Crowd Detection that Potentially Violate Covid-19 Health Protocol Using Convolutional Neural Network (CNN)

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***Abstract*— This study aims to propose a system that can detect crowds that have the potential to violate the Covid-19 health protocol. The criterion used is the distance between each person in the crowd. In this case, the permissible distance between each person is 1 meter. The camera is used to detect the distance. The input from the camera is connected to the laptop. The images obtained are processed using Deep Learning. In this case, the Convolutional Neural Network (CNN) is used. If the distance between each person in the image is less than 1 meter, the color of that person's bounding box will be red, otherwise, it will be green. In this case, testing was carried out on 3 conditions with the number of people varying from 2 to 20 people. The first condition is the condition that the distance between each person is more than 1 meter. The second condition is the condition that the distance between each person is less than 1 meter and some is more than 1 meter. The third condition is the condition that the distance between each person is less than 1 meter. The proposed system achieves average specificity, sensitivity, and accuracies of 91.03, 91.7, and 91.83, respectively.**

Keywords— Crowd Detection, Covid-19 Health Protocol, Camera, Convolutional Neural Network (CNN)

I. INTRODUCTION

Until now, Indonesia is still fighting against the corona virus, just like other countries in the world. Based on data on the spread of Covid-19 obtained from the https://covid19.go.id/peta-sebaran-covid19 page, there have been more than 13,094 cases, with a total of 1,012,350 confirmed cases of the virus. The number of people who recovered was 820,356 people (81%) and the total number of people who died was 28,468 people (2.8%). From these data, it can be seen that the death rate is relatively high, so it requires serious attention from the government. One of the government's efforts to prevent the spread of the Covid-19 virus is to carry out socialization so that citizens keep their distance and avoid crowds. Sometimes this is constrained by the discipline of the community members themselves.

Usually if there is a crowd, then the authorities or the authorities will come to the location to disperse the crowd. However, the slow information about the occurrence of a crowd of residents obtained by the authorities caused the process of disbanding the crowd to be slow. For that we need a system that can provide information to the authorities in the event of a crowd[1][2]. Research on crowd detection has been carried out by LIPI which uses a quadcopter to detect crowds but the quadcopter has weaknesses, including: control distance, limited battery power which can only work for a duration of ± 20 minutes[3]. Besides, this system only works remotely, so there must be an operator running the quadcopter and there is no reporting of crowds to the authorities.

In this research, a system is designed that is able to detect crowds through images. The image is obtained from a camera located at a predetermined location. In this case, deep learning is used to identify the distance between each person in the image. Deep learning is a method that is able to detect objects very well and can be in real time [4]. In terms of object detection and analysis, deep learning is able to obtain excellent results[5]. Processing using GPU (Graphic Processing Unit). If there is a potential for violating the Covid-19 health protocol, the system will automatically send a WhatsApp message to the authorities that a protocol violation has occurred at that location. Thus, it is hoped that the authorities can immediately take action to break up the crowd.

The research conducted to determine social distancing has been investigated, which is related to human detection and monitoring of social distance [6][7][8][9]. This study uses the opencv and CNN methods, the results obtained an accuracy of 98.2% [10]. CNN is one method that has a very rapid development which is able to perform including processing, analysis and detection of an object, both images and videos [11] [12] [13]. Next, research related to decisions about social distance uses the LSTM-RNN method with the ANN Regression model. the results of this study point to the fact that planning through predictive analysis can be improved to facilitate the implementation of more effective social distancing guidelines during pandemic disease outbreaks [14][15][16]. Other research is still related to social distance, namely using the Visual Social Distancing (VSD) method. The results obtained are able to detect body poses well[17]. As for the next research related to social distancing, research using drones with the method used is YOLO. The results obtained from the experiment obtained good accuracy results, which is about 90% for both people and crowd detection[18][19][20][21][22]. The first feature detects social distancing violations, while the second feature detects violations entering prohibited areas. In another study, namely about the detection of people for social distancing warnings. This study uses the Segmented ROI method, with the results of the first feature detecting social distancing violations, while the second feature detects violations entering prohibited areas [23][24][25][26].

In this research, social distance detection will be carried out in a location, where the system developed can determine

the distance between several people. Then if it is detected that the distance between several people is less than 1 meter, it will give an unsafe message. Then if the number of unsafe distances is more than 5, it will be categorized as a crowd.

II. Materials and Methods

In this study, the data used is own data taken using a 16 MP cellphone camera. The data used in the form of photos and videos. The photo data used is 10 photos which are augmented into 1000 photos. Then the video data used is 1 video with a duration of 10 seconds with a speed of 25 fps.

The first data used is photo data where there are several people in a condition that has a distance from one another. Here is a picture of remote people's photo data.

Fig. 1. Photos of People Far Away

The second data used is photo data where there are several people in fairly close conditions or not far from one another. Here is a picture of the photo data of people who are not far away.

Fig. 2. Photos of People Not Distance

The third data used is a 15-second video, where there are several people walking in a certain direction. The video will later be executed using the developed system, so that later every object in the video will be detected. One of the effective media to visually see social distance in a condition[27][28][29] Here is a screenshot of the video data image.

Fig. 3. Video Screenshots

A. Architectural Solutions

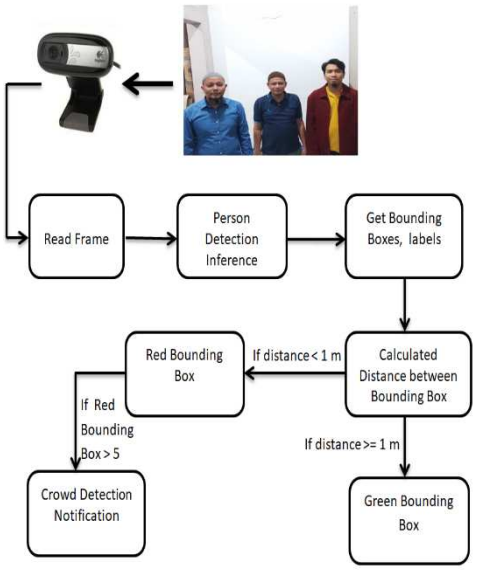

Fig 4. Architectural Solutions

The block diagram shows that the image from the camera is read frame by frame. Furthermore, the process of detecting people in the image is carried out. If a person is found there, a bounding box will be created on that person's image and a label will be created. After that the distance between each bounding box is calculated. If the distance is equal to 1 meter, then the bounding box is green. However, if the distance is less than 1 meter, the bounding box will be red. Furthermore, if the number of red bounding boxes is more than 5, a crowd notification will be displayed.

B. Determining the Distance between Bounding Boxes

In Figure 5 there is a block diagram of the Boundary Box determination block. To determine the bounding box, the thing to do is calculate the distance between the first bounding box and the next bounding box. In the illustration, there are two bounding boxes. In the figure 5, it can be seen that there are Horizontal Distance 1 and Horizontal Distance 2 which function to determine the distance between the bounding boxes horizontally. Furthermore, there are also Vertical Distance 1 and Vertical Distance 2 which function to determine the distance between bounding boxes vertically.

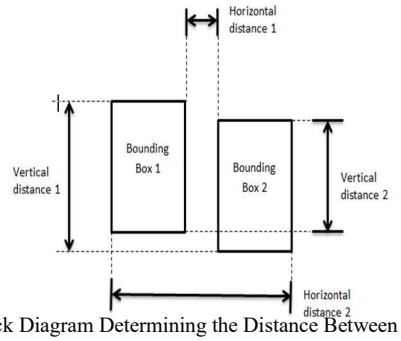

Fig. 5. Block Diagram Determining the Distance Between Bounding Boxes

The process of determining safe and unsafe conditions is based on the value of Vertical Distance and Horizontal Distance value. If the Value of Vertical Distance 1 or Vertical Distance 2 is <75 and the Value of Horizontal Distance 1 or Horizontal Distance 2 is <50, then this is categorized in an unsafe condition. In addition to these conditions, it is categorized in a safe condition. If the number of bounding boxes is more than 2, for example there are 3 bounding boxes, then the distance calculation process is also carried out between bounding box 1 and bounding box 2 and the distance between bounding box 2 and bounding box 3.

C. *Determining Crowd Potential*

Figure 6 shows a block diagram to determine the potential crowd. The method is to count the number of red bounding boxes. In the picture, the red bounding boxes are bounding boxes 1, 2, 3, 4, 5, 6. While the bounding boxes 7 and 8 are green. If the number of red bounding boxes is more than 5, then it is defined as a crowd. Then in the figure frame added the information: "Crowd that potentially violate covid-19 health protocol".

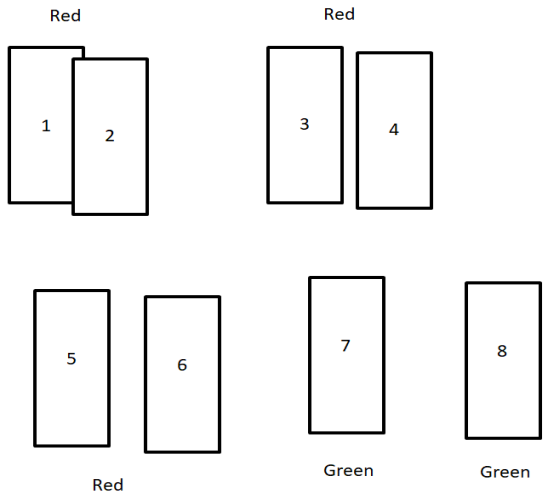

Fig. 6. Block Diagram Determining Crowd Potential

III. Experimental Result

A. *Photos of People Far Away Result*

In the distance photo test, the detection results are obtained in the 'safe' category with the color Green. The test results can be seen in Fig. 7.

Fig. 7. Photos of People Far Away Result

B. *Photos of People Not Distance Result*

In the distance photo test, the detection results are obtained in the 'unsafe' category in red. The test results can be seen in Fig. 8.

Fig. 8. Photos of People Not Distance Result

C. *Video Test Results*

- Test Video 1

  In the results of testing 1 the system is able to detect objects of people well and the system is also able to detect the distance between one another. Where in this 1st test, there are 3 objects detected as unsafe with a red bounding box and 2 objects detected as safe with a green bounding box. The following is a picture of the test results 1.

Fig. 9. Video Test Results 1

- Test Video 2

  In the results of testing 1 the system is able to detect objects of people well and the system is also able to detect the distance between one another. Where in this 2nd test, there are 3 objects detected as unsafe with a red bounding box and 3 objects detected as safe with a green bounding box. The following is a picture of the test results 2.

Fig. 10. Video Test Results 2

- Test Video 3
  In the test results 3 the system is able to detect objects of people well and the system is also able to detect the distance between one another. Where in this test, the condition of the object of people has the potential to generate crowds. The system detects that there are 5 objects detected as unsafe with a red bounding box and 1 object detected as safe with a green bounding box. Here's a figure of the test results 3.

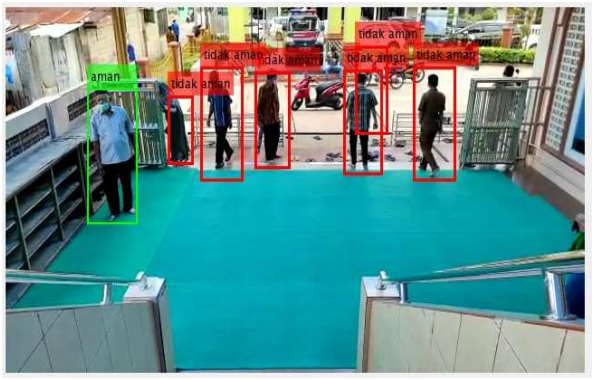

Fig. 11. Video Test Results 3

Tests were carried out on 100 sample images. The number of people in the picture varies from 2 to 20 people. Then the sample image is augmented so that it becomes 1000 images. The testing technique is carried out by determining the values of TP, TN, FP and FN, where TP stands for the number of true positives; TN stands for true negative number; FP stands for number of false positives; FN stands for number of false negatives.

$$\text{Accuracy} = \frac{TP + TN}{TP + FN + TN + FP} \quad (1)$$

$$\text{Precision} = \frac{TP}{TP + FP} \quad (2)$$

$$\text{Recall} = \frac{TP}{TP + FN} \quad (3)$$

Testing was carried out with MATLAB 2020a software on laptop Core I7 8th Generation software MATLAB 2020a. The test results can be seen in the following table. The test results can be seen in the following Table I.

TABLE I. TEST RESULTS TABLE

No.	Type	Accuracy (%)	Precission (%)	Recall (%)
1	Image	94.63	95.8	95.9
2	Video	85.97	87.6	87.76
Average		91.03	91.7	91.83

IV. Conclusion and Future Work

In this study, a crowd detection process was carried out based on the number of red bounding box values. This value is taken based on the distance between each person contained in the image and video. The detection results are in the form of information on crowd conditions in the form of labels on processed images and videos. In further research, it is hoped that this information can be forwarded directly to the authorities in the form of messages via applications such as SMS (Short Message Service), WhatsApp or Telegram. With this information, immediate action can be taken to break up crowds that have the potential to violate the Covid-19 health protocol.

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