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# Implementation of Backpropagation Method with MLPClassifier to Face Mask Detection Model

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***Abstract*— The COVID-19 virus is highly contagious and can be spread through respiratory droplets when an infected person coughs or sneezes. To prevent the spread of the virus, the Minister of Health of the Republic of Indonesia has issued guidelines, including the use of personal protective equipment in the form of masks that cover the nose and mouth. This study aimed to develop a backpropagation neural network method from MLPClassifier and use the CRISP-DM framework to detect masks on human faces. The study used the RMFD (Real-World Masked Face Dataset) to train the model, which contains images of human faces with and without masks. The results of the study showed that the backpropagation neural network method had an accuracy of 94.4% in detecting masks on human faces. This accuracy outperformed other algorithms, such as the DNN algorithm from the paper with the title "SSDMNV2: A real time DNN-based face mask detection system using single shot multibox detector and MobileNetV2". This research is expected to contribute to the efforts to prevent the spread of COVID-19 by detecting the use of masks.**

***Index Terms*—Backpropagation; COVID-19; CRISP-DM; Face Mask; Neural Network; MLPClassifier;**

## I. INTRODUCTION

The COVID-19 pandemic has had a significant impact on global health and economies [1]. As of August 2021, over 218 million people have been infected and over 4.5 million have died. The virus interferes with the respiratory system and can lead to severe illness and death [2]. It has also caused widespread economic disruption due to measures such as lockdowns and travel restrictions. The Minister of Health of the Republic of Indonesia has issued guidelines to prevent the spread of COVID-19, including the use of masks [3]. However, data from covid19.go.id shows that the number of cases in Indonesia is still increasing, indicating low compliance with these guidelines in the community [4]. A survey also found low use of masks in the community. There is a need for increased awareness and compliance with guidelines to prevent the spread of COVID-19 in Indonesia [5].

One way to increase the level of compliance with guidelines to prevent the spread of COVID-19 is to improve supervision of the use of masks. Previous research has shown that machine learning models can be used for this purpose with different algorithms and methods. For example, the research "SSDMNV2: A real time DNN-based face mask detection system using single shot multibox detector and MobileNetV2" by Nagrath Preeti and colleagues has an accuracy of 93%. Data augmentation was performed in this research, without using HOG extraction and using the DNN (Deep Neural Network) algorithm [6]. The second research "Face Mask Detection by using Optimistic Convolutional Neural Network" by Suresh and colleagues has an accuracy of 98%. the Optimistic CNN (Convolutional Neural Network) algorithm was used without data augmentation and without using HOG extraction in this research [7].

The idea to use the backpropagation method in developing a machine learning model that can detect the use of masks on human faces is from a previous study named "Detection of Fire With Image Processing Using Backpropagation Method", which had an accuracy of 95% in detecting fire images. The dataset of that research was composed of images of fires that were processed using HOG extraction and without data augmentation [8].

The model for this research will be based on the CRISP-DM framework and will use the MLPClassifier from Scikit learn library to use backpropagation neural network algorithm. The dataset used will be the RMFD (Real-World Masked Face Dataset) from GitHub, and image augmentation and HOG extraction will be applied to the data. The goal is to create a model with high accuracy in detecting the use of masks on human faces. This approach can help automate the supervision of the use of masks as personal protective equipment to prevent the spread of COVID-19.

## II. LITERATURE REVIEW

### A. Face Mask Detection

This study focuses on detecting the use of masks on human faces to help control the spread of COVID-19. COVID-19 itself is a virus that spreads widely and became a global pandemic starting in the city of Wuhan, China in December 2019 [1]. COVID-19 can be spread through droplets made from coughs or sneezes, which are inhaled by other humans. This virus can live on droplets for up to 8 hours, which makes it very easy for the virus to spread. Therefore, the use of masks is recommended in preventing the spread of COVID-19 [9]. This research uses RMFD data as the research object. The dataset contains image data with 2 classifications, namely faces that use masks and faces that do not use masks [10].

### B. Histogram of Gradient (HOG)

A histogram of gradient is a technique used in image processing to detect objects by separating them from the background or noise. This separation helps improve the accuracy of the detection by focusing on the object of interest. The method uses the features and characteristics of the image, such as lines, contours, and shape, to measure the object. The measurement is divided into several areas, each of which is divided into pixels. Each pixel contains a value that is represented in the form of a histogram. This information is used to identify the object in the image and distinguish it from the background or other irrelevant objects [11].

$$f(x,y) = \begin{cases} fx(x,y) = f(x+1,y) - f(x-1,y) \\ fy(x,y) = f(x+1,y) - f(x-1,y) \end{cases}$$
(1)

$$Arg(x,y) = \sqrt{fx(x,y)^2 + fy(x,y)^2}$$
(2)

$$(x,y) = arctan\frac{fx(x,y)}{fy(x,y)}$$
(3)

The value of the brightness level in the image is based on equation 1, while equations 2 and 3 are calculations that are used for gradient-oriented gradient values [12].

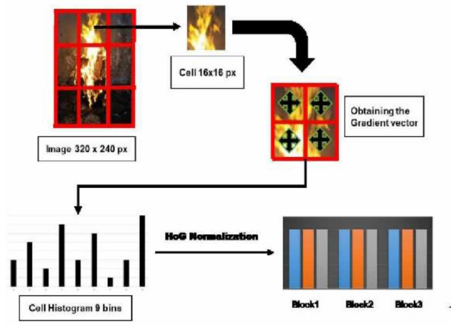



Figure 1. Example of HOG extraction [8]

### C. Image Augmentation

Image Augmentation is a procedure used to add to existing image data by transforming the initial image data used. The result of image augmentation itself is new data that comes from the initial image data. This serves to increase the variety of image data used by not merely duplicating existing image data. The limitation of the data used is one of the problems that can be overcome using image augmentation so that more data can be studied [13]. Things that are done, for example, are rotating images based on degrees (90 degrees, 180 degrees, 270 degrees) and mirroring or flipping image data.

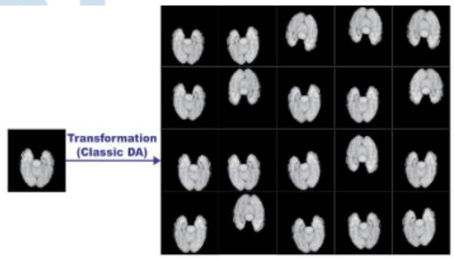



Figure 2. Example of augmentation on tumor images [14]

### D. Backpropagation

The purpose of this method is to minimize the mean-squared error that occurs between the network output and the actual output for input to the network or the network itself [15]. This algorithm is very popular in learning artificial neural networks. This learning can also be referred to as error-correction learning, which has a forward (forward) and backward (backward) path [16], [17]. The workings of this method can be seen as shown in Figure 3 which has 2 paths, namely forward and backward.

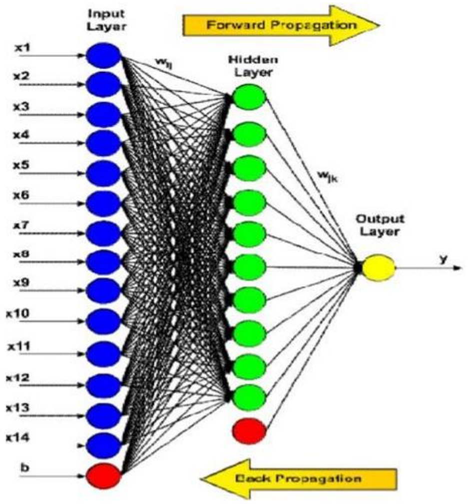



Figure 3. Backpropagation neural network [8]

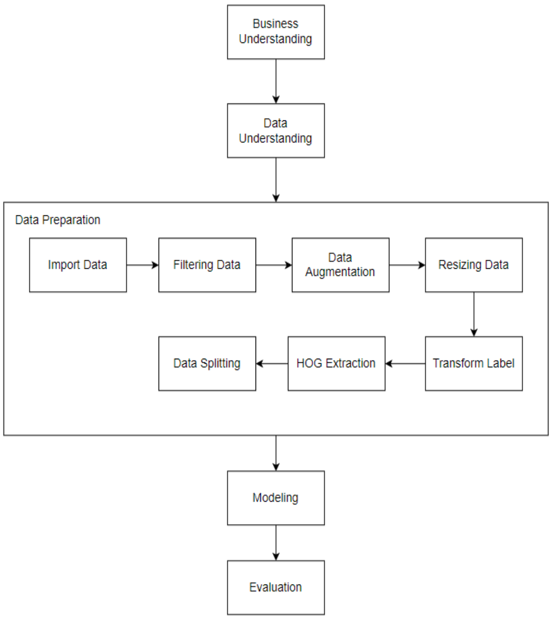



Figure 4 Research flow from CRISP-DM framework

Figure 4 backpropagation neural network explanation [8]:

- X1 – X14 : Data input (input layer)
- b (red): Bias
- Wij : Weight to hidden node
- Wjk : Weight to output node
- Z1 – Z10 (Green): Hidden Layer
- Y : Output (output)

The first flow which is forward propagation is to update the weights for each hidden layer that is built. The hidden layer itself is given weight from the data that has been prepared, up to the output stage. In the second flow which is backward propagation (backpropagation) begins. backpropagation is the flow of returning the training pattern received by the artificial neural network to activate output propagation. From the output results, the artificial neural network uses the output as a target for the training pattern of the hidden layer.

## III. Methodology

### A. *Object of Research*

This research focuses on detecting the use of masks on human faces to help control of the spread COVID-19. COVID-19 itself is a virus that spreads widely and became a global pandemic starting in the city of Wuhan, China in December 2019 [1]. COVID-19 can be spread through droplets made from coughs or sneezes, which are inhaled by other humans. This virus can live on droplets for up to 8 hours, which makes it easy for the virus to spread. Therefore, the use of masks is recommended in preventing the spread of COVID-19 [9]. This research uses RMFD data as the research object. The dataset contains image data with 2 classifications, namely faces that use masks and faces that do not use masks [10].

### B. *Research Method*

Figure 5 explains CRISP-DM or Cross Industry Standard Process for Data Mining used in this research. CRISP-DM is a standardization process for the life cycle of a data mining project [18].

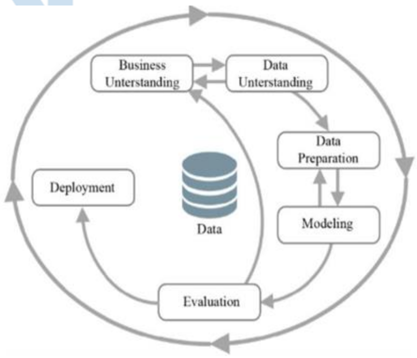



Figure 5. CRISP-DM [19]

The framework used in this research can be seen as the flow in Figure 4, which is a framework based on the CRISP-DM framework. This research only does the life cycle of CRISP-DM until the Evaluation

1) *Business Understanding*

Business Understanding is useful for identifying and determining the targets and objectives to be researched [19]. In this research, the main objective is to detect the use of masks on the human face, which has 2 classifications. The two classifications are human faces that use masks and human faces without a mask. The classification used the backpropagation method.

2) Data Understanding

In this second stage, there is a process of data collection, data understanding, and data analysis [19]. This study uses data called RMFD dataset [10]. The data comes from GitHub (https://github.com/X-zhangyang/Real-World-Masked-Face-Dataset) which contains photos of human faces using masks such as surgical masks, KN-95 masks, and others. And the data contains the image of human faces without masks. Figure 6 and Figure 7 are the example of the RMFD data.

Figure 6. RMFD human faces using a mask

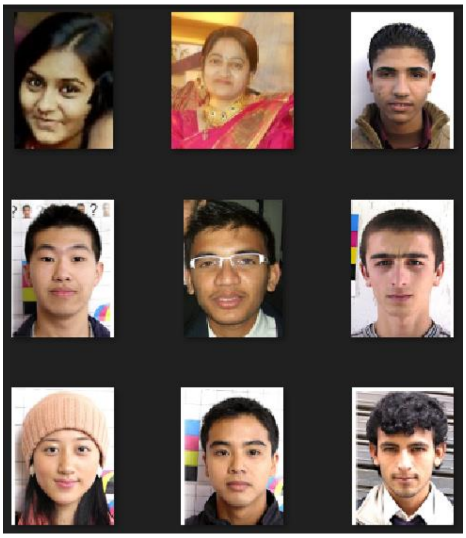


Figure 7. RMFD human faces without a mask

3) Data Preparation

The flow of data preparation in this research can be seen in Figure 8.

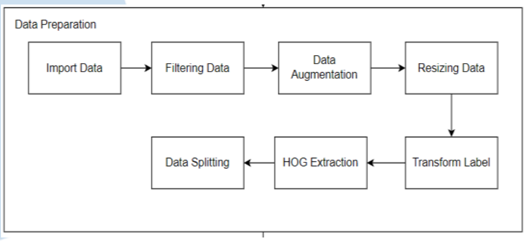



Figure 8. Data Preparation

The first process is importing the data to Google Colab. Filtering the image data that has been obtained is the second process. The dataset will be filtered based on their data type and features. The data type used in this research is "jpg" data type, and the second filter is a feature of the image itself. The only features used are images that have only “RGB” feature. When the data type is not “jpg”, then the data will be changed to “jpg”, also the data feature is not RGB, then the data will be deleted. The result of filtering process can be seen in Table I.

TABLE I. The result of filtering process

| **Data Classifi-cation** | **Data Type** | | | **Data Feature** | | |
|---|---|---|---|---|---|---|
| | ***jpg*** | ***png*** | ***jpeg*** | ***RGB*** | ***RGBA*** | ***P*** |
| With_ mask | 1613 | 224 | 88 | 1798 | 117 | 15 |
| Without_ mask | 1930 | 0 | 0 | 1930 | 0 | 0 |

After filtering the image, the next process is data augmentation. This stage is useful for multiplying existing data up to 10000 image data (each label/ classification has 5000 image data). Augmentation is done by flipping the image from bottom to top, from left to right, and rotating the image by 90 degrees, 180 degrees, and 270 degrees at random. The augmented data are shown in Figure 9.

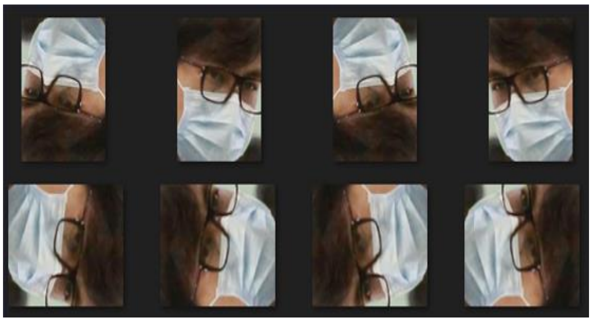


Figure 9. Augmented image

After augmenting the image, the image data will also be resized to a size of 320x240 pixels and converted the data into an array. This process is based on previous research that became the reference in this study, named "Detection of Fire With Image Processing Using Backpropagation Method" [8]. Label/ Classification from the dataset also transformed into binary class from multi-class, using LabelBinarizer library.

HOG extraction will be carried out on the image data that has been successfully converted into an array. HOG extraction is a descriptor of the elements in the image or photo by separating the elements that are important in the data (which is the main goal) and removing elements that are not important in the image under study [20]. Data from the previous process will be divided into 3 according to its function, data for the training model, test model, and validation model with a portion of 10% for the validation model, 10% for the test model, and 80% for the training model.

4) Modeling

The modeling process will use Google Colab tools that use Python language. Initially, the existing data, named photo data of humans using masks and photo data of humans not wearing masks will be imported into Google Colab. The data will then be labeled into 2 classifications according to the classification of each photo, named photos of masks and photos without masks. The data will also be split into 3, train data which is useful for training the model, validation data is for validating the model, and test data which is useful for evaluating the model. The results of the model itself are in the form of accuracy.

Modeling with the backpropagation neural network method will use the MLPClassifier or Multi-layer Perceptron Classifier derived from the Scikit Learn library. MLPClassifier itself is a supervised learning that has one hidden layer or even more with stacked links or neurons originating from the received input. The model created using the MLPClassifier will be optimized again by using the log-loss function obtained in the first model creation [21].

5) Evaluation

In this fifth stage, the results of the model will be assessed and evaluated. This is useful as a benchmark, whether the model has been made in accordance with the initial objectives of this research with the accuracy as the output. The evaluation of this research itself is the level of mask detection accuracy on the human face. The purpose of this research is whether this model can detect faces wearing a mask, and those who don't wear a mask.

6) Deployment

This research did not reach the deployment stage. This is because this study only focuses on comparing the level of accuracy of previous studies.

## IV. Result and Discussion

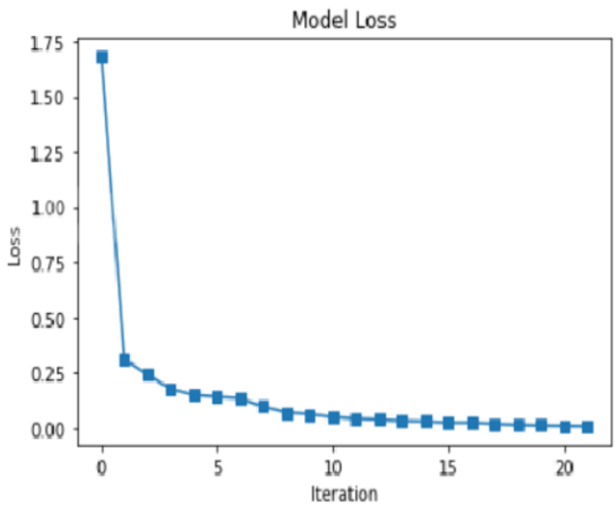



Figure 10. Loss from the model

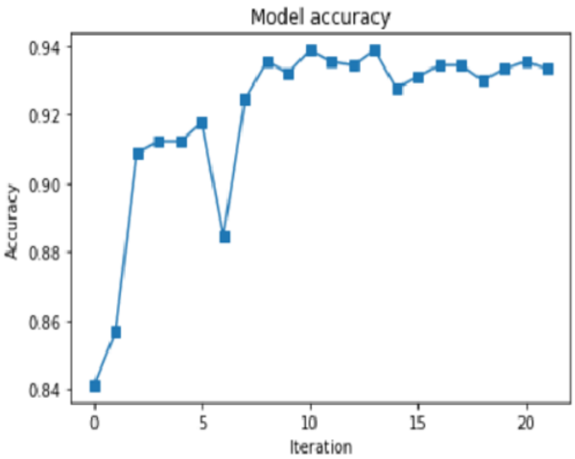



Figure 11. Accuracy from the model

The results of the model can be seen in Figure 10 and Figure 11. There were 22 iterations with a loss of 0.008 and a validation score of 0.933. As for the accuracy score obtained in the testing data, it is 0.944 with a confusion matrix as shown in Figure 13. The model that has been built produces a confusion matrix like Figure 12, with 465 true positives, 479 true negatives, 35 false positives, and 21 false negatives.

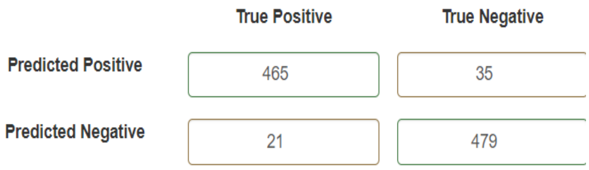
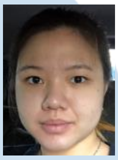
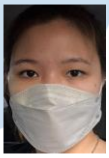
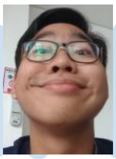
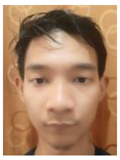



Figure 12. Confusion matrix from the model

| Photo | Actual | Prediction | Photo | Actual | Prediction |
|---|---|---|---|---|---|
|  | With_mask | With_mask |  | Without_mask | Without_mask |
|  | Without_mask | Without_mask |  | With_mask | With_mask |
|  | Without_mask | Without_mask |  | Without_mask | Without_mask |
|  | With_mask | With_mask |  | With_mask | Without_mask |
|  | With_mask | With_mask |  | Without_mask | Without_mask |
|  | Without_mask | Without_mask |  | With_mask | With_mask |

| | | | | | |
|---|---|---|---|---|---|
|  | Without_mask | Without_mask |  | Without_mask | Without_mask |
|  | With_mask | With_mask |  | With_mask | With_mask |
|  | With_mask | With_mask |  | Without_mask | Without_mask |
|  | Without_mask | Without_mask |  | With_mask | Without_mask |

Test to the model also has been done with photos owned by the researcher. There are 20 photos taken by camera handphone as shown in Figure 13. The 20 photos contain photos of human faces that wear a mask and do not wear a mask, in pairs and the results are shown in Table II

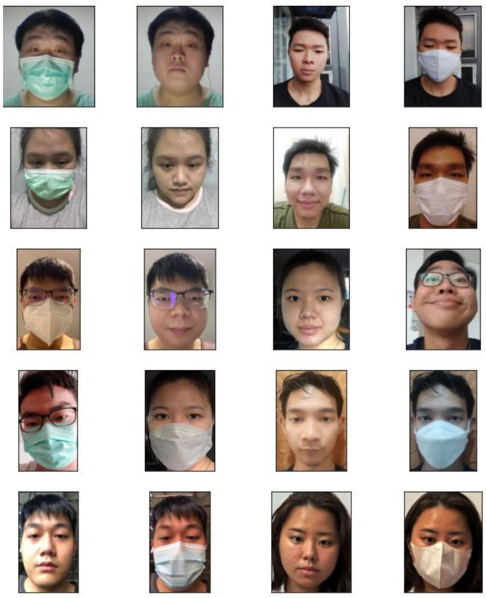


Figure 13. Sample of photos

Testing the data that has been tested on the 20 image data managed to guess the image correctly as many as 18 data. There is a predicting error in the 13th and 20th data. The image data used has taken the same pre-processing stage as the modeling stage (such as resizing data, converting data into arrays, and performing HOG extraction). From the predictions that have been made, it can be concluded that the predictions for the data from the model testing results get an accuracy of 90%.

## V. Conclusion

The application of the backpropagation neural network method using the CRISP-DM framework, as well as modeling is carried out through several pre-processing stages such as filtering data based on the data type and features of the image data itself, multiplying the data using an augmentor library in augmenting research image data, and processing data using HOG extraction before building a neural network model with the backpropagation method has been done with an accuracy of 94.4%.

Based on the results, the backpropagation method can outperform the DNN algorithm by 1.4% in detecting masks on human faces. Even though the Optimistic CNN algorithm is still superior to the backpropagation method, with a difference of 3.6%. From the results that have been achieved, it is can be concluded that this research has succeeded in achieving its goal, which is detecting face masks on the human face by obtaining an accuracy of 94.4% using the backpropagation method. This research also succeeded in manually validating to detect face mask on the human face and this model was able to predict 18 out of

20 photos provided by the researcher, which means getting 90% accuracy from the test.

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