method for human detection by using the default dataset from YOLO-v5. Namely, the Common Objects in Context (COCO) dataset and Euclidean Distance calculations to calculate the distance from 2 human objects to detect social distancing violations. After testing using the camera to object distance from 4 to 15 meters, the accuracy of this system can be calculated, namely the accuracy of human detection using YOLO-v5 reaches 83.28% and accuracy for social distancing detection reaches 90.8%. From the results of the analysis in the study, the factor that affects the accuracy of this system is the distance from the camera to the object. If the distance is too far so that the human object looks small, it cannot be detected by YOLO-v5. In the distance test carried out, the accuracy of human detection will decrease when the object distance from the camera reaches 10 meters and above. Another factor is that humans cannot be detected if other objects block them, so social distancing systems cannot detect them. With this application, there is great hope that it can be useful to suppress the spread of the Covid-19 virus in Indonesia and the world.

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