Detection of Covid-19 in Chest X-ray Image using CLAHE and Convolutional Neural Network

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Abstract*—In 2019, the COVID-19 virus has spread to various parts of the world including Indonesia. This global pandemic becomes a lethal outbreak since there is no vaccine to treat or prevent transmission of the virus. Rapid Test is selected as an essential method to detect Covid-19 in Indonesia because the price is fairly cheap compared to the SWAB test. The increase in Covid-19 patients tends to lead to limited capacity for the Covid-19 test available at the hospital so that the latest technology to detect and overcome this pandemic issue is needed. Thus, the present research aims to examine the total of 100 X-Ray chest images of the Covid-19 patients and 100 X-ray normal chest images. The application of Contrast Limited Adaptive Histogram Equalization (CLAHE) and Convolutional Neural Networks (CNN) methods are implemented to analyze the dataset with two scenarios in obtaining the detection results. The results of this research reveal that the application of CLAHE is likely to affect Covid-19 detection accuracy using CNN. Also, the application of the CNN basic model shows significant results compared to the application of VGG16 transfer learning.

Keywords—Detection, Covid-19, Chest X-ray, CLAHE, CNN

I. INTRODUCTION

In 2019, the Covid-19 virus has spread to various parts of the world [1,2] including Indonesia. This has led to the designation of Covid-19 as a global pandemic resulting in more than 29 million cases in September 2020 [3]. Covid-19 is considered as the evolving form of the virus so that no vaccine can treat or prevent the transmission of the virus yet. Therefore, people mostly rely on Rapid Test as a method to detect whether someone is infected with Covid-19 or not.

Some research studies on Covid-19 reveal that women are less likely to be infected with Covid-19 than men. Additionally, another research also discovers that the mortality rate in children aged 0-9 years caused by Covid-19 has not been found [4].

There are several indications to find out whether someone has been infected by the virus, such as fever, cough, and respiratory symptoms. Several worse things may also happen such as pneumonia, septic shock, acute respiratory syndrome, multi-organ failure, and even death [5][6]. Furthermore, someone who has a history of pneumonia can be infected by the Covid-19 virus more quickly than someone who does not have a history of respiratory problems [7].

Rapid test, as an alternative to detecting Covid-19, is currently considered problematic to carry out since the diagnostic system is not available in all places. Given the limitations of Covid-19 testing, other alternative diagnostic measures are urgently needed. Therefore, the automatic detection instrument, such as the application of X-ray scans, is needed to analyze the patient's lungs and to detect whether someone has been infected by the virus or not. The application of X-Ray scans can be applied as an alternative diagnostic mechanism since nearly all hospitals have an X-ray machine. Hence, Covid-19 virus detection can be conducted without using a special kit.

This study aims to examine the patterns emerging from the X-ray chest images of the patients who have been infected by the Covid-19 virus. The observation is implemented using deep learning. The deep learning algorithm that is selected to be applied in the present research is Convolution Neural Networks (CNN). Apart from applying the CNN basic model, the VGG16 transfer learning model is also used to compare and reveal which model has the best performance. Also, a pre-trained model is used in this research as the dataset. After that, the pre-trained model is re-implemented on the new dataset, one of which is VGG16 [8]. The application of image processing is also applied to improve the image quality using Contrast Limited Histogram Equalization (CLAHE). The combination of CNN and CLAHE is implemented to recognize objects in the form of medical images and image enhancement, especially the detection of the Covid-19 virus on X-ray chest images. In the present research, the programming language used to implement CLAHE and CNN is Python along with the OpenCV library.

II. LITERATURE REVIEW

Computer science in artificial intelligence (AI) is one type of technological advancement shown by machines. Unlike the natural intelligence displayed by humans, the term "artificial intelligence" is often used to define machines that mimic the "cognitive" functions related to the human mind, such as "learning" and "problem-solving". In contrast to traditional machine learning methods that require hand extraction features from the input, artificial intelligence performs a deep learning method by studying the features derived from certain data.

The Convolutional Neural Networks (CNN) algorithm is an “artificial intelligence” with a deep learning method that is quite superior to other models. That is to say, CNN is likely to be the dominant method in the processing tasks of computer vision [9]. The objective of this research is to explore the feasibility of CLAHE and CNN's basic performance with some primary deployment scenarios and transfer learning trials. The dataset used is 200 X-ray chest images. To be specific, the dataset used consists of 100 normal X-ray images and 100 Covid-19 X-ray images.

Pneumonia is one of the lung’s deadly diseases. The pneumonia diagnosis involves a set of chest radiographs interpreted by a radiologist. However, a diagnosis that is assisted by humans has its limitations such as the availability of experts, fees, and other issues [10]. In the current X-ray chest image of the Covid-19 patients, the researchers add the non-Covid pneumonia dataset so that the number of datasets used can be obtained with maximum accuracy. In other words, in this research, the dataset used contains normal X-ray chest images and Covid-19 X-rays chest images.

After the researchers select the proper method to detect Covid-19 through X-ray chest images, the researchers start enhancing the image quality by implementing Contrast Limited Histogram Equalization (CLAHE). The process involves histogram equalization procedure to process X-ray datasets and analyzes the performance levels of CNN that are combined with CLAHE.

Neural Network (NN) is a basic algorithm system that is often used at present. Neural Network (NN) mechanism is inspired by the learning process of the humans' brain. The perceptron is one of the primary systems of NN that was first proposed by Rosenblatt [11]. Convolutional Neural Network (CNN) is a developmental variation of Neural Network (NN) suggested by Weasel and Hubel after observing the visual cortex of cats in 1968 [12]. The visual cortex generally possesses a small area formed from a cell that is sensitive to the point specified in the visual field. That is to say, the cell within the cortex can be activated only in a particular shape and orientation.

The basic structures of CNN are essentially similar to the structures of NN in general. They consist of some similar aspects, such as input, hidden, and output layers. Meanwhile, every layer on CNN generally contains several parts such as activation, convolution, and pooling. The condition of each layer is set regarding the spatial grid structure in which a small area on the previous layer specifies any value in the feature.

Image enhancement is a factor that needs to be taken into account to carry out high-quality segmentation, especially in X-ray images. The enlarged contrast and sharpness of the image are likely to improve the accuracy of subsequent modes for further diagnosis of autonomic disease systems [13]. In this research, there is an analysis of various preprocessing techniques for vertebral bone segmentation. The three methods employed are Contrast Limited Adaptive Histogram `Equalization (CLAHE), Histogram Equalization (HE), and Gamma Correction (GC).

The objectives of the present research are to compare and measure the accuracy of the techniques used to improve image quality. In other words, three pre-processing methods are compared, namely HE, GC, and CLAHE. The results in this research discover that GC shows the best sensitivity even though CLAHE displays the best accuracy. Due to the correct detection accuracy, either positive or negative, CLAHE is considered the most suitable performance metric to use. Thus, the most suitable algorithm for image enhancement is CLAHE.

III. METHOD

An Adaptive Histogram Equalization (AHE) is a procedure used to enhance the image contrast by increasing the local contrast of the image. The local contrast is acquired by forming a symmetrical grid on the image so-called region size. The issue of excessive contrast enhancement in AHE can be solved by 0using CLAHE that assigns a limit value to the histogram. This value is called the clip boundary which represents the maximum height of a histogram [14].

Convolutional Neural Network (CNN) is a development of Multilayer Perceptron (MLP) designed to process two-dimensional data. CNN is involved in the Deep Neural Network since it has a high network depth. It is also widely applied to process the image data. In the case of image classification, MLP is not suitable to use due to its incapability to store the spatial information of the image data. Besides, it also considers each pixel to be an independent feature resulting in poor outcomes.

CNN was established under the name of NeoCognitron proposed by Kunihiko Fukushima, a researcher from the NHK Broadcasting Science Research Laboratories, Kinuta, Setagaya, Tokyo, Japan [15]. The concept was then finalized by Yann LeChun, a researcher from AT&T Bell Laboratories in Holmdel, New Jersey, USA. The CNN model with the name LeNet was successfully applied by LeChun in his research on numbers and handwriting recognition [16].

The X-ray detection of Covid-19 patients on their chests using Contrast Limited Adaptive Histogram Equalization (CLAHE) and Convolutional Neural Networks (CNN) was carried out through several stages as illustrated in Fig. 1.

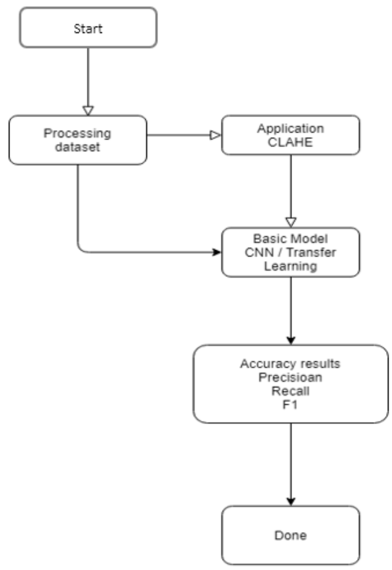

Fig. 1. Flowchart of research

A. *Processing Dataset*

Regarding the process of data collection, the datasets used were 200 images of chest X-Ray consisting of 100 images of Covid-19 chest X-ray and 100 images of normal chest X-ray. The collected datasets of Covid-19 chest X-ray were obtained through GitHub [17] while the datasets of normal chest X-ray were obtained through Kaggle [18].

B. *Application of CLAHE*

The CLAHE implementation served to improve the quality of images that had been classified. It also functioned to enhance the image contrast to get significant outcomes.

C. *Scenario Analysis*

The process of data analysis was conducted through two scenarios. The first scenario was carried out by comparing the detection between the normal dataset and the dataset that had been improved by CLAHE. The second scenario was implemented by comparing the CNN basic model with VGG16 transfer learning. In the process of scenario analysis, the researchers examined the level of accuracy, precision, recall, and F1. In the process of Covid-19 detection analysis using CNN's basic model, the researchers implemented the procedures as seen in Fig. 2. Meanwhile, in the process of Covid-19 detection analysis using VGG16 learning transfer, the researchers employed created procedures as illustrated in Fig. 3.

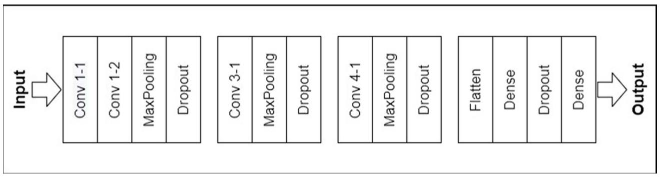

Fig. 2. CNN basic architecture

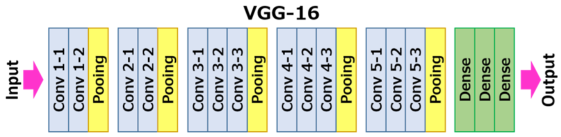

Fig. 3. Architect VGG16

IV. Results and Discussion

This section presents the experimental process and results that have been carried out to evaluate the proposed method. Fig. 4. portrays the research steps that are carried out in the present research.

Fig. 4. Research steps

A. *Processing Dataset*

The researchers obtain the main data from two sources, namely Github and Kaggle. After collecting the data, the researchers classify the dataset manually into 100 Covid-19 X-ray images and 100 normal X-ray images as seen in Fig. 5. Then the dataset is processed and analyzed using Google Colab so that the researchers can set the form path of data.

Fig. 5. Covid-19 and normal X-ray image

B. *Application of CLAHE*

At this stage, the researchers use CLAHE that is combined with the Python language programming. Fig. 6. shows an image before the process of analysis while Fig. 7. presents the results after the image being processed with CLAHE. Regarding the image shown in Fig. 6. it can be concluded that there is a significant change in image contrast and clarity which automatically improves the image quality in Fig. 7. The key factors in CLAHE are clip limit (CL) and the number of tiles (NT) [19]. The clip limit is a system regulating noise amplification so that the height of the clip does not exceed the specified limit. Meanwhile, the number of tiles is the non-overlapping number of squares or areas at the same size.

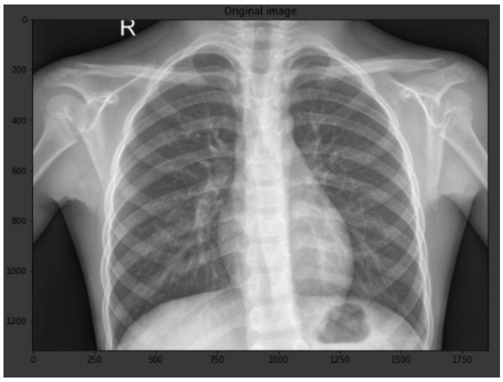

Fig. 6. Before CLAHE

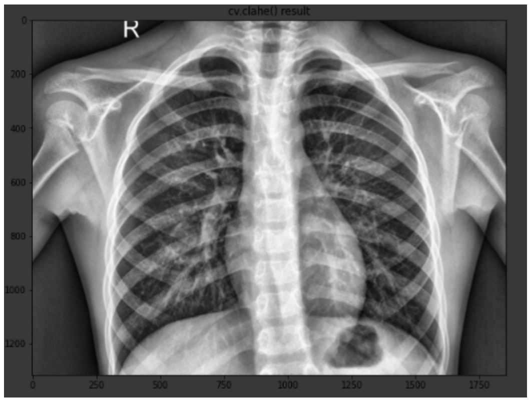

Fig. 7. After CLAHE

C. *Scenario Analysis*

This stage contains two scenarios to be compared. The first scenario is the comparison between the basic dataset and the CLAHE-enhanced dataset. The second scenario is the comparison between CNN's basic model and VGG16 transfer learning. The CLAHE implementation has shown an improving performance on the accuracy and validation as shown in Fig. 8. indicates portrays 98% accuracy and 97% validation. Moreover, Fig. 9 indicates 99% accuracy and 97% validation. That is to say, the results display an improvement on the regular dataset enhanced by CLAHE that is examined using CNN's basic model.

```
model.evaluate_generator(train_generator)

[0.0191231369972229, 0.981249988079071]

model.evaluate_generator(validation_generator)

[0.057231537997722626, 0.9750000238418579]
```

Fig. 8. Using a regular dataset

```
[13] model.evaluate_generator(train_generator)

[0.0018916826229542494, 0.9937499761581421]

[14] model.evaluate_generator(validation_generator)

[0.09678425639867783, 1.0]
```

Fig. 9. Using CLAHE

In the first scenario, the researchers propose the graph of loss and precision models that are shown in Fig. 10. to Fig.13 is the visual form of Fig. 8. And Fig. 9. The models can be used to determine the accuracy of each epoch. The results of applying the accuracy model on the usual data set using CLAHE can also be seen in the Confusion matrix in Fig. 14. By using the Confusion Matrix, it can be observed that of the 40 data used for the validation process, there are 20 true positives, 19 true negatives, 0 false positives, and 1 false negative.

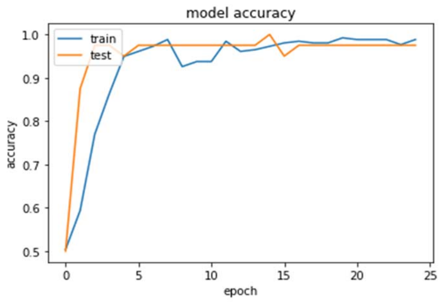

Fig. 10. Dataset Model Accuracy

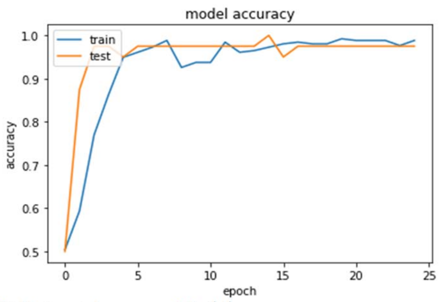

Fig. 11. CLAHE Dataset Accuracy Model

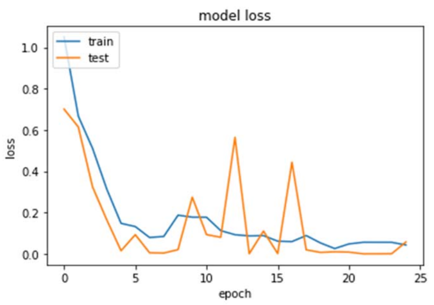

Fig. 12. The usual dataset loss model

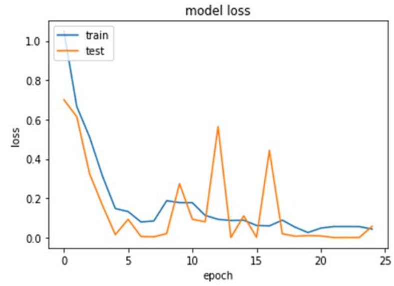

Fig. 13. CLAHE Model Loss dataset

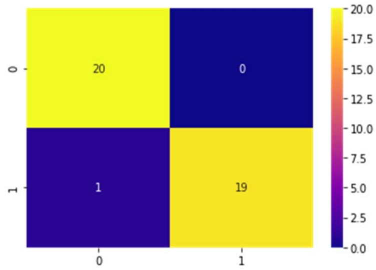

Fig. 14. Confusion matrix

The continuing step is the comparison of the first scenario's results that is carried out using precision, recall, and F1 analysis. The results of applying the normal dataset and the dataset that has been improved by CLAHE have the same percentage as shown in Fig. 15. The dataset used only contains 40 images. Therefore, even though there are differences in the accuracy and validation models, it still has no significant effect on the results of precision, recall, and F1.

```
Precision: 1.000000
Recall: 0.950000
F1 score: 0.974359
```

Fig. 15. Precision, recall, F1

The second scenario is a comparison of the VGG16 learning transfer using the same data. The process of analysis reveals less than optimal results in the second experiment as seen in Fig. 16. The VGG16 transfer learning model application with a similar dataset that is measured using the CNN basic generator model shows the accuracy rate of 44% and 50 %. On the contrary, the data loss displays a higher accuracy that is 69%. These results show that there is an error in combining the generator model applied to VGG19. The researchers present the accuracy graph produced in Fig. 17. and the graph of the loss model in Fig. 18.

```
[ ] model.evaluate_generator(train_generator)

[0.6931498646736145, 0.4437499940395355]

[ ] model.evaluate_generator(validation_generator)

[0.6931484341621399, 0.5]
```

Fig. 16. Train accuracy and validation of VGG16

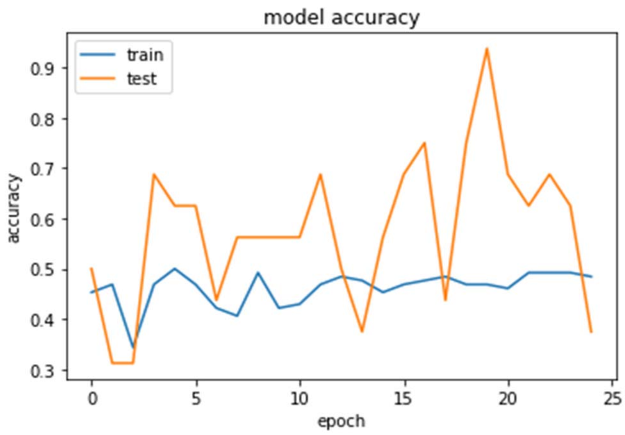

Fig. 17. VGG16 Accuracy Model

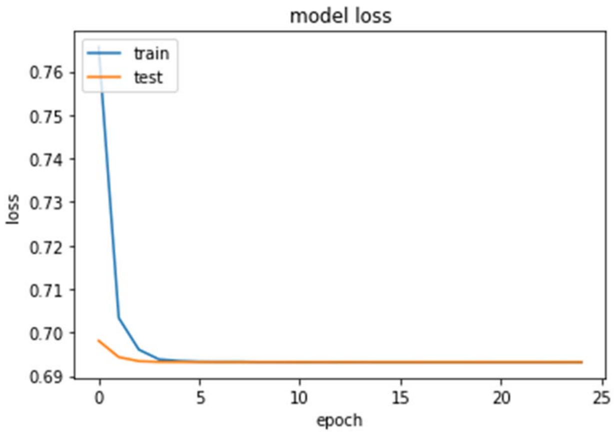

Fig. 18. VGG16 Loss Model

V. CONCLUSION

Various experiments have been conducted resulting in several conclusions. In the first comparison scenario, it can be concluded that the application of CLAHE is considered able to affect the accuracy of the generate evaluating model as shown in Fig. 9. However, since this research examines a small dataset consisting of 40 images, the detection of Covid-19 cannot affect the precision, recall, and F1. In comparison, in the second scenario, between CNN basic model and transfer of learning, it can be seen that the VGG16 transfer of learning is not appropriate to be applied with a similar evaluating model that analyzed using basic CNN. This is due to an error in the detection process so that the accuracy of the transfer learning application is considered low. Besides being able to increase accuracy, this research can also show the enhancement of CLAHE accuracy by changing the value of epochs in the training process. In developing further research, it is suggested that future researchers use additional datasets, namely X-ray pneumonia to gather many variations. Thus, the system is likely to distinguish the differences among the Covid-19 virus, pneumonia, and normal chests of the patients. Also, adding the pneumonia dataset can improve the performance on the accuracy, precision, recall, and F1 so that the distinguishable differences can be seen clearly.

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