Detection of Covid-19 on X-Ray Images Using a Deep Learning Convolution Neural Network

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Abstract—Pneumonia Coronavirus Disease 2019 (COVID-19) is an inflammation of the lung parenchyma caused by Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Supporting examinations carried out to establish a diagnosis of Covid-19 is through radiological examinations, one of which is a X-Ray The current method used to diagnose COVID-19 from X-Ray images is by studying the 2-D X-Ray image data set using the naked eye, then interpreting the data one by one. This procedure is ineffective. Proposed research aims to develop a Covid-19 detection application on localized X-Ray images using a Deep Learning Convolution Neural Network. This research includes four main points. The first is taking a X-Ray image from the internet. The second is X-Ray image preprocessing. The third is the determination of Region of Interest (ROI) from X-Ray imagery containing Covid-19 and normal X-Ray. The fourth is to detect COVID-19 automatically by classifying image suspected of being COVID-19 on X-Ray using the Deep Learning Convolution Neural Network method. The accuracy obtained is an accuracy of 95%.

Keywords—Covid-19, CNN, Deep Learning, ROI, X-ray.

I. INTRODUCTION

Severe acure respiratory syndrome coronasvirus 2 (SARS-CoV- 2) is a new virus that was first reported in Wuhan City, Central China, which was reported on December 31, 2019, which finally WHO gave the name Coronavirus disease 2019 (COVID-19) [1]. Genome sequence of new Coronavirus (SARS-CoV-2) is known to be almost similar to SARS-CoV and MERS-CoV. In evolutionary terms it is same as SARS-CoV and MERS-CoV but not exactly the same [2-9].

The supporting diagnosis that is carried out to establish a diagnosis of Covid-19 is a radiological examination, which includes: chest X-ray, chest CT scan, and chest ultrasound.[10-14]. Radiological results may show: bilateral opacity, subsegmental consolidation, lobar or pulmonary collapse or nodule, groundglass view. In the initial stage, a small multiple plaque shadows with obvious intertitial changes appear in the periphery of the lung and then develop multiple ground-glass shadows and infiltrate in both lungs. In severe cases, even "white-lung" lung consolidation and (rare) pleural effusion can be found [15]. During the last few months research on Covid-19 has been widely discussed by researchers**.** Because, this disease was discovered at the end of 2019. From the research that has been done by several researchers, it can be concluded that to detect Covid-19 using an intelligent system, almost all the methods proposed for classification use global-based and region-based. The global-based method used is a color histogram. This method only calculates the pixel frequency of the image so it is very sensitive to light and geometric changes. As a result, two images that have different colors and geometric positions will be recognized as two different images, even though both images are semantically the same. A region based approach, the image is segmented into several regions that represent objects. The weakness of this method is that during the image segmentation process, the segmentation results are often not in accordance with the desired object. Hence the accuracy is low.

This paper describes the classification of Covid-19 and not Covid-19 images on ct-scans which are localized using a deep learning convolution neural network Convolutional Neural Network (CNN) is a deep learning (DL) method that can be used to detect and recognize an object in a digital image. Deep Learning is one of the sub-fields of Mechine Learning. Basically, Deep Learning is an implementation of the basic concept of Mechine Learning which implements the ANN algorithm with more layers. The number of hidden layers used between the input layer and the output layer, this network can be said to be a deep neural net.

The last few years Deep Learning has shown great performance. This is largely influenced by stronger computational factors, large datasets and techniques for training deeper networks [16]. CNN's ability is claimed to be the best model for solving object detection and object recognition problems. In 2012, research on CNN could perform digital image recognition with an accuracy similar to that of humans on this particular dataset [17]. However, CNN, like other deep learning models, has a weakness, namely, the model training process is quite long. But with the rapid development of hardware, this can be overcome using Graphical Processing Unit (GPU) technology and high specification PC.

Based on the above background, this research applies the implementation of the deep learning method using CNN to detect Covid-19 on a localized Ct-Scan. This study focuses on how to classify normal Covid-19 X-Ray and not normal X-Ray Images.This research is divided into four stages, first is

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taking X-Ray images from the internet. Second is X-Ray image preprocessing. Third is determination of Region of Interest (ROI) from X-Ray images containing Covid-19 and normal X-Ray. Fourth is to detect COVID-19 automatically by classifying image suspected of being COVID-19 on a localized X-Ray using Deep Learning Convolution Neural Network method.

II. METHOD

A. Classification of Covid and Non-Covid Using a Deep Learning Convolution Neural Network

Convolutional Neural Network (CNN) is a development of a multilayer perceptron (MLP) which is designed to process two-dimensional data in the form of images [18-19]. CNN is included in the type of Deep Neural Network because of its high network depth and is widely applied to image data. Deep Learning is one of the areas of Machine Learning that utilizes artificial neural networks to implement problems with large datasets. Deep Learning techniques provide a very strong architecture for Supervised Learning. For classification using the Convolution Neural Network consists of two stages, namely Feature Learning and classification. For a clearer classification using a Convolution Neural Network, it will be explained step by step as shown in Figure 1 below.

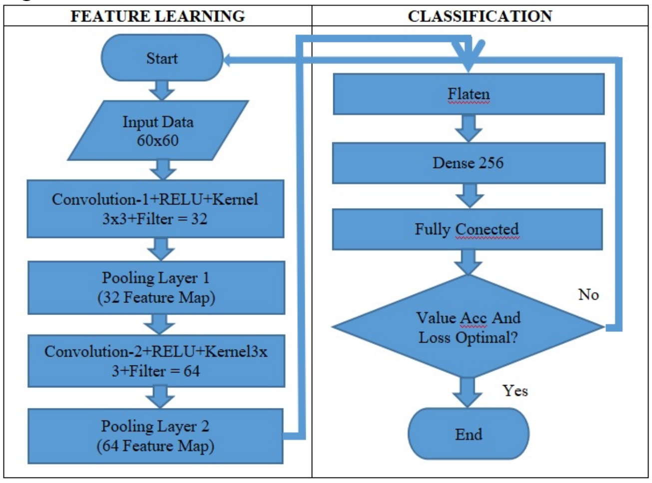

Figure 1. Flowchart Classification Using Convolution Neural Network

Based on the figure above, it is explained that there are two stages in CNN's architecture, namely Feature Learning and classification [20-21]. Feature learning is a technique that allows a system to run automatically to determine the representation of an image into features in the form of numbers that represent the image. The classification stage is a stage where the results of feature learning will be used for the classification process based on predetermined subclasses. If the flowchart above is converted into an image, it can be seen as shown in Figure 2 below:

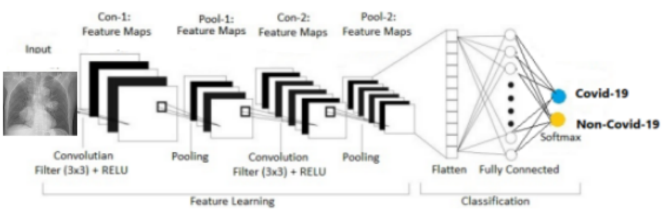

Figure 2. CNN Architecture

Feature learning is a technique that allows a system to run automatically to determine the representation of an image into features in the form of numbers that represent the image. The image used is a X-Ray image that contains Covid and those that do not contain Covid which is obtained from the segmentation process. Segmentation of lung field using Active Appearance Model (AAM) [22-26]. The results of the segmentation using AAM are described in Figure 3.

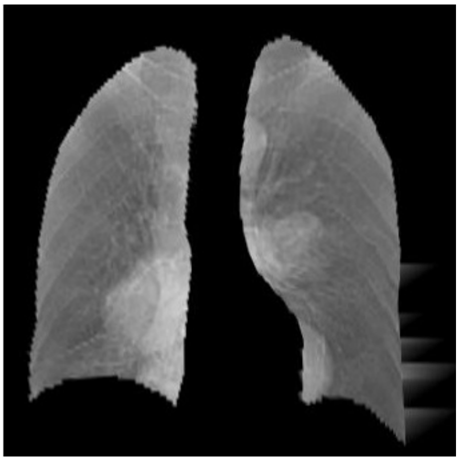
Figure 3. Result of Lung Field Segmentation

The first stage in feature learning is convolution. Convolution is the process of combining two number series to produce a third number series. Convolution is in the form of a matrix array. In Figure 3, the input is in the form of an image that has a pixel size of 224x224x3, this shows that the pixel height and width of the image is 60 and the image has 3 channels, namely red, green, and blue or what is commonly referred to as RGB.Each channel pixel has a different matrix value. The input will be convoluted with the specified filter value. A filter is another block or cube with a smaller height and width but the same depth that is swept over the base image or original image. Filters are used to determine what patterns will be detected which are then convoluted or multiplied by the value in the input matrix, the value in each column and row in the matrix is highly dependent on the type of pattern to be detected. The number of filters in this convolution is 60 pixels with a kernel size (3x3), this means that the resulting image of the convolution will be 60 map features. The convolution process is shown in figure 4.

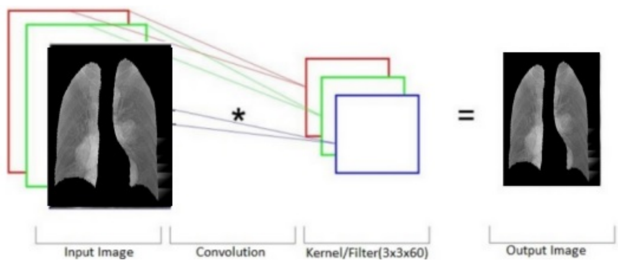

Figure 4. Convolution Process

The first convolution process used a 3x3 kernel and 32 filters. This convolution process is a combination process between two different matrices to produce a new matrix value. After the convolution process, an activation function is added, namely RELU (Retrified Linear Unit). This activation function aims to convert negative values to zero (eliminating negative values in a convoluted matrix).The result of this convolution has the same size, namely 60x60, because during the convolution process the padding value of 0 is use. The second covolution process is to continue the results of the first pooling process with an image matrix input of 32 x 32 with a total of 64 filters and a kernel size of 3x3.This second convolution process both uses the RELU activation function.

Then before proceeding to the pooling layer process, to eliminate negative values in the results, the network architecture uses ReLU (Rectified Linear Unit) activation after the convolution process. The function of this activation is to "threshold" from 0 to infinity. The values that are in the resulting negative convolution will be changed by this activation to zero and the others until infinity. After the convolution process is the pooling process. Pooling is a reduction in the size of the matrix by using a pooling operation. The method used in the pooling process uses max-pooling. Max-pooling is a common method commonly used by researchers related to deep learning research. In a study conducted by Dominik Scherer, it was shown that the use of the max pooling method was superior to the sub-sampling method. The use of this method is one of the best methods in the pooling process. An overview of the pooling process is shown in the following figure 5.

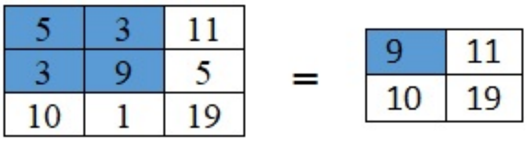

Figure 5 Pooling Process

This pooling process uses a size of 2x2 with a stride of 1, where the number of shifts in the kernel to the input matrix is one. In this pooling process, the max-pooling method is used, where the window will be shifted according to its size and strident to get the maximum value. It can be seen in Figure 7 that the output of this process has the maximum value that is taken from the convolutional map feature matrix. The max-pooling results are 2x2 in size. Basically, the pooling layer consists of a filter of a certain size which will alternately shift the entire feature map area. This study uses max-pooling to obtain new matrix values as a result of the pooling process. Based on the results of pooling, it produces a new matrix measuring 30x30 using a 2x2 pooling kernel. The way max-pooling works is to take the maximum value based on the shift in the kernel as the value of the stride is 2. The next process enters the second pooling process, this process is almost the same as the first hang pooling process, but there is a difference in the final output value of the matrix. The resulting output has an image size of 15x15.

The next step is the classification of Covid-19 and Noncovid-19. At the classification stage, it is divided into 2, namely Flaten and Fully Conected. At this stage only one hidden layer is used in the Multi Layer Perceptron (MLP) network. Flatten converts the output pooling layer into a vector. Before doing the classification process or predicting an image, this process uses the Dropout value. Dropout is a neural network regulation technique with the aim of selecting several neurons randomly and not to be used during the training process, in other words, these neurons are randomly discarded. The purpose of this process is to reduce overfitting during the training process. The last process is to use Softmax function activation. This function is specifically used in the classification methods of multinomial logistic regression and multiclass linear discriminant analysis. The last process is the Fully Connected Process. The second stage in the classification process is the Fully Connected Layer. This process aims to transform the dimensions of the data so that the data can be classified linearly.

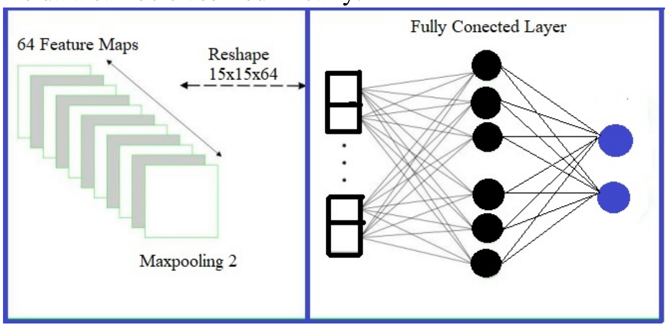

Figure 6 Process of Fully Connected Layer

B. Dataset

The dataset used in this study came from Wuhan China. The image data used is a X-Ray image with a thickness of 0.5 mm. The total number of images collected for a sample of 140, with 70 X-Ray images for each type category. Covid and Non-Covid X-Ray images are shown in Figure 7.

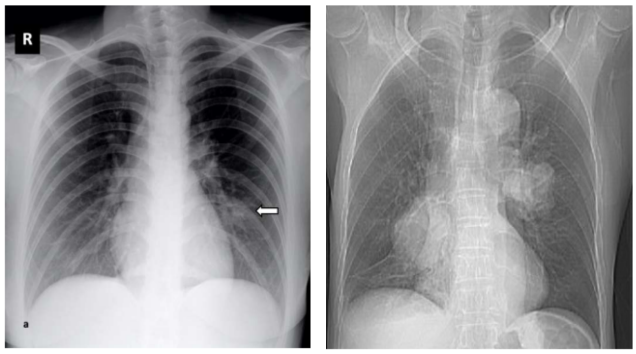

Figure 7. X-Ray Images
(a). Covid (left), (b) Non Covid (right)

III. RESULT

The purpose of this study was to classify two image classes, namely Covid and Non-Covid on X-Ray using the Convolutional Neural Network (CNN) algorithm. The classification process begins with the training data process. Training data used is 140, with 70 training data for each class. Data training process aims to create a model that will be used for testing data testing. Parameter to measure the success rate of the model is the accuracy value. Accuracy value can be determined by testing using testing data. This process uses a total of 20 epochs, the value of learning rate is 0.001. The test was carried out 3 times. Three tests are described as follows.

A. Testing with Original X-Ray Image Dataset

This test uses the original X-Ray image dataset, with a size of 1024 x 1024 pixels. The total number of training data used was 160, each class was 80. The test data used were 40

(20 Covid-19 data, 20 Noncovid-19 data). The results of test are shown by Confusion Matrix as shown in Table 1.

Table 1. Confusion Matrix Testing Using X-Ray Original Image Training Data

Matrix		Predict Class	
		Covid-19	Not Covid-19
Actual Class	Covid-19	14	6
	Not Covid-19	0	20

Based on table 1 above, the predictive results of the model against testing data using training data show good results. Predictions for Covid-19 are classified as Covid-19, the total is 14, Covid-19 is classified as non-Covid-19 by 6, predictions in non-Covid-19 images are classified as Covid-19 totaling 0, and non-Covid-19 images are classified as non-Covid-19 images by 20. The calculation of the accuracy of the entire matrix above is as follows:

$$\text{Overall Accuracy} = \frac{TP\ all}{\text{Tota Number of Testing Entries}}$$

$$= \frac{34}{40}$$

$$= 0.85\ (85\%)$$

So the accuracy of testing with the original X-Ray image input, the learning rate value of 0.001 and the number of testing samples 40 data, obtained an accuracy value of 85%.

B. The Second Test Uses X-Ray Data For Lung Field

The second test uses training data and testing data from X-Ray images of the lungs that have been separated from the surrounding tissue. Method used for lung segmentation is Active Appearance Model (AAM). Training data used were 80 X-Ray images (40 Covid-19 lungs, 40 Non-Covid-19 lungs). The test data used were 20, for each class 10 data. The confusion matrix results are as follows:

Table 2. Confusion Matrix Testing Using X-Ray Lung Image Data

Matrix		Predict Class	
		Covid-19	Not Covid-19
Actual Class	Covid-19	9	1
	Not Covid-19	0	10

Based on table 2 above, the prediction results from testing data using X-Ray data for the lung area show good results. The prediction against Covid-19 is classified as Covid-19, as many as 9, predictions on the Covid-19 image and classified as non-covid-19 as much as 1, Non-Covid-19 images are classified as non-Covid-19 totaling 10, and non-covid-19 images are classified as Covid-19 images totaling 0. The calculation of the accuracy of the entire matrix above is as follows:

$$\text{Overall Accuracy} = \frac{TP\ all}{\text{Tota Number of Testing Entries}}$$

$$\frac{19}{20}$$

$$= 0.95\ (95\%)$$

So the accuracy generated by the model with an image input of 340x340 pixels, a learning rate of 0.001 and the number of testing samples of 20 data obtained an accuracy value of 95%. Result of Covid-19 Detection use original X-Ray is shown in figure 8.

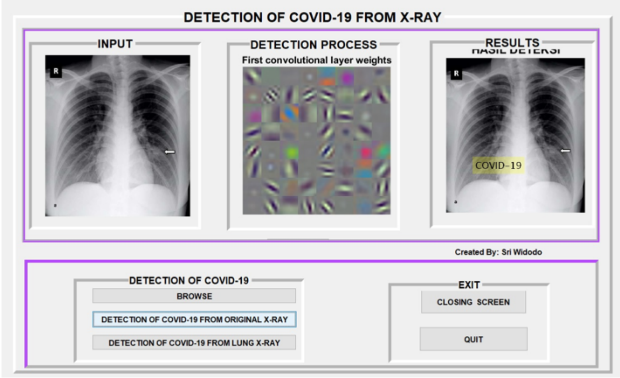

Figure 8. Result of Covid-19 Detection Uses Original X-Ray

Result of Covid-19 detection uses lung field X-Ray is shown in figure 9.

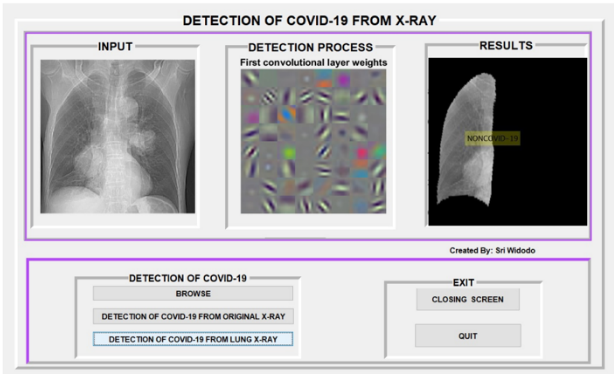

Figure 9. Result of Covid-19 Detection Uses Lung Field X-Ray

Comparison of accuracy with other papers is shown in Table 3.

Table 3. Comparison of Accuracy with Other Papers

No	Work	Material	Database (Sample)	Accuracy
1	T. Ozturk	X-Ray	Cohen JP (127)	87,02%
2	Ali Narin,	X-Ray	Dr. Joseph Cohen (100)	87%
3	Asmaa Abbas	X-Ray	Japanese Society of Radiological Technology (*JSRT*) (1764)	93,36%
4	Md Zahangir Alom	X-Ray	different sources around the world and a publicly a (5216)	84,67%
5	Chuangsheng Zheng	CT 3D	Union Hospital, Tongji Medical College, Huazhong University of Science and Technology (540)	95%.
6	Chunqin Long	CT	204	83,3%.
7	Widodo, S.	X-Ray	Wuhan (140)	95%

IV. CONCLUSION

The CNN model in this study uses an image input with a size of 224x224, a learning rate of 0.001, a filter size of 3x3, the number of Epochs 20, 140 training data, and 60 testing data, the accuracy obtained is 95% in classifying Covid-19 and Non- ovid-19 images.

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