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The Performance of the Covid-19 Pneumonia Classification Machine using the Convolutional Neural Network Method with 5 Convolutional Layers

Budi Nugroho *, Eva Yulia Puspaningrum, M. Syahrul Munir

Informatics Department, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya 60294, Indonesia

Corresponding author:
E-mail:
budinugroho.if@upnjatim.ac.id

ABSTRACT

One health disorder that is categorized as a serious disease and can cause death is an inflamed lung condition, which is then called pneumonia. Each year, pneumonia infects about 450 million people (about 7% of the world's total population) and causes about 4 million deaths. The World Health Organization (WHO) in 2020 reported that this disease is the cause of 15% of deaths in children under 5 years old. In Indonesia, based on a report from the Indonesian Ministry of Health in 2018, the number of people experiencing health problems due to pneumonia is around 2%. The Covid-19 pandemic that has occurred since the beginning of 2020 has worsened this condition massively. The SARS-CoV-2 Corona Virus, which causes Covid-19, attacks the respiratory tract and infects the lungs, which then causes the lungs to become inflamed. Pneumonia due to COVID-19 is then known as Covid-19 Pneumonia. This research aims to detect COVID-19 pneumonia based on digital images obtained from the acquisition of lung objects from X-rays / x-rays of the lungs. The experimental process is carried out to classify the image of the lungs in normal conditions (no inflammation), experiencing inflammation due to the SARS-CoV-2 corona virus (covid-19 Pneumonia), or experiencing inflammation due to other factors (pneumonia). The classification approach used is the Convolutional Neural Network (CNN) method which uses a 5-layer convolution architecture with filter values of 16, 32, 64, 128, and 256. The experimental process uses 3900 images for the training process, 450 images for the validation process, and 225 images for the testing process. Based on the testing process that has been carried out, the performance of the Covid-19 Pneumonia classification resulted in an accuracy of 84.88%, a precision of 0.85, a recall of 0.84, and an f1 score of 0.85.

Keywords:SARS-CoV-2, Covid-19 pneumonia, classification performance, convolutional neural network

Introduction

Lung disease occurs in almost all parts of the world. This disease is associated with chronic obstructive pulmonary disease, asthma, tuberculosis, fibrosis, and pneumonia (Bharati et al, 2020). Pneumonia is an infection that causes inflammation of the air sacs in one or both lungs. Usually, this pneumonia is an area of the lung that has increased opacity (Franquet, 2018). In people with pneumonia, a collection of small air sacs at the end of the respiratory tract in the lungs (alveoli) will become inflamed and filled with fluid or pus. So, people with this disease experience cough with phlegm, fever, chills, chest pain, and difficulty breathing. Bacteria, viruses, and fungi are organisms that can cause pneumonia. However, in adult patients, this condition is most often

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caused by a bacterial infection. Figure 1 is a digital image from an X-ray that shows pneumonia in one part of a patient's lungs (Mooney, 2019).

Pneumonia is one of the leading causes of death in children in the world. The World Health Organization (WHO) estimates that this disease has caused 15% of deaths in children under 5 years old (WHO, 2019). Each year, pneumonia infects about 450 million people, 7% of the total world population, and causes about 4 million deaths. The discovery of antibiotic therapy and vaccines in the 20th century has increased survival. However, in developing countries, pneumonia is still the leading cause of death for the very old, the very young, and the chronically ill. In Indonesia, based on data from the Basic Health Research at the Ministry of Health, the number of people experiencing health problems due to pneumonia is 2%, an increase compared to 2013 which was 1.8% (Kemenkes, 2018). Though pneumonia is a disease that has a serious impact that can cause death.

Figure 1. X-ray images of the lung showing Pneumonia (left) and Normal (right) conditions

One of the causes of pneumonia which is currently a global pandemic is Covid-19. This disease is caused by a corona virus called SARS-CoV-2 which has never been found before. People infected with Covid-19 can be divided into 4 categories. The first is patients who fall into the subclinical category. In this category, patients are infected with the corona virus but do not show any symptoms. The second is an infected person in the upper respiratory tract, where a person experiences fever, cough, and other mild symptoms such as headache or conjunctivitis. Patients in this category can transmit the virus but may not be aware of it. The third is people who are infected with Covid-19 and need to be hospitalized or undergo surgery. And the fourth is patients who experience severe symptoms that require intensive and very strict treatment. WHO also mentions that people who are older or with a history of diseases such as high blood pressure, heart problems, lung problems, or diabetes, are more likely to experience more serious symptoms.

Pneumonia caused by Covid 19 is then known as Covid-19 Pneumonia. Those infected are reported to have a cough, fever, and difficulty breathing. In serious cases, someone who has COVID-19 pneumonia can experience organ failure. Many of the Covid-19 patients died because they had a previous history of poor health. The process of recovering from Covid-19 depends on the strength of each individual's immune system. The Covid-19 pandemic has certainly put pneumonia into a serious disease that needs to be handled appropriately (Heidari et al., 2020).

In this research, the detection process was carried out on Covid-19 pneumonia using X-ray images. This is very important to do considering that Covid-19 has become a global pandemic and mostly causes pneumonia for sufferers. The virus that causes Covid-19 does attack the body through the respiratory tract, so the lungs are the organs most affected. In this case, the lungs can experience inflammation whose severity is determined by the body's resistance (immunity) and the condition of the lungs themselves. Through this research, the system will detect whether inflammatory conditions in the lungs are caused by Covid-19 (Covid-19 Pneumonia) or not (pneumonia caused by other factors). This information is very important to assist the process of

medical diagnosis so that patient management can be carried out appropriately. Medical treatment for patients with Covid-19 Pneumonia is certainly different from ordinary pneumonia.

Material and Methods

Classification machine design

Many studies have been done related to the problem of pneumonia. In the early stages, the early detection process is very important. One of the pneumonia detection techniques that is currently being developed is the classification of lung images from x-ray photos. One way to detect pneumonia early is to take an X-ray of the chest (the area where there are lung organs), then identify whether the lungs are inflamed (pneumonia) or not. Many studies have been carried out that utilize machine learning techniques to predict diagnostic information from x-ray images (Song et al, 2017).

One of the recent studies conducted by Jain et al tested several Convolutional Neural Network (CNN) models, including VGG16, VGG19, ResNet50, and Inception-v3, to detect pneumonia (Jain et al., 2020). The CNN method used can extract features and classifications automatically. The test was carried out using an x-ray lung image database from Kaggle (Kaggle, 2020). Another research that also uses the CNN method was carried out by Stephen et al, where the architecture uses 4 Convolutional layers, 4 Max-pooling layers, 1 Flatten, 7 Dense layers, and adds re-scale variations, rotations, width shifts, height shifts, shear ranges, spans. zoom, and flip horizontally (Stephen et al., 2019). Polsinelli and his research team used the Light Convolutional Neural Network (light CNN) which is based on the SqueezeNet model (Polsinelli et al., 2020). Xiang Xu uses the Graph-Knowledge Embedded CNN method for the CNN machine training process to obtain a Feature Extractor to produce high classification performance (Yu et al., 2021). Sirazitdinov et al combined 2 CNN architectures, namely RetinaNet and Mask R-CNN, to get a better ability to detect pneumonia (Sirazitdinov et al., 2019). Meanwhile, other research modifies the CNN method by adding ELM techniques to get better results (Yoo et al., 2016).

This research uses the CNN method which has 2 main processes, namely feature extraction and classification, as shown in Figure 2. The feature extraction process is used to encode the image into features in the form of numbers that represent the image. This process consists of 2 parts, namely the Convolutional Layer and the Pooling Layer. The convolutional layer consists of neurons arranged in such a way that they form a filter with length and height (pixels). While the classification process is used to identify image objects.

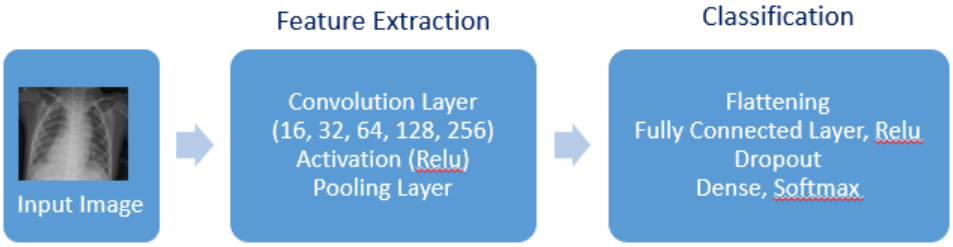

Figure 2. Feature extraction and classification process in this research

In its implementation, the CNN method was developed through several stages, namely Model Building, Model Training, Model Evaluation, and Final Model Prediction. The CNN architecture used to detect COVID-19 pneumonia in this study is shown in Figure 3. As shown in the figure, the CNN architecture used has 22 layers, consisting of an input layer, 5 convolution layers, 5 Rectified Linear Units (Relu), 5 Maxpooling, and 2 fully connected layers (FCL), 2 Dropout, Softmax, and 1 Classification / Output layer. The convolution layer has a 3x3 filter with dimension values of 16, 32, 64, 128, and 256, respectively.

Figure 3. CNN Architecture for Covid-19 Pneumonia Detection in this research

The Convolution Layer performs a convolution operation on the output of the previous layer. This layer is the main process that underlies a CNN. The purpose of convolution on image data is to extract features from the input image. Convolution will produce a linear transformation of the input data according to the spatial information in the data. The weights on the layer specify the convolution kernel used so that the convolution kernel can be trained based on the input to the CNN. The pooling layer is used to reduce the size of the image so that it can be easily replaced by a convolution layer with the same stride as the corresponding pooling layer. The Fully Connected layer is used in the application of MLP and aims to transform the data dimensions so that the data can be classified linearly. Each neuron in the convolution layer needs to be transformed into one-dimensional data before it can be entered into a fully connected layer. Because this causes the data to lose its spatial information and is not reversible, the fully connected layer can only be implemented at the network end.

Image dataset

In this research, the Image Dataset used is a collection of digital images from lung x-ray photos, which have been grouped into Covid-19 Pneumonia, Pneumonia, and Normal conditions. Figure 4 is an example of an image of the lungs with these 3 conditions.

Figure 4. An X-ray image showing Covid-19 Pneumonia (left), Pneumonia (middle), and Normal (right)

In the experiments that have been carried out, the image dataset used is divided into 3 main groups, namely training data, validation data, and evaluation/testing data, where each group contains a collection of lung images with the condition of Covid-19 Pneumonia, Pneumonia, and Normal. The dataset for training contains 3900 images (1300 images of Covid-19 pneumonia, 1300 images of pneumonia, and 1300 normal images). The dataset for validation contained 450 images (150 images of Covid-19 pneumonia, 150 images of pneumonia, and 150 normal images). While the dataset for evaluation contained 75 images (75 images of Covid-19 pneumonia, 75 images of pneumonia, and 75 normal images). The arrangement of this dataset is used to test the process of detecting Covid-19 pneumonia, which in this research uses the Convolutional Neural Network method with 22 layers, following the testing procedures established by experts in this field.

Results and Discussion

Tests were carried out repeatedly on the program code by modifying several parameters, input image size, convolution layer, and so on. This needs to be done to find the best performance results. Based on the results of the trials that have been carried out, the best performance results are obtained as shown in Figures 5 to 9. The performance in this experiment is measured using accuracy, precision, recall, and F1 score.

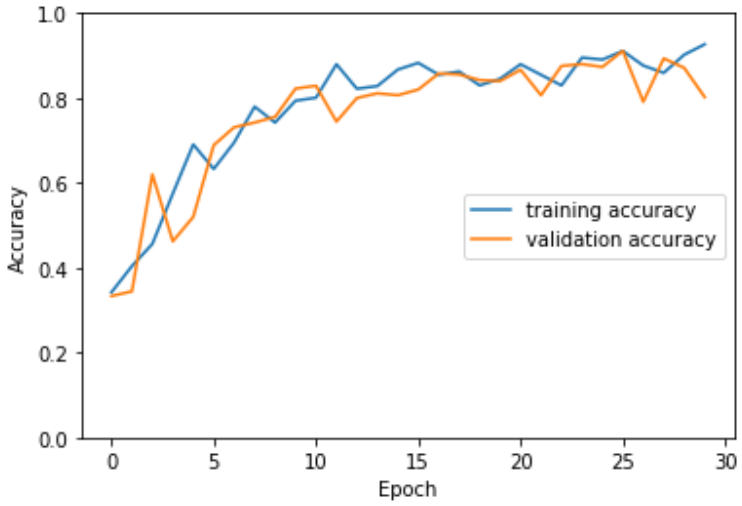

Figure 5. Experimental results: Accuracy in training and validation sessions

Performance Accuracy in the training and validation process is shown in Figure 5, where in the last epoch, the training accuracy is 92.66% and validation accuracy is 80.22%.

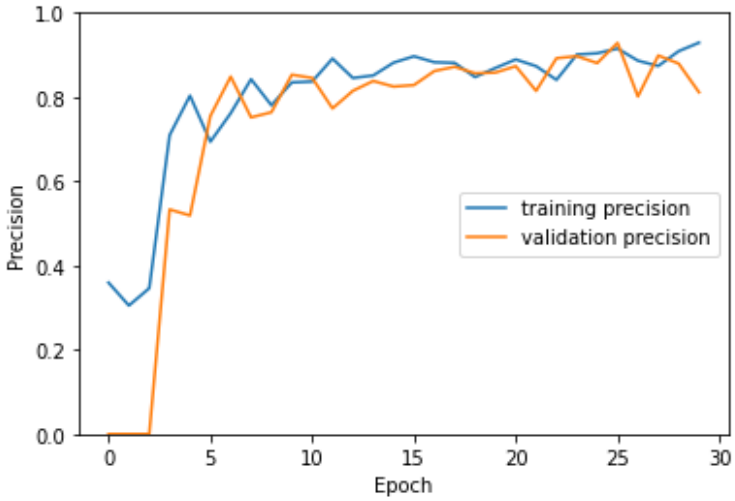

Figure 6. Experimental results: Precision in training and validation sessions

Performance Precision in the training and validation process is shown in Figure 6, where in the last epoch the training precision is 0.93 and the validation precision is 0.81%.

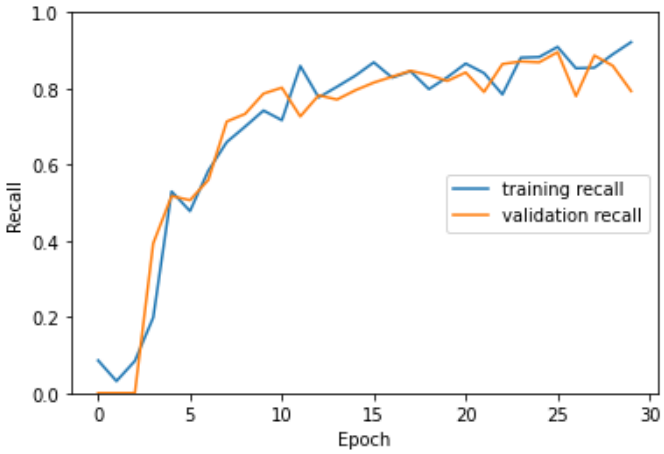

Figure 7. Experimental results: Recall in training and validation sessions

Recall performance in the training and validation process is shown in Figure 7, where in the last epoch the training recall was 0.92 and the validation recall was 0.79%.

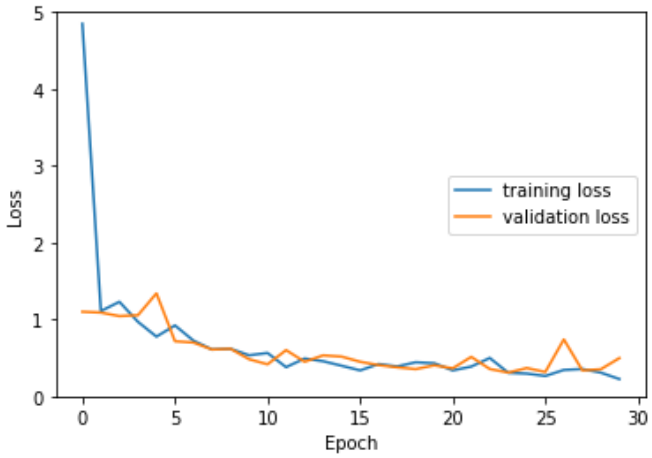

Figure 8. Experimental results: Loss in training and validation sessions

Loss in the training and validation process is shown in Figure 8, where in the last epoch the training recall was 0.92 and the validation recall was 0.79%.

```
Measure Rate at Evaluation Data:
loss rate = 0.33616894483566284
accuracy rate = 0.8488888740539551
precision rate = 0.8520179390907288
recall rate = 0.8444444537162781
f1 score / F measure rate = 0.848214291318852
```

Figure 9. Experimental results: evaluation session

While the performance of the final evaluation results is shown in Figure 9, where the accuracy is 84.88%, precision is 0.85, recall is 0.84, and f1 score is 0.85.

Conclusion

Based on experiments that have been carried out empirically, this research concludes that the Covid-19 pneumonia detection system has a fairly good performance, namely 84.88% accuracy, 0.85 precision, 0.84 recall, and 0.84 f1 scores. The experimental process involves a fairly large image dataset so that the performance results obtained have a good level of confidence. The more data used to test the reliability of an image analysis method, the more valid the results obtained.

The results of this research can later be applied to the medical world (medical / health) to identify early on the condition of a person's lungs, especially those caused by Covid 19 (Covid 19 Pneumonia). As the Covid-19 pandemic is still ongoing, where most cases cause severe pneumonia to cause death, it is hoped that health institutions in the future have a database of lung X-rays of many people, so that early detection of covid-19 pneumonia can be carried out, so that appropriate treatment strategy can be carried out more quickly. Patients with mild pneumonia certainly cannot be equated with patients with severe pneumonia, especially if the pneumonia is caused by an easily contagious virus such as Covid-19. Classification of the level of pneumonia is important to determine the level of treatment that is different for each patient's pneumonia cluster.

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