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Application of Object Mask Detection Using the Convolution Neural Network (CNN)

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Abstract

The spread of Coronavirus Disease (Covid-19) is still a serious problem we are currently facing. The spread occurred very quickly through the process of face-to-face interaction. The process of face-to-face interaction that occurs both in public spaces and closed spaces has a great risk of transmitting the Covid-19 virus. One of the efforts to deal with the spread of the Covid-19 virus is by increasing the use of masks both in public and closed spaces. Based on this, this study aims to develop an Object Detection process in image processing techniques. Object Detection development using the Convolution Neural Network (CNN) method to provide optimal output. The CNN can process the input image which is converted into a pixel matrix and then forwarded to the convolution layer. The research dataset consists of 2000 images of face masks and not masks. The images were obtained from the open sources github.com and kaggle.com. The results of the study present a system capable of detecting masks in real time. CNN provides very good performance with an accuracy rate of 99.05%. With these results, the contribution of this research can be used for the process of monitoring public services for the community to increase the use of masks.

Keywords: *covid-19; object detection; image processing; convolution neural network (CNN); public services*

1. Introduction

The Coronavirus (Covid-19) has a fairly fast spread rate and has infected thousands of millions of people around the world in just a short time [1]. Based on this, the World Health Organization (WHO) has declared that the Covid-19 virus has been declared a global pandemic [2], [3]. As a result of the spread of the Covid-19 virus, it has had a fairly broad impact on all sectors [4], [5].

In responding to the spread that occurred, the government followed up by demanding that all citizens comply and be disciplined in implementing health protocols [6],[7]. One of the applications for implementing health protocols is by using masks both in open and closed spaces [8-10]. The application of the health protocol is carried out in every public facility such as markets, offices, supermarkets, and schools [11]. With the implementation of these health protocols, not a few people are aware of the high risk of spreading so many people in public spaces do not use masks [12]. Based on these facts there are still many people currently not using masks when doing activities outside the home [13]. This is also inseparable from the lack of the current mask object detection system [14]. This, research in the development of object detection systems is expected to have an increasing effect on the community in the use of masks by utilizing Artificial Intelligence (AI) technology.

AI is a branch of science that studies the ability of computers to be able to simulate and think like humans [15]. One of the goals of AI is to be able to create a computer system or device that can help human performance [16]. One form of the resulting system is the existence of an object detection system by utilizing image processing [17]. Object detection is a form of technological result developed in digital images that are used in the process of identifying an object [18]. Object detection performance allows objects in an image to be identified [19].

Based on previous research, it has been reported that the application of AI in image processing in object detection plays an active role in the process of detecting an object [17],[20]. Other research also explains that object detection makes a major contribution to handling identification problems [21]. Further object detection was developed to provide maximum results in image pattern recognition [22].

The development of object detection has gone hand in hand with many problems in the object detection

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process in image processing [23]. This development can be seen from the algorithms and techniques used in the object detection process in an image [24]. Based on this, previous research has presented that the object detection process can be carried out using the concept of Deep Learning (DL) resulting in quite good performance [25]. Other research also explains that object detection can be developed using the feature fusion method, presenting experimental results which show that the method can accurately and efficiently detect an object [26]. Furthermore, the same research was also carried out in object detection using the transfer learning model which gave quite good results [27].

Based on the results of previous research, this research will propose an object detection process by developing the Convolutional Neural Networks (CNN) method in detecting mask objects. This development was carried out to maximize the object detection process in the image. Previous research explained that the CNN method is capable of carrying out the process of detecting and identifying objects in images [28]. The detection process by adopting the CNN method has had quite a good impact [29]. The performance of the CNN method has also been able to be combined with the transfer learning model providing a good recognition rate in different behavioral data sets [30].

With some of the previous explanations, the detection of mask objects can be done using the development of the CNN method. The development of the CNN method is carried out by adopting Multi-Stage Detection based on multilayer convolution. The Multi-Stage Detection process is carried out to classify each layer level in identifying mask objects. The development of the CNN method will be able to present output with a much better level of precision and accuracy in the detection process. Thus the research contribution produces a model in the object detection process to determine the use of masks.

2. Research Methods

The process of detecting mask objects in this study was carried out by developing the CNN method using Multi-Stage Detection. The CNN development is presented at the convolution layer level used in the convolution matrix. This layer level can be referred to as a convolution multilayer because the CNN process classifies objects in a multi-stage manner. The process of developing the CNN method can be presented in a research framework. An overview of the research framework can be seen in Figure 1.

Figure 1 presents the process of developing the CNN method in mask object detection. CNN development is carried out using the convolution multilayer concept to produce the level of accuracy of detected objects. The results presented from this process will produce optimal image matrix values and will later be forwarded to the object classification process using the Artificial Neural Network (ANN) learning concept.

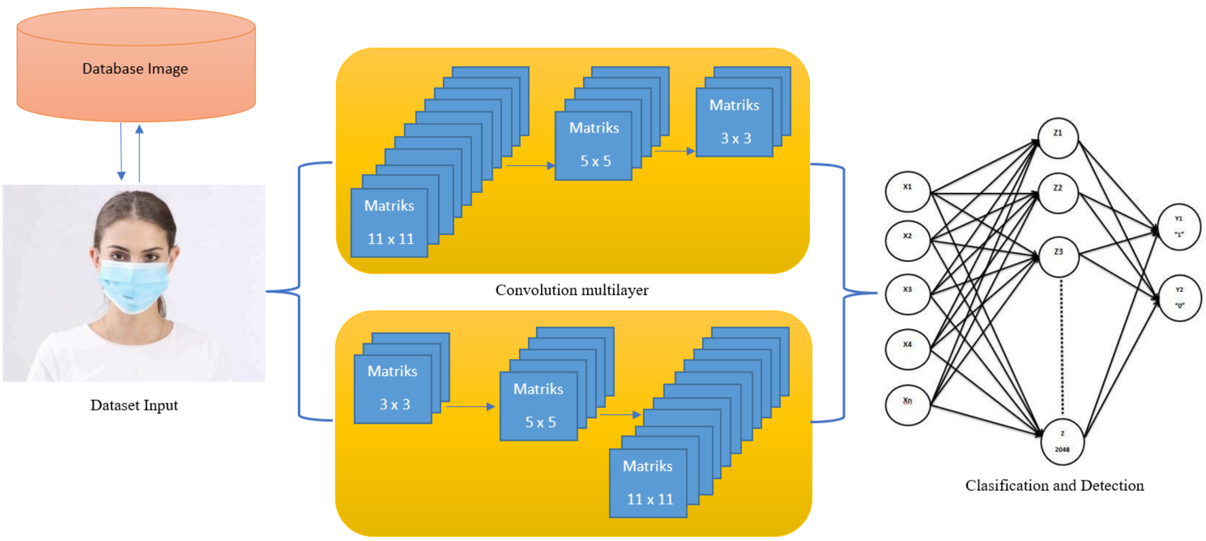

Figure 1. Research Framework

The process of classification and detection of ANN will present calculations by adopting Supervised Leaning (LS) learning. The learning process will be divided into the form of a training and testing process to provide an optimal level of accuracy of detection results.

The research dataset is sourced from the websites github.com and kaggle.com by taking 2000 data samples which are divided into 1000 training datasets and 1000 testing datasets. The criteria for detecting mask objects are medical and non-medical masks, as shown in Figure 2. Figure 2 is the result of the dataset obtained to describe the mask object. The object criteria that are the focus of this research can be seen based on the description of the mask that covers the face area. The shape of the mask object includes of a medical

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mask or masks in general which are used as the target object to be detected.

(a) Medical Mask Object

(b) Mask Object

(c) Object Without Mask

Figure 2. Research Dataset

Artificial Neural Networks (ANN) is an algorithm that is used to process datasets through the way the human brain works [31]. ANN refers to the neuron system being processed to get the output used to act [32]. The ANN architectural model can be seen in Figure 3 [33].

Figure 3 shows that the ANN architecture is composed of the input layer, hidden layer, and output layer. Each layer is interconnected with a weighting value in each unit. Overall ANN architecture will form a pattern that can be used in an analysis process.

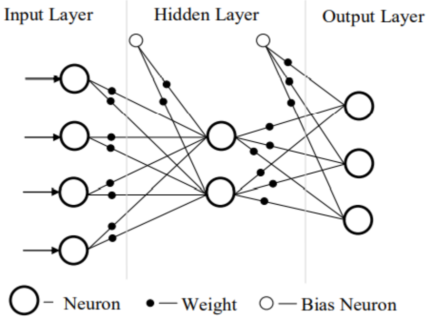

Figure 3. ANN architecture

Convolution Neural Network (CNN) is a method that is widely used in the concept of Deep Learning (DL) [34]. CNN has also participated in the scientific development of Computer Vision [35]. CNN's performance can be adopted in discussions such as digital image processing in object detection [36]. Basically, CNN is a technique used in image recognition using the mathematical method of convolution [37].

Convolution is a mathematical term in which the application of a function to the output of another function is repeated [38]. Convolution in image processing is defined as a process to obtain a pixel based on the pixel value itself [39]. Besides that, convolution can involve a matrix called a kernel. The term kernel can be represented as a weighted value [40]. Thus convolution is the main process in the CNN method [41]. In the input image convolution layer can be presented in Figure 4 [42].

Figure 4 describes the convolution process carried out by running a filter on the input section. The process aims to recognize the image by multiplying the image pixel value by the filter value (Karnel). The kernel contains the matrix values obtained from the training process. Karnel is run on each image using a predetermined kernel shift.

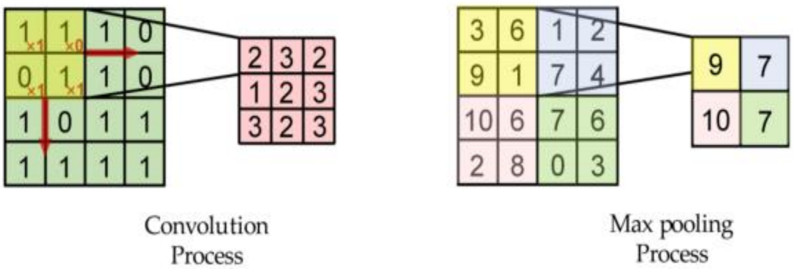

Figure 4. Convolution Process

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3. Results and Discussions

In detecting the use of face masks, two main processes will be carried out, namely the process of detecting faces and mask objects using the CNN method. Detection refers to the development of a method that is carried out using a convolution multilayer. The architecture of the CNN model can be presented in Table 1.

Table 1 is the CNN architectural model in the mask object detection process. The convolution process is carried out by adopting the multilayer concept to present optimal results. The form of the process of calculating the kernel that is carried out can be seen in Figure 5. Figure 5 is the convolution process performed on each pixel matrix of the input image. In this process, it can be seen that each part of the input pixel matrix is multiplied by the predetermined kernel weight value. Each value in the input will be carried out throughout the other pixel matrix. The input image is divided into 2 object criteria, namely the face image object with a mask and without a mask. After the entire convolution process has been carried out, the final stage of the performance of the CNN method is that the results of the visualization of the convolution process can be seen in Figure 6.

Table 1. CNN Object Mask Detection Model

Layer	Carnel	
Convolutional 1	11x11	Face Detection
Convolutional 2	5x5	
Convolutional 3	3x3	
Layer	Carnel	
Convolutional 1	11x11	Mask Detection
Convolutional 2	5x5	
Convolutional 3	3x3	

0	0	0	0	0	0
0	0,39215	0,56078	0,43529	0,67843	0
0	0,52549	0,68627	1	0,43529	0
0	0,43529	0,654901	0,56862	0,74117	0
0	1	0,56078	0,60784	0,47843	0
0	0	0	0	0	0

X

1	2	-1
0	0	0
0	-2	1

Figure 5. 3x3 Matrix Convolution Process

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 55, 55, 96)        34944

 max_pooling2d (MaxPooling2D  (None, 28, 28, 96)       0
 )

 conv2d_1 (Conv2D)           (None, 28, 28, 128)       307328

 max_pooling2d_1 (MaxPooling  (None, 14, 14, 128)      0
 2D)

 conv2d_2 (Conv2D)           (None, 14, 14, 384)       442752

 conv2d_3 (Conv2D)           (None, 14, 14, 192)       663744

 conv2d_4 (Conv2D)           (None, 14, 14, 128)       221312

 max_pooling2d_2 (MaxPooling  (None, 7, 7, 128)        0
 2D)

 flatten (Flatten)           (None, 6272)              0

 dense (Dense)               (None, 1024)              6423552

 dense_1 (Dense)             (None, 2)                 2050

=================================================================
Total params: 8,095,682
```

Figure 6. CNN Layer Visualization

Figure 6 provides an overview of the results of the processes that occur in the CNN layer. These results present the resulting total parameter values of 8,095,682 parameters. After all the layers are formed, proceed

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with training the CNN method using 1000 masked and unmasked image object datasets. The process is carried out using Sequent Gradient Descent (SGD) optimization in 200 Epoch. The training results can be seen in Figure 7. Figure 7 is the result of the training process carried out on the predetermined CNN model. These results can give the result that the loss value is 0.6904, and the accuracy value is 0.5625. for more details, the results of training and testing can be described in the graph presented in Figure 8.

```
Epoch 1/200
50/50 [==============================] - 66s 1s/step - loss: 0.6904 - accuracy: 0.5625 - val_loss: 0.6858 - val_accuracy: 0.5
250
Epoch 2/200
50/50 [==============================] - 52s 1s/step - loss: 0.6810 - accuracy: 0.6513 - val_loss: 0.6657 - val_accuracy: 0.7
375
Epoch 3/200
50/50 [==============================] - 52s 1s/step - loss: 0.6574 - accuracy: 0.6506 - val_loss: 0.6184 - val_accuracy: 0.7
650
Epoch 4/200
50/50 [==============================] - 51s 1s/step - loss: 0.6393 - accuracy: 0.6725 - val_loss: 0.7903 - val_accuracy: 0.5
100
Epoch 5/200
50/50 [==============================] - 52s 1s/step - loss: 0.5825 - accuracy: 0.7269 - val_loss: 0.4772 - val_accuracy: 0.8
375
```

Figure 7. CNN Training Result

Figure 8 is an illustration of the performance of the CNN method in the training process. The graph shows that the level of accuracy obtained is still not optimal, so the testing process needs to be done. The testing process uses 1000 samples of test data based on the image of the mask object. Based on the testing process that has been carried out, the accuracy results increase with a value of 0.9905. the accuracy value is optimal enough to carry out the mask detection process in an image. The results of the testing process can be seen in Figure 9.

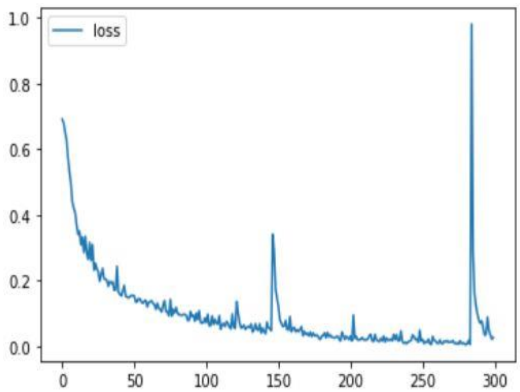

Figure 8. Graph of CNN Training Results

Figure 9 is a graphical description of the test for detecting mask objects. The results presented are quite good at recognizing objects so that the CNN output gives maximum output. To test the results of the CNN performance that has been developed, the system is designed in the form of a mask object detection testing application. The several tests can be presented in Figure 10.

Figure 9 is the result of the implementation of the system testing process in the mask object detection process. The testing process is carried out using two input models, namely the input image and the real-time video camera. The results of the tests carried out have been able to provide the status of using masks.

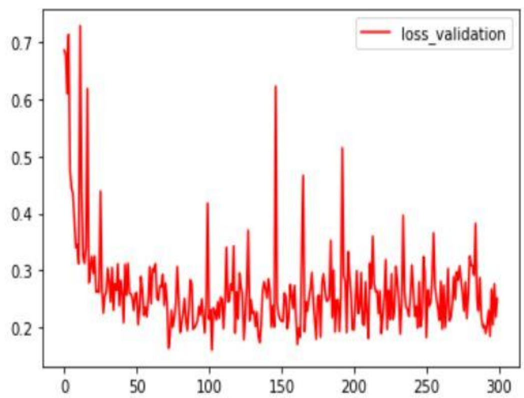

Figure 9. Graph of CNN Testing Results

Based on the results of the discussion that has been carried out, it is explained that the development of the CNN method with Multi-Stage Detection provides maximum results. The Multi-Stage Detection process can provide novelty in the object detection process for mask use. Object detection includes medical masks and non-medical masks. The output of validation results can be measured with a fairly good level of accuracy. Thus this research has contributed to presenting a maximum object detection process in detecting the use of masks.

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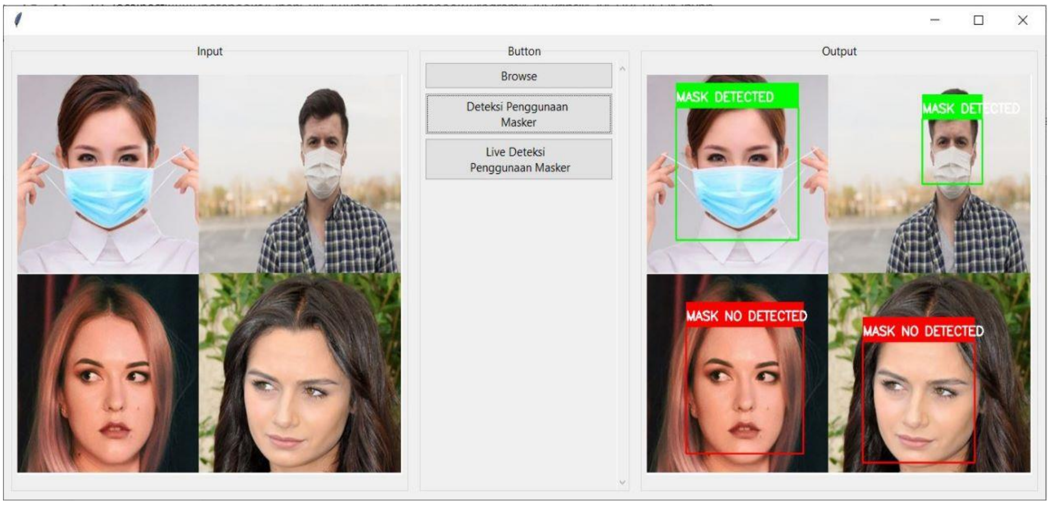
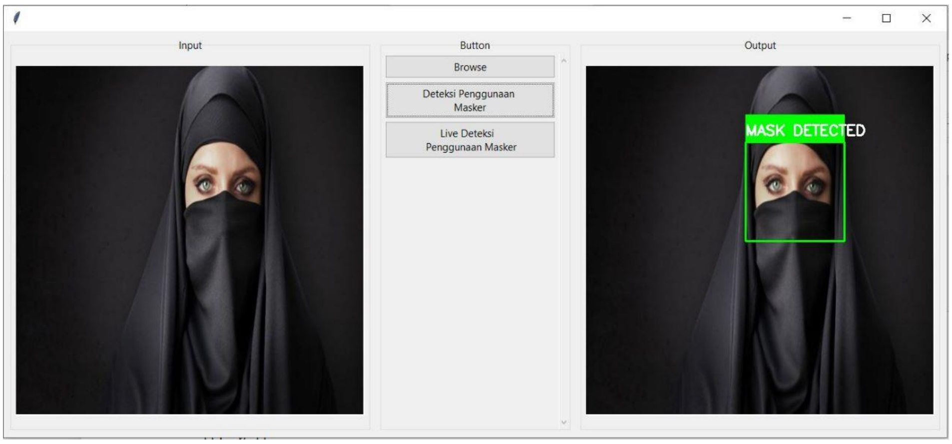
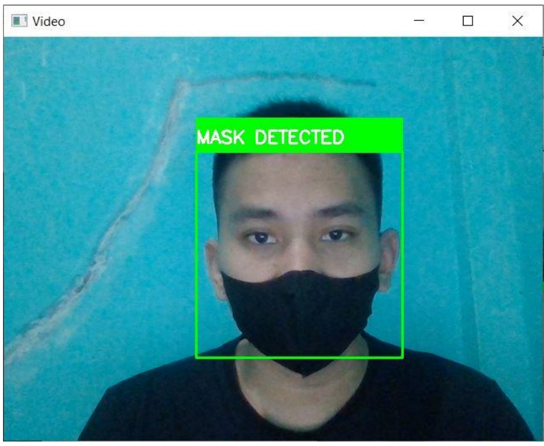


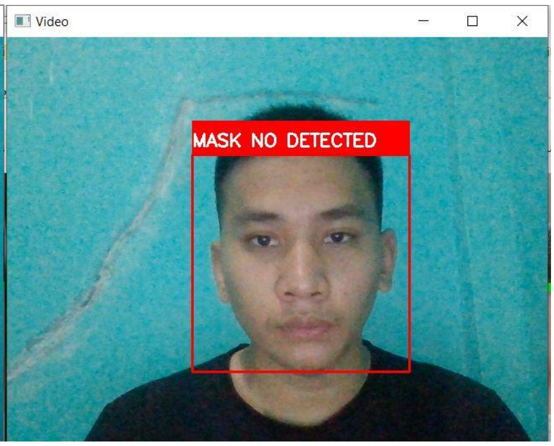
(a) Mask object detection process with Image Input



(b) The process of detecting veil objects with Image Input



(c1) Realtime Mask object detection process



(c2) Realtime object detection process without Mask

Figure 9. Test Results for the Mask Object Detection System

4. Conclusion

The development of the CNN method by adopting Multi-Stage Detection provides optimal mask object detection results. The level of accuracy of the detection results is presented at an accuracy value of 99.05%. the results of the development of the CNN method have also been applied to the testing of the system being built. The test results also present results that are in line with conducting tests based on the input image and a real-time video camera in detecting mask objects. Overall this research can provide alternative solutions in strategies to increase mask control both in public and closed spaces.

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