Improved Chest X-Ray Image Quality Using Median and Gaussian Filter Methods

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Abstract*—The lungs are one of the organs of the body that are responsible for the human respiratory process and are very susceptible to dangerous diseases. For this reason, early detection and diagnosis of lung organs is needed, one of which is through examination of Chest X-Ray (CXR) images. Examination of the results of CXR images is still done manually by doctors and radiologists, this requires time and high accuracy. To facilitate the examination, it is necessary to image quality enhancement in order to get better image quality results so as to produce an accurate diagnosis. The initial stage in this research is to apply the contour improvement technique to the image using Morphology Opening, and followed by noise reduction using Median Filter and Gaussian filter. The results of the two methods of noise reduction are compared with the results of image quality in order to find out the best method that can be applied. The implementation of image quality enhancement results was measured quantitatively using Peak Signal-to-Noise Ratio (PSNR), Mean Square Error (MSE), and Structural Similarity Index Metrics (SSIM). In the Morphology Opening and Median Filter methods, the values obtained are 39.187, 22.252, and 0.952, respectively. Meanwhile, the Morphology Opening and Gaussian Filter methods obtained values of 38.717, 23.917 and 0.956. Based on these results, it can be concluded that both methods are able to improve image quality well.

Keywords—Chest X-Ray images, Image Quality Enhancement, Median Filter, Gaussian Filter

I. INTRODUCTION

The lungs are one of the important organs in the human body which are located in the chest cavity [1]. The lungs are responsible for the human respiratory process and function to exchange oxygen with carbon dioxide which is associated with blood circulation [2]. With its very important function, the health of the lungs must be maintained, because these organs are susceptible to disease [3]. This is because the interaction between the lungs and the outside world is only limited by the respiratory tract [4]. When there is a disturbance in the lungs, the breathing process will be hampered and the supply of oxygen to the blood will also be disrupted. Some of the diseases that are dangerous and often attack the lungs are tuberculosis, pneumonia, lung cancer, and Covid-19.

For this reason, early treatment and diagnosis is needed so that the condition does not get worse [5]. In diagnosing diseases that occur in the lungs, it is generally done by examining physical symptoms using a chest examination technique via X-Ray. This technique aims to see the image of the lungs), whether the lungs and respiratory tract are affected or not [6]. The results obtained from this X-Ray technique are Chest X-Ray (CXR) images. This CXR image is used by doctors and radiologists in reading X-rays of the lungs lungs. In reading the results of the CXR image, a high level of accuracy is required, because a lot of tissue is piled up in the image [6]. To help doctors and radiologists to be clearer in reading the results of the CXR image, then an image quality enhancement is needed in order to get better image quality results and more clearly read so as to produce an accurate diagnosis [6].

Image quality enhancement is the process of changing the original image into a new image as needed to produce a clearer and sharper image [7]. The currently developing image quality enhancement methods are contrast enhancement, contour improvement and noise reduction. Contrast enhancement in the image works by using a histogram spread technique, where the darkest point in the image can reach solid black and the brightest point in the image can achieve brilliant white with an even distribution of pixels in each region [8].

One method that can be used for contour improvement is Morphology Opening [9]. Morphology Opening works by removing thin and smooth objects in order to make the image smoother [10]. It can be seen that several previous studies that have used the Morphology Opening method in improving image contours include: Wikanargo & Thenata

[11] improving image contours on CXR images using the Morphological Opening method resulting in smoother image quality and loss of thin objects around the area image. Another research conducted by Setiawan et al [12] using the Morphology Opening method to repair contours on retinal images resulting in thinning of blood vessels found in retinal images. In addition, the results obtained are still visible a little noise in some areas. From the two studies, it can be seen that the Morphology Opening method is very good in making contour improvements to improve image quality.

To overcome the weakness of this method, noise reduction can be done to image quality enhancement. The most frequently used method in improving image quality to reduce noise is the filtering method. Filtering method is a filtering technique used to remove or reduce noise. One of the filtering

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methods that are often used today is the Median Filter and Gaussian Filter [13]. The Median Filter has the ability to reduce noise well, especially salt and pepper noise, while the Gaussian Filter has the ability to reduce and smooth noise [14]. Several studies that have used the Filtering method include: Khilmawan & Riadi [13] compared the Median Filter and Gaussian Filter methods on bone images which showed that the Median Filter method had a better performance than the Gaussian Filter in reducing noise as seen from its PSNR value. Another study conducted by Sebatubun [14] performed noise reduction using the Median Filter and Gaussian Filter methods on cancer image data. This study compares the performance of the Median Filter method with the Gaussian Filter method which concludes that the Gaussian Filter method used can improve image quality better than the Median Filter method as seen from the MSE and PSNR values. This study used the Covid-19 Radiography Database dataset, where several studies have improved image quality using the dataset, including [18] with the methods used, namely Gamma Correction and Gaussian Filter. The results obtained for the PSNR value is 24.61, while the MSE is 229.92. Another research by [19] with the method used is the Wiener Filter and Poisson. The results obtained for the PSNR value is 33, MSE is 29, and SSIM is 0.7876. It can be seen that in both studies the evaluation values obtained are still quite low. Based on the advantages and disadvantages of previous studies in improving image quality, this study will improve image quality using the Morphology Opening, Median Filter, and Gaussian Filter methods to get better image quality.

II. METHODOLOGY

This study uses the Covid-19 Radiography Database dataset obtained from the kaggle website via the link https://www.kaggle.com/datasets/tawsifurrahman/covid19-radiography-database. In this study, there were 3 classes used, namely 3616 Covid-19 images, 10192 Normal images, and 1345 pneumonia images. The image in the dataset has an intensity that is not evenly distributed on the gray scale, making it difficult to detect the lungs. For this reason, techniques are needed that can improve the quality of the lung image so that it can make it easier for doctors and radiologists to detect diseases of the lungs. This research uses Morphology Opening for contour improvement and Median Filter and Gaussian Filter for noise reduction. The proposed system process diagram was presented in Fig. 1.

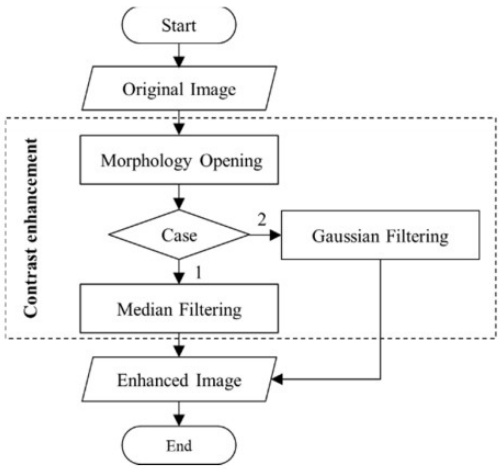


Fig. 1. Process Diagram of Proposed Method

A. Morphology Opening

Morphology Opening is an image quality enhancement technique in improving the contours of the image and eliminating thin objects that are around the image area so that the image looks clearer [9]. This method works by using erosion operations combined with dilation operations. The opening morphology can be calculated using Equation (1).

$$A^{\circ}B = (A \ominus B) \oplus B \tag{1}$$

with

$$A \oplus B = \{x|(B)_X \cap A \neq \emptyset\}$$

$$A \ominus B - \{x|(B)_X \cap A^c \neq \emptyset\}$$

where A is the initial image, B is a structuring element in the form of a matrix operator such as line shape, disk, diamond, and others. $\oplus$ is a dilation operation, $\ominus$ is an erosion operation, and $\circ$ is a Morphological Opening operation

B. Median Filter

Median Filter is a nonlinear function used for noise reduction and image smoothing. The Median Filter works by sorting the intensity value of a set of pixels in ascending order, then changing the value of the processed pixels to a certain value [15].

C. Gaussian Filter

Gaussian Filter is a linear function that is responsible for the noise reduction process in the image, where the weighting value is based on the Gaussian probability distribution function [13]. This method works by assuming the value of the distribution of pixels in the noise to follow the value of the distribution of pixels in the gaussian distribution or often called the zero mean [9]. Gaussian Filter calculation is defined in Equation (2).

$$g(x,y) = e^{\frac{(x^2+y^2)}{2\sigma^2}} \tag{2}$$

where x is the distance from the starting point on the horizontal axis, y is the distance from the starting point on the vertical axis, and σ is the standard deviation value.

D. Evaluation

The results of the method used in this study in the process of image quality enhancement can provide conclusions about how well the method is in the process of image quality enhancement. In this study, the performance evaluation of the output image that is measured and used is Peak to Signal Ratio (PSNR), Mean Square Error (MSE), Structural Similarity Index Metrics (SSIM). PSNR is a comparison between the input image value and the output image value based on the difference in the pixel values of the two images. If the resulting PSNR value is greater, then the quality of an image is said to be getting better [14]. MSE is the value obtained from the average of the squared intensity values. The intensity value in this study is the difference between the input image and the output image. Meanwhile, the MSE value is said to be getting better, if the resulting value is getting smaller [16]. SSIM is the level of similarity between 2 correlated images, where the SSIM value in the image is said to be getting better if the value is close to 1.

III. Result And Discussion

The lung CXR image dataset used consists of 3 classes, namely Covid-19, normal, and pneumonia images. Each image in the dataset is carried out in a pre-processing stage by improvement the quality of the image by eliminating unnecessary parts (noise) and increasing the contrast of the image. For example, one of the original images of COVID-1.png was taken in the dataset and the pre-processing stage was carried out which can be seen as shown in Figure 2. It can be seen that in Figure 2, the steps taken are to improve image quality by removing thin objects in the image using Morphology Opening. The next step is to remove the remaining noise in the image by comparing the Median filter and the Gaussian filter. The results of the comparison of image enhancement using the methods used in each image class can be seen in Table 1.

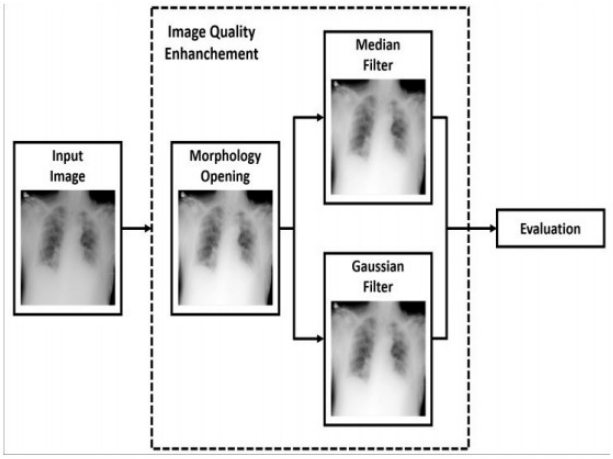
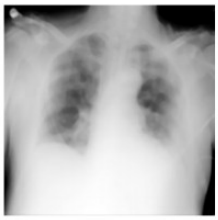
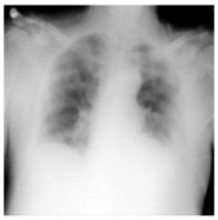


Fig. 2. Example of pre-processing results on CXR image

TABLE I. Comparison Of Image Enhancement Results

File Name	Original	Morphology Opening	Median Filter	Gaussian Filter
COVID-1.png				
Normal-1.png				
Lung_Opacity-1.png				

It can be seen that in Table 1, the comparison of the results between the methods used from one sample image in the three methods can be seen as shown in Figures 3, 4, and 5. It can be seen that in Figures 3, 4, and 5 the histogram comparison in the three methods is still difficult to determine the best image quality. For this reason, quantitative measurements of image quality parameters are needed by calculating the PSNR, MSE, and SSIM values. Based on measurements made on the COVID-1.png image, the results of Morphology Opening obtained PSNR, MSE, and SSIM values of 39.2954, 21.361, and 0.9629, respectively. In the Median Filter method, the PSNR, MSE, and SSIM values are 42.4599, 9.3201, and 0.9764, respectively. Meanwhile, Gaussian Gilter obtained PSNR, MSE, and SSIM scores of 42.1428, 9.5624, and 0.9792, respectively.

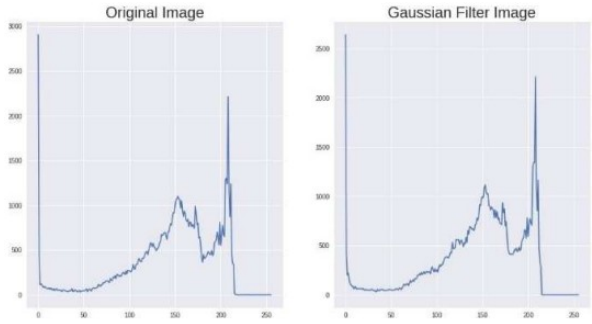


Fig. 3. Comparison of the Histogram on the original image and the image of the Gaussian Filter method

The graph of the comparison of PSNR, MSE and SSIM values between the Median Filter and Gaussian Filter

methods can be seen in Figures 6, 7 and 8. It can be seen that in Figures 6, 7, and 8 the comparison between the PSNR, MSE, and SSIM values in the three images, namely the Covid-19, Normal and Pneumonia images, there is a slight difference between the Median Filter and Gaussian Filter methods. If you look at the graph, the results from the Pneumonia image produce more varied values compared to the Covid-19 and Normal images. For this reason, the results of images in the dataset with the image quality parameters used produce the average PSNR, MSE, and SSIM values as shown in Table 2.

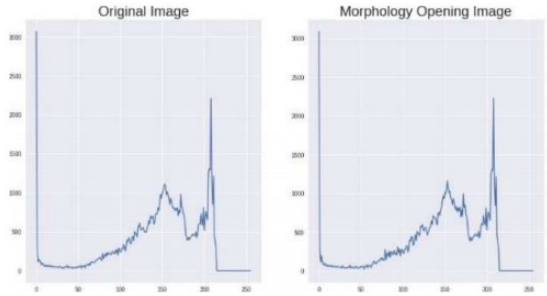


Fig. 4. Comparison of the histogram on the original image and the image of the Morhology Opening method

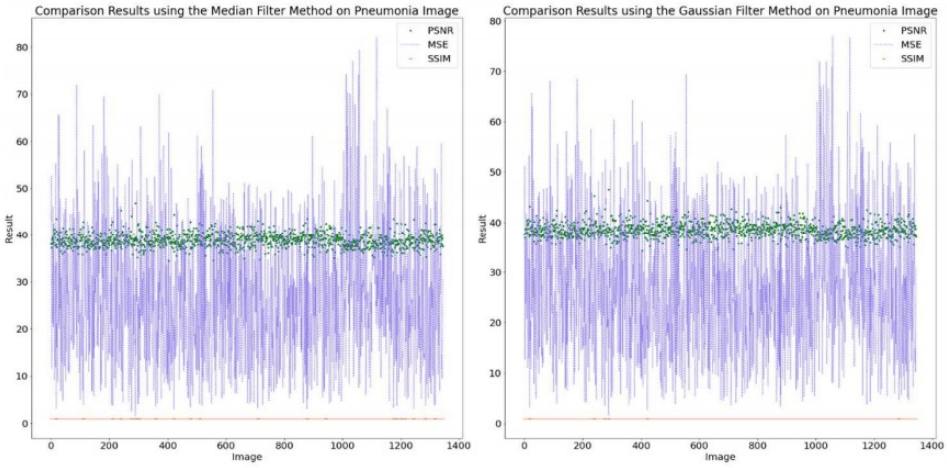


Fig. 5. Comparison of pre-processesd graphics on Pneumonia images using the Mediab Filter and Gausian Filter Methods

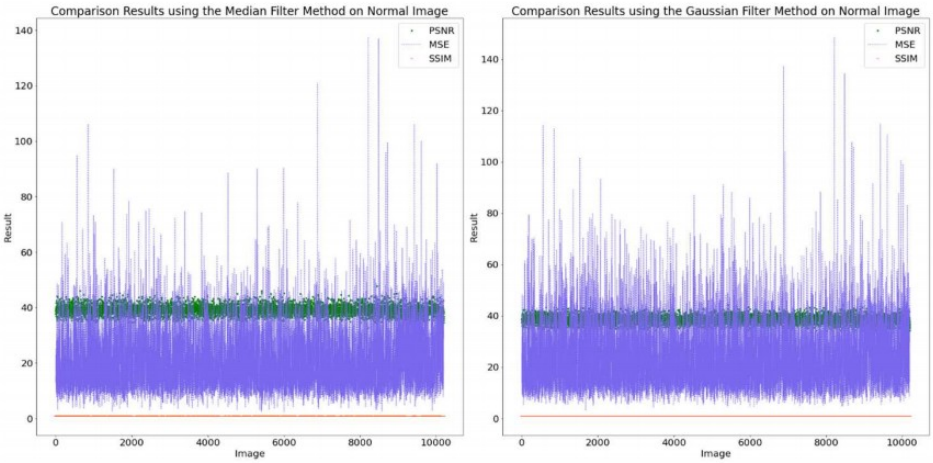


Fig. 6. Comparison of pre-processesd graphics on Normal images using the Mediab Filter and Gausian Filter Methods

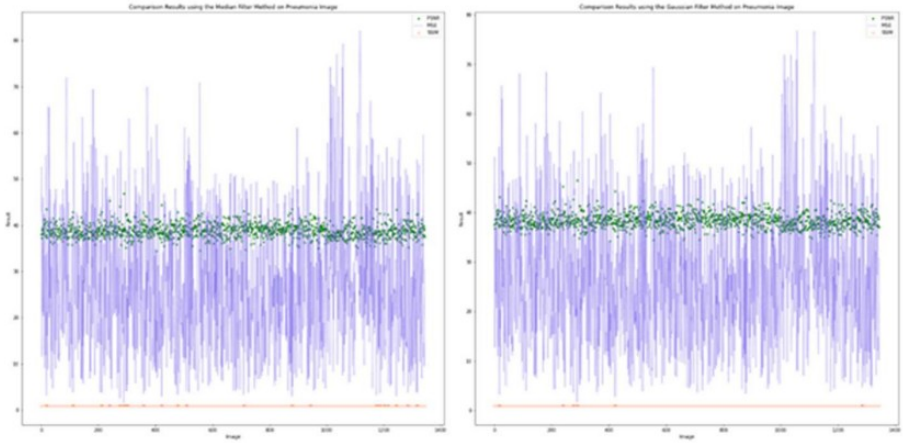


Fig. 7. . Comparison of pre-processesd graphics on Covid-19 images using the Mediab Filter and Gausian Filter Method

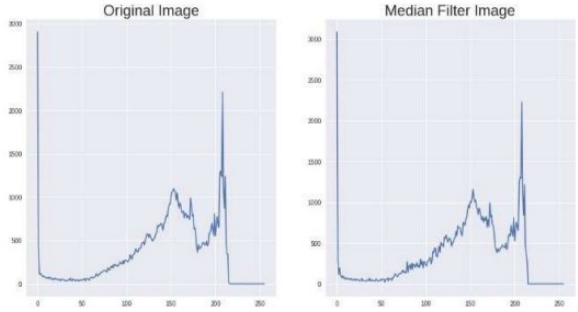


Fig. 8. Comparison of the histogram on the original image and the image of the Median Filter method

TABLE II. COMPARISON OF PSNR, MSE, AND SSIM IN THE DATASET WITH THE (A) MEDIAN FILTER AND (B) GAUSSIAN FILTER METHODS

File Name	PSNR		MSE		SSIM	
	A	B	A	B	A	B
COVID-1.png	39.714	39.356	19.891	21.840	0.952	0.957
Normal-1.png	39.022	38.407	19.965	23.024	0.954	0.957
Lung_Opacity - 1.png	38.825	38.390	26.901	26.889	0.951	0.955

It can be seen that in Table 2, the median filter method (A) obtained the highest PSNR value compared to the Gaussian filter method (B). The PSNR value has approached the value of 40 so it can be said that the image quality after pre-processing is good. Meanwhile, the MSE value is said to be good if the value is towards 0, from the comparison of the two methods the value obtained is in the range of 20. Meanwhile, the SSIM value in both methods produces very good results because the value is close to 1. The results obtained by the two methods proposed in the study. This will then be compared with previous studies which can be seen in Table 3.

TABLE III. COMPARISON OF THE EVALUATION RESULTS IN THIS STUDY WITH OTHER STUDIES

Methods	PSNR	MSE	SSIM
Region Growing and Wavelet Transform [17]	37.122	25.5911	-
Gamma Correction, Gaussian Filter [18]	24.61	229.92	-
Wiener Filter and Poisson Noise [19]	33	29	0.7876
Type-2 Neutrosophic Set [20]	28.58	23.6	0.9
Proposed Method (Morphology Opening and Median Filter)	39.187	22.252	0.952
Proposed Method (Morphology Opening and Gaussian Filter)	38.717	23.917	0.956

It can be seen that in Table 3, the research conducted by Allam Zanaty & Mostafa Ibrahim [17] and Umamaheswari & Geetha [18] only calculated PSNR and MSE values, while SSIM was not calculated. Research by Umamaheswari & Geetha [18] also obtained the lowest PSNR and highest MSE values compared to other studies. Meanwhile, another study by Roy & Maity [19] and Abdel- Basset et al [20] calculated all the values used. Research by Roy & Maity [19] obtained the lowest SSIM score compared to other studies. The proposed method uses Morphology Opening and Median Filter to obtain the highest PSNR and the lowest MSE compared to other studies. Meanwhile, the proposed method uses Morphology Opening and Gaussian Filter to obtain the highest SSIM results compared to other studies.

IV. CONCLUSIONS

Based on the results obtained on image quality enhancement using a combination of two methods, namely Morphology Opening and Median Filter and Morhology Opening and Gaussian Filter, it produces good values based on image enhancement parameters. It can be seen from the PSNR, MSE, and SSIM values that the two proposed methods obtained very good results, where the average PSNR value has approached the value of 40, the SSIM is close to 1, but the MSE is still above 20. From these results indicate that the application of the proposed method able to image quality enhancement very well, so it can help detect abnormalities in the lungs more accurately.

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