Application of Anisotropic Diffusion Filters and Convolutional Neural Network with Mobilenet Framework on X-Ray Image to Detect Pneumonia

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ABSTRACT

Pneumonia is the largest infectious disease that occurs in children worldwide. WHO reported that pneumonia killed 808,694 children under five years in 2017; 15% of children under five years died. Pneumonia is the largest infectious disease that can occur in children worldwide. These cases are most common in South Asia and Africa. All the experts suggest that it an easy to diagnose by using x-rays. The x-ray results from the lungs of patients with pneumonia can give an idea of how the pneumonia virus causes the infection in the lungs of patients. This study aimed to determine how the convolutional neural network method works with the framework MobileNet and anisotropic diffusion filters to detect pneumonia and determine the level of accuracy produced by the convolutional neural network method with the MobileNet framework and anisotropic diffusion filters in detecting pneumonia. In this study, the chest x-ray images (pneumonia) dataset from Kaggle was used as an object to be classified using anisotropic diffusion filters and convolutional neural networks to determine the presence of pneumonia based on x-ray images. Classification is carried out on the chest x-ray images (pneumonia) dataset for two weeks from august 14, 2021 to august 28, 2021 which will go through a classification process on x-ray images using the convolutional neural network algorithm and anisotropic diffusion filters. The results of testing with this method have increased compared to previous studies, with an accuracy of 96.67%.

1 Introduction

Advances in technology provide a source of information and communication that humans have owned. Technology must be used carefully and responsibly. Technology in the health sector is one part of the technological advances that are updated in modern life. The development of information technology in the health sector has a big impact on the community because if you want to get information in the form of health, you need a lot of information from experts. Health information has several factors, one of the most influential factors is respiratory health.

Breathing has become a vital sign of human life. Therefore, humans must take care of their lungs as one of the respiratory organs that help exchange oxygen and carbon dioxide. The lungs are the respiratory organs associated with the respiratory system and blood circulation in the human body. According to research that has been done by Nugroho and Puspaningrum (2021), Lung disease itself often happens, including chronic lung disease, asthma, and pneumonia. Pneumonia is an infection that causes inflammation in the lungs. Generally, the lung area will experience an increase in the soft membrane in the lungs. People with pneumonia will feel pain in several small air pockets at the end of the respiratory tract, known as alveoli, and will become inflamed and filled with fluids. In the end, people with pneumonia will experience several symptoms such as coughing with mucus, fever, chills, and difficulty breathing. Bacteria and viruses are types of things that can cause pneumonia. It shown in Figure 1.

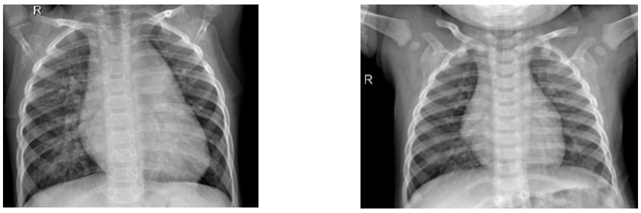

Figure 1. The left x-ray images (pneumonia) and the right x-ray images (normal) (Mooney, 2018)

World Health Organization (2020) reported that pneumonia is the largest infectious disease that occurs in young children in many countries. Pneumonia killed about 808,694 children under five in 2017, 15% of all deaths of children under five years. Besides establish in children, pneumonia also affects families, and the most common also occurs in South Asia and Africa. Pneumonia disease in children can be prevented through vaccines and treated with the best medication and technological care.

Syaukani and Kusnanto (2012) explain that pneumonia is an infection at the end of the respiratory tract, well known as bronchioles and alveoli, and pneumonia disease has resulted in death for children every year. Due to the limited number of medical personnel compared to the patient of the pneumonia disease itself, the results are frequent delays in services for pneumonia sufferers. In this case, deep learning can help patients to determine pneumonia and the right treatment for the disease. Deep learning is a science of machine learning that has recently developed due to GPU acceleration technology. The deep learning method can detect image objects, and the object in images can be classified using the convolutional neural network (CNN) method. The CNN method enable to identify the normal and pneumonia lungs (Putra, 2016).

CNN is a method that can identify digital images of normal and pneumonia lungs. The CNN algorithm is commonly used to solve difficult image-based pattern recognition tasks and with its precise yet simple architecture (O'Shea & Nash, 2015). Maysanjaya (2020) used CNN in his research. He said this method is considered to have features that can be uniquely determined to be classified in the image. Literally, in this study, there was a performance test on CNN in the classification of normal and pneumonia lung images. CNN has the advantage of eliminating the extraction steps on patterns that require the help of an expert. CNN uses layers known as convolutional to extract feature patterns directly. CNN has two convolutional layers, two pooling layers, and a fully connected layer. The convolutional layer has a function as a kernel to process the image filters into a smaller matrix size. Furthermore, the pooling layer further down samples the matrix size, while the fully connected layer is a multi-layer perceptron (MLP) structure. In this study, the results obtained an accuracy of 89.58% with a weakness in the form of overfitting on the results of accuracy in training and testing.

One method that can be considered to enhance image quality for further analyses with the CNN method is anisotropic diffusion filters. Anisotropic diffusion filter is a non-linear diffusion process introduced for edge detection and representation of image scale space (Suganthi & Ramakrishnan, 2014). Barita and Simangunsong (2017) stated that anisotropic diffusion filters are often used to eliminate image noises without omitting important parts of an image. In the case of medical image identification, the anisotropic diffusion filter serves as a fundamental basis that is done to overcome the noise problem in the image (Vera et al., 2020). The use of anisotropic diffusion filter method is considered a very useful tool in image smoothing, edge detection, image segmentation, and image enhancement (Tsiotsios & Petrou, 2013). Iryanto et al. (2016) opine that anisotropic diffusion filters method can be used to improve digital image quality. Also anisotropic diffusion filters method can improve image quality by smoothing the image and reducing blur image without eliminating the most important parts of the image, such as edges or the smallest parts that are considered important for detecting the image (Widyantara et al., 2015).

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2 Method

2.1 Research Approach

The research subject of this study is pneumonia. This study employed anisotropic diffusion filters with the convolutional neural network. These approaches were used to seek accurate results and find the disease experienced by the research subjects.

2.2 Data Sources

The dataset used in this current study was a chest x-ray (pneumonia) from the owner Paul Mooney gained from Kaggle. The dataset was taken from Kaggle (https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia), which consisted of 5,856 images, which have been divided into two different class normal and pneumonia. Consisted of 1.341 images of training normal, 2.875 images of training pneumonia, 234 images of testing normal and 390 images of testing pneumonia datasets.

2.3 Data Analysis

This subsection outlines the data analysis techniques carried out in the current study, which are anisotropic diffusion filters as image preprocessing and CNN as a feature selection as well as a classifier. The analyses processes are as follows:

1. The data were first preprocessed using anisotropic diffusion filters. This method was employed to remove noise in the x-ray image in order to help classify the images. The process of the anisotropic diffusion filters can be shown in Figure 2.

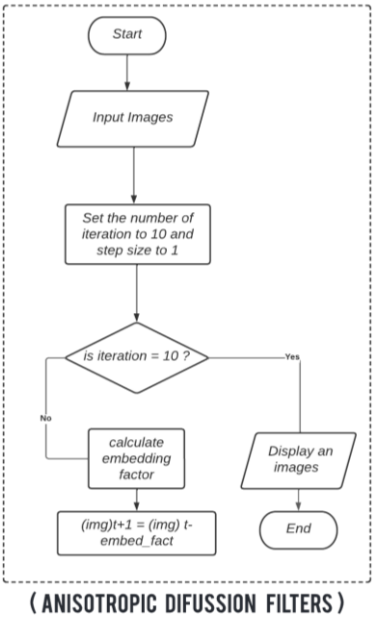

Figure 2. Flowchart of anisotropic diffusion filters

2. The preprocessed images were then trained using the processed MobileNet architecture of CNN. The first stage makes the image feature selection which consists of convolution layer depthwise and max pooling.
3. Then the CNN performance is tested using sample data from the testing data. If the CNN performance is less than 80%, feature extraction will be repeated by setting parameters such as epoch, learning rate, and batch size.
4. If accuracy is in line with the expectations, then it will be tested through the testing process. At the same time, testing a whether there is overfitting between training data and data testing through prediction.

5. The result of this research will have the output. It will have accuracy as expected and have a classification of a normal lung of pneumonia lungs.

3 Results

The outcomes of the study will be discussed in relation to the methodology employed in this sub-chapter, starting with the data used, namely chest x-ray pneumonia obtained from Kaggle, and moving on to the data sharing stage.

3.1 Preprocessing

The following shows the results of the preprocessing stage with anisotropic diffusion filters, as shown in Figure 3.

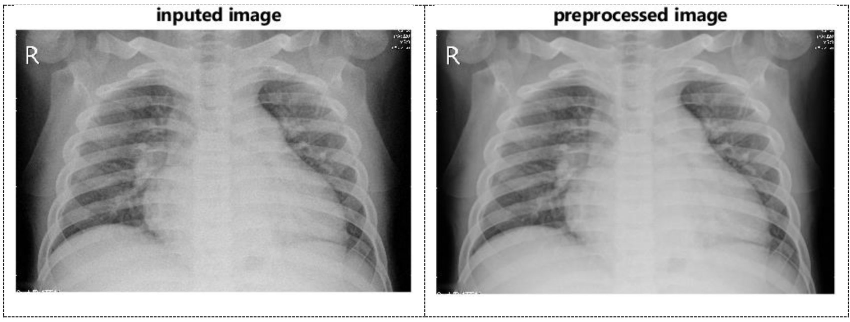

Figure 3. Original image (a) and image after preprocessing with anisotropic diffusion filters (b)

Figure 3 (a) is the original image, which will be noise-free or smoothed, while Figure 3 (b) is the image after anisotropic diffusion filters were applied. The difference between the two images was shown when noise is reduced. The noise is removed noticed by the little dot on the inputed images is smoothed by anisotropic diffusion filters, then the preprocessed images is the result make the images cleaner.

3.2 Classification

This sub section outlines the classification of chest x-ray images with a convolutional neural network show in Figure 4.

Classified as

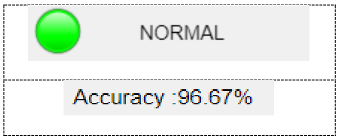

Figure 4. Display of classification

Figure 4 shows the results of the classification of the proposed testing data to obtain normal results with an accuracy of 96.67%. In this classification, it contains about convolutional neural network performs accurate identification by displaying input images and displaying the expected classification results and accuracy. The next page will display the results of identifying CNN, which includes the confusion matrix and several other things. Confusion matrix itself define predicted class and true class and it's show in Table 1.

Table 1. Confusion Matrix

		Predicted class	
		Positive (1)	Negative (0)
True Class	Positive (1)	TP (*true positive*) *correct result*	FN (false negative) missing result
	Negative (0)	FP (false positive) unexpected result	TN (true negative) correct absence of result

The explanation regarding the contents of the predicted class and true class in the Table 1 is described as follows.

a. True Positive (TP)

Represents positive data that is predicted correctly. The patient didn't have pneumonia (class N) and the model predicts that the patient didn't have pneumonia (class N).

b. True Negative (TN)

Represents negative data that is predicted to be true. The patient has pneumonia (class P) and the model predicts that the patient has pneumonia (class P).

c. False Positive (FP)

Represents negative data but predicted as positive data. The patient has pneumonia (class P) but the model predicts that the patient didn't have pneumonia (class N).

d. False Negative (FN)

Represents positive data but predicted as negative data. The patient didn't have pneumonia (class N) but the model predicts that the patient has pneumonia (class P).

4 Results and Discussion

This study uses CNN as the algorithm, MobileNet as a framework from CNN, and anisotropic diffusion filters as preprocessing to highly accurate classifying images on pneumonia x-ray datasets. The CNN deep learning algorithm, which is supported by the MobileNet framework, was employed in this study. This study classifies image data that has undergone anisotropic diffusion filter preprocessing, and the accuracy level that results is in line with expectations. The more accurate the results, the better the algorithm and data preprocessing. The classification of image data carried out through preprocessing, and feature selection will produce an accuracy level that is measured using a confusion matrix. The higher the accuracy results obtained, the better the data preprocessing and algorithm used.

The results in the program "Application of Anisotropic Diffusion Filters and Convolutional Neural Network with MobileNet Framework on X-Ray Image to Detect Pneumonia" using anisotropic diffusion filters and CNN has a different appearance according to the mode that has been selected. In the input image classification mode, it contains the results of the input image classification in the form of a table labeled with the result in the form of accuracy. The process of testing chest x-ray images of pneumonia patients uses the mobilenetv2 library, which provides the convolutional neural network framework function, and the confusionmat library, which provides the confusion matrix function as a method for calculating the level of accuracy. The result of the stage is a classification of the input image along with the accuracy of the classification results. As shown in Table 2, it can be read that the classification results using confusion matrix function to make an accuracy value, precision value, recall value, and specificity value. In Table 2, it can be concluded that the model's performance is outstanding, where it can classify 93.33% is correctly indicated on the specificity value, 100% is correctly indicated on the recall value, and 93.75% is correctly stated on the precision value. This conclusion can be drawn from the average of the predictions gives the model accuracy value, which can be seen in the accuracy value is 96.67%.

Table 2. Confusion Matrix of the purposed model

		Predicted class	
		Positive (1)	Negative (0)
True Class	Positive (1)	30	0
	Negative (0)	2	28

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{P} + \text{N}} \qquad \text{Precison} = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

$$\text{Accuracy} = \frac{30 + 28}{30 + 30} \qquad \text{Precison} = \frac{30}{30 + 2}$$

$$\text{Accuracy} = \frac{58}{60} \qquad \text{Precison} = \frac{30}{32}$$

$$\text{Accuracy} = 0.9667\% \qquad \text{Precison} = 0.9375\%$$

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}} \qquad \text{Specificity} = \frac{\text{TN}}{\text{FP} + \text{TN}}$$

$$\text{Recall} = \frac{30}{30 + 0} \qquad \text{Specificity} = \frac{28}{2 + 28}$$

$$\text{Recall} = \frac{30}{30} \qquad \text{Specificity} = \frac{28}{30}$$

$$\text{Recall} = 100\% \qquad \text{Specificity} = 0.9333\%$$

The difference in accuracy results from the combination of several different sample datasets is shown in the recall, specificity, and precision values testing on the x-ray image dataset classification in pneumonia patients. To make sure the proposed model is not overfitting, this study used 4 (2 Pneumonia, 2 Normal) partitions of dataset, which is resulting in 4 validation of new datasets. This is necessary to provide new unseen data for the model validation. For the validations and trials result can be seen in Table 3.

Table 3. Validation result of the purposed model

Sample Data (Pneumonia and Normal)	Recall	Specificity	Precision
DATA O1 (P)	90%	93,33%	93,10%
DATA O2 (N)	90%	96,67%	96,42%
DATA O3 (P)	96,67%	80%	82,85%
DATA O4 (N)	93,33%	100%	100%

The results of the study in Table 3. show that the level of accuracy obtained by using a combination of preprocessing on anisotropic with CNN classification results in the highest accuracy with a recall value of 96.67%, a specificity value of 100%, and a precision value of 100%. Using two sample data in each class (N) for Normal and class (p) for Pneumonia.

Based on the results of the value produced in this study, using deep learning algorithms CNN with the framework MobileNet and combined with anisotropic diffusion filters as data preprocessing has proven to be a model that can be used to carry out classifications with high accuracy on the topic dataset taken in this study. Namely regarding the chest x-ray of a pneumonia patient.

With a given level of accuracy, this model can be proven to adequately process and classify chest x-ray image datasets of pneumonia patients. A comparison was made with previous studies using the same dataset to find out that this method is better than existing methods. Accuracy variations are the consequence of comparisons with earlier studies that used the same dataset. Table 4 shows the outcomes of the comparisons.

Table 4. Comparison Table

Writer	Dataset	Method	Accuracy
Maysanjaya (2020)	Chest x-ray Images (Pneumonia)	Convolutional neural network	89.56%
Rahman et al. (2020)	Chest x-ray Images (COVID-19)	CNN + VGG19	89.50%
Shah et al. (2020)	Chest x-ray Images (Pneumonia)	CNN + VGG16	96.50%
Widyantara et al. (2015)	Lung and Heart Image	Anisotropic Diffusion Filters	94.34%
Proposed Method	Chest x-ray Images (Pneumonia)	Anisotropic diffusion filters + CNN	96.67%

In this current study, anisotropic diffusion filters was combined with convolutional neural networks and the MobileNet framework resulting in the highest accuracy rate of 96.67%. This research differs from Maysanjaya (2020) research in the way it handles overfitting situations, how the CNN architecture is configured, and the number of epochs. The use of image preprocessing has a significant impact on the classification and quality of an image. Maysanjaya's study did not use image preprocessing and only used CNN as a classification method, which produced the highest accuracy rate of 89.56%.

Rahaman et al. (2020) used augmentation techniques on training datasets to simplify the validation and prediction of a dataset. It has an accuracy of 89.50% when classifying data using the CNN and VGG19 algorithms. Rahman chose that MobileNet has the advantage of avoiding excessive processing, the VGG19 architecture operates on the principle that the more layers, the higher the accuracy. Due to its filter thickness matching the thickness of the input image, MobileNet improves detection speed and lowers latency, making it more effective in its own right.

Shah et al. (2020) study used CNN classification with the VGG16 framework. VGG16 has a flaw in that it is challenging to assess and detect image datasets using more parameters than MobileNet, which causes the process to take longer and use more memory. The results of this study employing the VGG16 framework, which got a result of 96.50%, demonstrate that using the MobileNet framework increases accuracy.

Widyantara et al. (2015) employed gaussian lowpass and anisotropic diffusion filters. Both methods were compared, and the results were significant. Gaussian lowpass had the highest accuracy in the lungs at 92.29%, while anisotropic diffusion filters had the highest accuracy at 92.87%. The weakness in this study is the process of blurring the noise contained in the image, the edges should still be detected, but in this study, the edges of the image object, after being segmented, become less than optimal and affect the edges of an image. This demonstrates how using anisotropic diffusion filters for image data preparation can improve accuracy and produce better results.

According to the comparison of previous studies, it can be concluded that using anisotropic diffusion filters and CNN with the MobileNet framework is better since it has higher accuracy than the previous method. Anisotropic diffusion filters are used to reduce noise in digital images so that they are clearer and more detailed. CNN is also used as a classifier to identify images and deliver accurate results. With its benefits in reducing latency and overcoming computing overload, the MobileNet framework can be used to increase productivity. It can detect images with the same number of layer filters as input layer images in order to make it more optimal than earlier studies.

5 Conclusion

Based on the results of the research and discussion of the classification of the chest x-ray pneumonia dataset with details on the topic of "application of anisotropic and CNN on x-ray images to detect pneumonia", the following conclusions can be drawn. The application of the CNN and anisotropic diffusion filters in detecting pneumonia has its own way of working. By dividing the dataset into 70% for training data and 30% for testing data. In order to get the best image quality results, anisotropic diffusion filters remove noise from digital images to help create clearer, more detailed images. The CNN process then aids in detecting images that have undergone preprocessing to produce accurate detection results. Additionally, validation tests will be run to get results on model accuracy. This study proves that the combination of anisotropic diffusion filters and CNN becomes an optimal combination model. The accuracy level of the model, which combines anisotropic and CNN data, achieves an accuracy level of 96.67%. The accuracy value is 7.11% greater than Maysanjaya's (2020) study, which only achieved an accuracy value of 89.56% using the CNN method.

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