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Pneumonia Detection Using Extraction Features Oriented Fast and Rotated Brief and Convolutional Neural Network

Rif'Atunnisa[1], Raden Sumiharto[2]
[1]Department of Computer Science and Electronics, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2]Department of Computer Science and Electronics, Universitas Gadjah Mada, Yogyakarta, Indonesia

Abstract— *Pneumonia is a contagious lung infection which is caused by bacteria. Pneumonia can be diagnosed by looking at the results of rontgen x-ray images of human lungs. Pneumonia detection requires fast computation time with the highest accuracy value. The Convolutional Neural Network algorithm has an accuracy close to 100%, but requires a long computation time. To overcome the long computational time, a preprocessing method is added in the application of pneumonia detection. The research is carried out by utilizing the preprocessing stage, namely ORB feature extraction which is combined with the classification stage using the CNN algorithm. The data used is secondary data obtained through the kaggle website. The research is conducted using three methods to get the highest accuracy value and the fastest computation time. The three methods are CNN method, CNN method combined with ORB feature detection, and CNN method without convolution layer combined with ORB feature detection. Research tests are conducted on three different CNN models with two types of datasets. The dataset consists of two-class and three-class datasets. When testing only the CNN model, the accuracy is 96.3% for 2 classes and 82.1% for 3 classes. In the CNN test with combined ORB feature detection, the accuracy score is 60.17% for 2 classes and 53.1% for 3 classes. The CNN test without using the convolution layer combined with the detection of the ORB feature obtained an accuracy value of 64.93% in two classes, and 55% in three classes. For the computational time obtained from the CNN method test results without using the convolution layer and combined with feature detection, the result is 23 times faster than the CNN method only.*

Keywords— *ORB, Image Processing, Pneumonia, Convolutional Neural Network.*

I. INTRODUCTION

Pneumonia or lung infection is one of the infectious diseases that can attack one or both lungs of humans which is generally caused by bacteria called streptococcus pneumoniae [1]. Pneumonia can affect all ages, but the highest death rate caused by pneumonia occurs mostly in children. Pneumonia consists of two types, bacterial pneumonia and viral pneumonia. Symptoms of pneumonia are generally accompanied by a cough with phlegm, fever, shortness of breath and chest pain when breathing or coughing. Every year pneumonia infects 450 million people worldwide with 156 million in children.

Pneumonia can be detected by reading X-Ray images of human lungs. X Ray image reading can only be done by a doctor or person who is an expert in the field, this is because reading errors will result in a different diagnosis or treatment for the patient. To be able to overcome these errors, the pneumonia detection process is carried out, which can be known through X Ray images with classification using deep learning methods, one of which is Convolutional Neural Network (CNN). CNN is a subclass of deep neural networks that has been successful in computer vision such as image segmentation, image classification, object detection, etc. [2]. CNN can also extract pneumonia characteristics to get better results [3]. However, CNN has a weakness, namely a long computation time [4] The CNN architecture itself consists of an input layer, an output layer and a number of hidden layers, where the hidden layers generally contain convolution layers, pooling layers, normalization layers, ReLu layers, fully connected layers and loss layers [5].

To be able to overcome the weakness of CNN, namely the computational time is to combine the CNN algorithm with preprocessing stages on the input image using reducing information in order to speed up computational time. One of the methods chosen is by detecting the Object Oriented Fast and Rotated Brief (ORB) feature. ORB is a feature detection method in the image that can extract special features in the image. the output of the ORB itself is a keypoint that contains the description value itself. ORB itself is very sensitive to rotational changes.

ORB is well known for having faster computational times than the other two feature detections, namely SIFT (Scale Invariant Feature Transform) and SURF (Speeded-Up Robust Features). The ORb stage itself consists of keypoint detection and keypoint description. This study combines the CNN method with the ORB method to determine the computational time that occurs when the two methods are combined in the detection of normal pneumonia, bacterial pneumonia, and viral pneumonia.

II. LITERATUR REVIEW

A. *Pneumonia*

Pneumonia is a form of acute respiratory infection that is most often caused by viruses, bacteria, or fungi [6]. Pneumonia can affect people of all ages, from children to the elderly. However, pneumonia is the cause of the biggest infectious death in children worldwide.

There are two types of pneumonia, namely Community-Acquired Pneumonia (CAP) and Hospital-Acquired Pneumonia [6]. The causes of pneumonia are viruses, bacteria and fungi. The most common causes are streptococcus pneumonia or

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bacterial pneumonia which is the most common in children, Haemophilus influenzae type b (Hib) is the second most common cause of bacterial pneumonia, respiratory syncytial is the most common virus causing pneumonia, and pneumocystis jiroveci is the most common bacteria. commonly causes pneumonia in HIV-infected infants [6]. .An example of a lung with pneumonia and a normal lung can be seen in Figure 1.

Fig. 1. Pneumonia and normal lungs

B. CNN

Convolutional Neural Network is one of the deep feed-forward artificial neural networks class that is applied to image analysis. CNN consists of one input layer and one output layer and a number of hidden layers. The hidden layers consist of convolutional layers, pooling layers, normalization layers, ReLu layers, fully connected layers and loss layers [5]. The CNN architectures that were very popular in the early days of CNN were LeNet-5, AlexNet, and ZFNet. Next the experts build other architects with deeper layers such as GoogleNet, VGGNet, and ResNet. CNN architecture in general as shown in Figure 2.

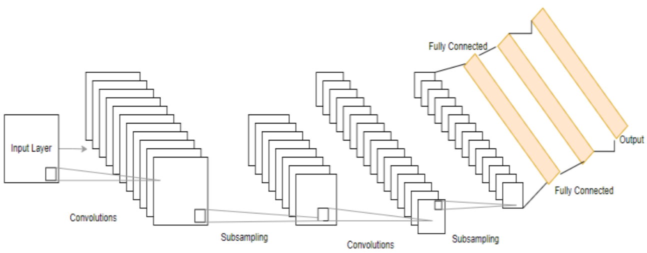

Fig. 2. CNN Architecture [9]

Convolutional layer or convolutional layer is a core layer of CNN, where most of the computation is done at this layer. Convolutional layers usually use more than one filter, so when used four convolutional layers will contain neurons arranged in a grid of a certain size which is multiplied by four [7].

C. ORB

Oriented Fast and Rotated Brief (ORB) is an OpenCV library introduced by Ethan Ruble in 2011. ORB is the best detection feature compared to SIFT and SURF in computing time. ORB is a combination of FAST keypoint detector and BRIEF descriptor with many changes to improve performance [3]. Figure 3 is the stage of the ORB algorithm.

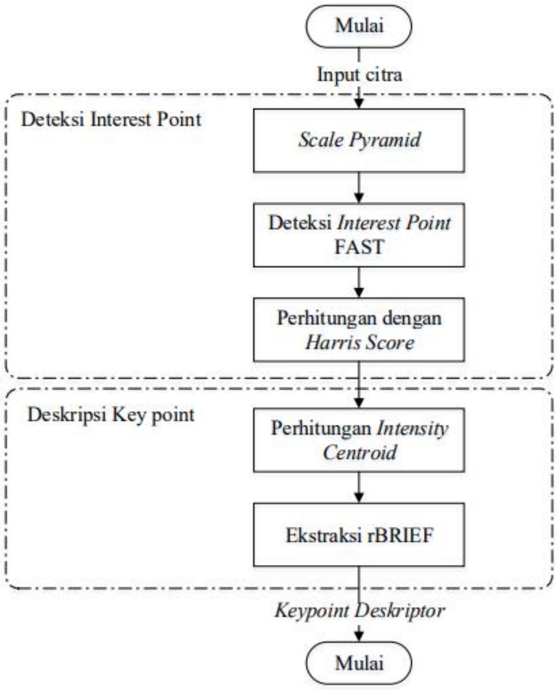

Fig. 3. ORB Algorithm Stages [10]

a. Feature Detection

In the ORB algorithm, the first step done is the detection feature. The detection feature used is FAST keypoint. The detection feature requires several steps. The first stage is to detect feature points in the image. The candidate features or candidate keypoints are seen as the center and the difference in the gray value between the central keypoint p and all the surrounding keypoints at the calculated p value. If the number of points that meet the difference is greater than a certain point, then point p can be said to be a keypoint [8]

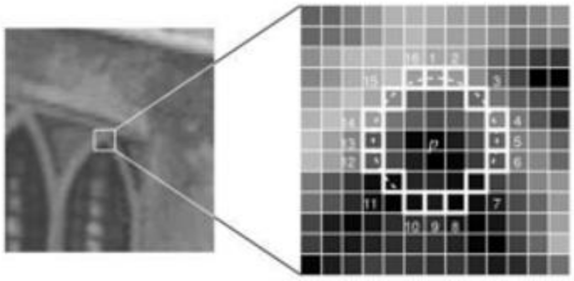

Fig. 4. Fast Detection [3]

The second stage is the Harris feature to select feature points and get the first N value. The next stage is a multi-scale pyramid. This stage is carried out to get fast features on each layer. Stages The last one is the grayscale centroid. This method is used to find the grayscale centroid in the key points region.

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b. Description Feature

A feature description is a feature that chooses a pair of keypoints around a randomly designated feature. The grayscale values will be compared to obtain a binary feature descriptor [8]. The description of the features used is the BRIEF descriptor. BRIEF is known as an algorithm that is not sensitive to changes. BRIEF is used to have key point pairs and compare grayscale levels and label them as binary feature descriptions [11].

III. RESEARCH METHOD

A. Dataset

This study uses data obtained from the website kaggle Chest X-Ray Image (Pneumonia) owned by Paulo Breviglieri. The dataset used consists of training data, test data and validation data. Each dataset is divided into three classes, namely non-pneumonia (normal), bacterial pneumonia, and viral pneumonia. The ratio of the dataset used is 80:20, with 80% being training data and validation data, while 20% is test data. From 80% of the datasets used, it is further divided into 80:20 of the total of the two datasets with a percentage of 80:20 with 80% for training data and 20% for validation data. The number of data sets used are 1910 training, 600 testing, and 480 validation.

B. Analysis System

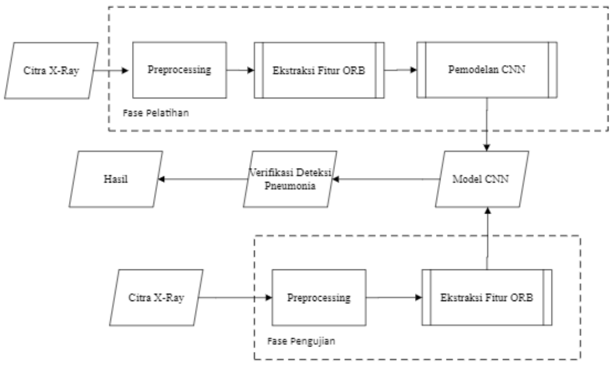

Fig. 5. Training block diagram

In Figure 5 it is the overall flow chart in this study. This study uses an X-Ray image dataset which is divided into training data and test data. The first stage in image classification is to separate the data between the training data and the test data. In this separation, the data labeling stage is also carried out which is divided into three classes, namely non-pneumonia, bacterial pneumonia, and viral pneumonia. The next stage is the preprocessing stage. The image that has been changed is then carried out a feature extraction process using the ORB method with the Open-CV library. Furthermore, the descriptor is then used to build a model using the CNN algorithm. CNN modeling is carried out in two different stages. The first modeling of CNN uses a convolutional layer, while the next modeling does not use a convolutional layer. In general, the research block diagram can be seen in Figure 6.

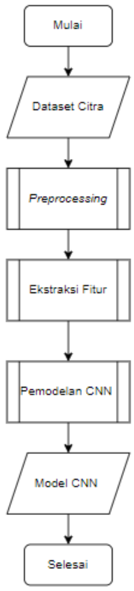

Fig. 6. Flowchart system analyst

C. Implementation of Image Preprocessing

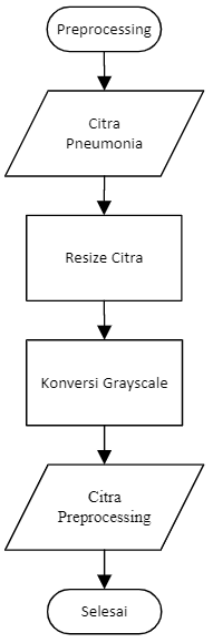

Fig. 7. Preprocessing flowchart

This stage begins by inputting an X-Ray image of the lungs with different pixel values. Then the next step is to resize the image size to 128 x 128 pixels. The next step after changing the pixel size of the image converts the image into a gray scale.The preprocessing stages can be seen in Figure 7.

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D. Implementation of Feature Detection

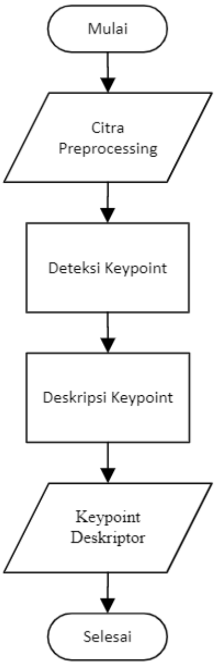

Fig. 8. Feature detection flowchart

The detection feature stage is the keypoint detection stage using the ORB algorithm. The results obtained in the previous stage, namely the conversion of images into gray scale are used as input for ORB feature detection. This step is used to find the coordinates of the key points and calculate the descriptor of each keypoint. Figure 8 is a flow in the detection of keypoints using ORB.

E. Implementation Model CNN

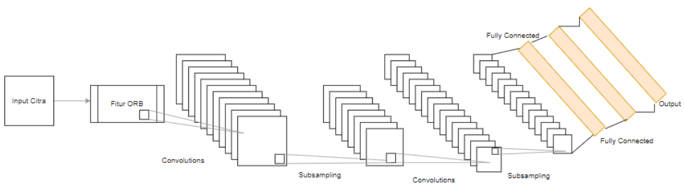

Fig. 9. System Architecture (LeCun et al., 1998)

Figure 9 which combines ORB feature extraction with CNN algorithm. The input image is processed into the ORB feature extraction feature which will later generate a keypoint. The result of the ORB process is called the input layer or the first layer that will be used in the CNN process.

Figure 10 is a CNN architecture combined with ORB feature detection without a convolution layer. The CNN architecture generally consists of several layers, namely the input layer, convolution layer, max pooling layer, fully connected layer, and lastly the output layer.

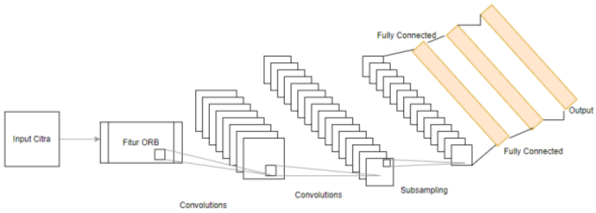

Fig. 10. CNN System Architecture coupled with ORB feature detection

IV. Research Result and Discussion

A. Testing the Number of ORB Features

TABLE I. Testing the Number of ORB Features Table

Number of Keypoints	Accuracy	Time (minute)
1000	**100%**	**116.693**
2000	100%	119.993

Testing the number of ORB features aims to determine the fastest computation time at the best accuracy obtained from the keypoint extraction results. Variations in the number of features used are 1000 to 5000 with an interval of 1000 for each increase. The results of testing the number of features in ORB extraction can be seen in Table I. The result of the fastest computation time is using the number of feature points, namely 1000 with a time of 116.693 minutes with an accuracy of 100%.

B. Testing Image Size on ORB

TABLE II. *Testing Image Size on ORB Table*

Image size (piksel)	*Accuracy*	*Time (minute)*
128x128	100%	83,47794337
256x256	100%	88,01509136
512x512	100%	95,29188327
1024x1024	100%	106,732803

The image size test is obtained after the feature number testing process is carried out, where the results of the feature number test are used to get the fastest computation time. In Table II it can be seen that the fastest computation time was obtained using a pixel value of 128 with a time of 83 minutes with 100% accuracy. From the results of testing the image size, it is obtained that the larger the value of the image is, the faster the computation time required.

C. Hyperparameter Test Result

TABLE III. *Hyperparameter Test Result*

Tuning Method	Epochs	Batch Size	Learning Rate	Optimizer	Accuracy	Loss
Grid Search	10	30	0.001	RMSprop	0.956806	0.006545
Random Search	10	50	0.001	Adam	0.948953	0.002618

Hyperparameter testing is performed with two tuning methods, namely Grid Search and Random Search. The hyperparameters tested to get the best accuracy results are the epoch value, batch size, optimizer and learning rate. The first hyperparameters which firstly look for are batch size and epochs. After obtaining the best batch size and epochs values, then search for the best values for the optimizer and learning rate. The values tested for batch sizes are between 10 and 50 with an interval of 10, while the values for epochs are between 10 and 50 with an interval of 5. For the optimizer itself, it is tested on three types of optimizers, namely RMSProp, Adam, and SGD with varying values. Learning rates are 0.0001, 0.001, 0.01, 0.1, and 1.0.

The results of tuning parameter value testing through two methods of tuning Grid Search and Random Search, it is known that the best accuracy is in epochs 10, batch size 30, learning rate 0.001 and the optimizer is RMSProp with an accuracy of 96.6806%. The comparison of these two methods can be seen in Table III.

D. CNN Model Testing

The three models tested achieve maximum accuracy values in the CNN method only without combining it with feature detection or by eliminating the convolution layer. For testing two kinds of datasets which were tested on the three models, the results showed that testing on two types of classes resulted in a greater accuracy value than testing on three types of classes.

TABLE IV. Comparison of Model Testing Table

	Accuracy		**Computing Time**	
	two classes	three classes	two classes (seconds)	three classes (seconds)
CNN	96,3%	82,1%	23,4	31,92
CNN + ORB	60,17%	53,1%	2,42	3,011
CNN without layer convolution + ORB	64,93%	55%	1,014	1,397

The accuracy value obtained by CNN in the two classes is 96.3% with a computation time of 23.4 seconds. While the accuracy value obtained by CNN in the three classes is 82.1% with a computation time of 31.92 seconds. For the second test, the CNN model uses a convolution layer combined with the detection of the ORB feature, the accuracy value in two classes is 60.17% with a computation time of 2.42 seconds, while in the three-class dataset, it is 53.1% with a computation time. computation of 3.01. In the third test, namely the CNN model without using a convolution layer combined with ORB feature detection, the accuracy value in two classes is obtained, namely 64.93% with a computation time of 1,014 seconds, while in the data set of three time classes the accuracy obtained is 55. % with a computation time of 1397 seconds.

V. Conclusion

The CNN method combined with ORB feature detection can detect X-Ray images of the lungs in three classes and two classes. In addition, the CNN method without a convolution layer combined with ORB feature detection produces a computation time of 23 times faster than the CNN model alone with an accuracy of 64.93%.

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