Paper 8

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Comparison of Conventional Edge Detection Methods Performance in Lung Segmentation of COVID19 Patients

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Abstract. Digital image processing techniques have been widely used in the medical field, including in medical image analysis. One part of the image processing technique that plays an essential role in medical image analysis is image segmentation. This paper will discuss the performance of conventional edge detection, which consists of the Sobel, Canny, Prewitt, and Robert methods in segmenting the lungs, especially COVID19 patients. Based on the conventional edge detection method, we conducted a trial of measuring the lung area and the white patches contained therein. In addition, we compared the area between the lungs of normal patients and the lungs of Covid patients. The experimental results show that of the four types of conventional edge detection methods used, all of them have almost the same performance both in processing time and the results of the calculation of lung area obtained. Based on the experimental results, the conventional edge detection method can be considered for further development.

INTRODUCTION

Digital Image Processing is a field of science that studies how an image is formed, processed, and analyzed to produce information that humans can understand. Based on the form of the constituent signal, images can be classified into two types, namely analog images and digital images. An *analog image* is an image formed from continuous analog signals, while digital images are images formed from discrete digital signals. Analog images are generated from analog image acquisition tools, for example, the human eye and analog cameras. The image captured by the human eye and the photo or film captured by an analog camera is an example of an analog image. The image has a quality with a level of detail (resolution) which is very good but has weaknesses; among them is that it cannot be stored, processed, and duplicated on a computer [1]. Nowadays, digital image processing techniques have started to spread to various fields, especially in the health sector, one of which is diagnostic radiology. In the past, in radiology, the technique used was still effortless so that the resulting radiological image could not be manipulated with image processing techniques. However, along with the increasingly rapid development of the era, radiographers have been facilitated by creating a tool called Computer Radiography (CR). With the presence of computer radiographs, now the images can still be reprocessed on a computer screen to be edited according to the criteria of a good radiograph.

On the other hand, currently, COVID19 is a world pandemic that has caused many casualties. Various efforts have been made to prevent and resolve pandemics. One of the most intensively carried out efforts is to detect whether someone is exposed to the COVID 19 virus or not. Currently, SWAB PCR (polymerase chain reaction) is used as the primary standard in detecting COVID19 in the human body. However, considering that the deadly symptom of

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COVID19 is a disturbance in the lungs, usually, apart from using SWAB PCR, diagnosis can be supported using X-Ray images of the lungs. The X-ray results are in the form of x-ray images of the lungs that show white patches such as clouds or fog that can arise due to infiltrates or consolidation in the lungs of sufferers of Covid-19 [2]. The X-ray results are in the form of x-ray images of the lungs that show white patches such as clouds or fog that can arise due to infiltrates or consolidation in the lungs of sufferers of Covid-19. Referring to the critical role of the lungs concerning COVID19, the ultimate goal of our research is to take advantage of the role of Digital Processing Techniques in supporting the diagnosis of COVID19 by exploiting the lung area based on the X-Ray image modality.

Many previous researchers have done lung segmentation using digital image processing. Pang [3] developed a new automatic segmentation model using radiomics combined with hand-crafted features and deep features. His research used the *MedGIFT* database with a total of 128 patients. From the number of patients, 108 images were obtained, which could be identified and further divided into 1946 Regions of Interest (ROI) in lung tissue patterns for training and testing. The performance result of this method is 89.42%. Yang [4] developed a new lung segmentation and algorithm for the extraction of lung tumors on CT scan images. The algorithm starts with lung segmentation, maximum intensity screening, tumor symptom extraction, and the re-segmentation process. The performance of this method produces a sensitivity of 87.9%, a specificity of 89.9%, and an accuracy of 88.5%. Owens [5] developed a new method to evaluate the uncertainty of radiomics features at the time of CT scanning for lung cancer survivors. In his research, he analyzed CT scan images using two types of software, namely 3D-slicer and MIM Maestro. In addition, manual observation from three observers uses two types of semi-automatic segmentation tools, namely the Lesion Sizing Toolkit (LSTK) and the GrowCut. The reliability of each system was then tested using the intraclass correlation coefficient. The results obtained are that of the 83 analyzed features, 40 met the information requirements, 40 required further analysis, and three failed. Kim [6] proposed a lung segmentation method using the deep learning method. The novelty aspect of his method is the self-attention module, in which the output of the channel and spatial modules is combined to obtain a map connected to the "what" and "where" areas we will analyze. Sahu [7] proposed a method of lung segmentation on CT scan images for lung cancer detection based on the clustering approach, a Fuzzy-C_means algorithm with automatic thresholding and morphological operations. The data used came from 20 patients with a total of approximately 3600 images. The results obtained are accuracy of 99.94%, Jaccard index of 0.94, and a similarity coefficient of 0.97. Shi [8] proposed a lung segmentation method based on the integration of various algorithms. The first is to remove lung area noise by filtering. After that, it is converted to a binary image using a threshold. Then proceed by using the Region Growing algorithm. Then segmentation is carried out. The segmented image is a CT scan image. Gill [9] proposed a 4D lung segmentation method using all measurable volume CT scan images. The experiment was carried out on 152 CT scan images consisting of normal lungs and diseased lungs. This method can obtain an average Dice coefficient value of 0.9773 ± 0.0254. Cornelli [10] also proposed a deep learning-based segmentation method but applied it to the parenchyma. The amount of CT scan data used, although small, has a very high resolution of patients with pulmonary fibrosis. He uses two methods, namely U-net and E-net. The results obtained are the accuracy value of the similarity dice 95.9%. In our paper, we will now compare the performance of traditional edge detection methods to get complete images of the segmentation of the lung area and the white patches contained therein as the primary markers of COVID19. We chose this method because, based on our previous research [11][12][13][14][15][16][17][18], the results obtained will be more focused on our research's final objectives, as mentioned above. The contribution of this paper is as initial research on the localization of the lung area and the white patches in it in the development of a COVID19 screening instrument based on image processing techniques.

METHODS

Data Acquisition

In this experiment, we used the lung dataset published by data providers, such as 18 images on the NIHCC website, 25 images for KAGGLE, and seven images for RADIOPEDIA so that there are 50 images for normal lungs. The standard lung data is an image with RGB and Grayscale colors. PNG and. JPEG image formats. For images of the lungs of patients with Covid-19, 45 images were used from the Italian Society of Medical and Interventional Radiology. Figure 1 shows some examples of images used in this paper.

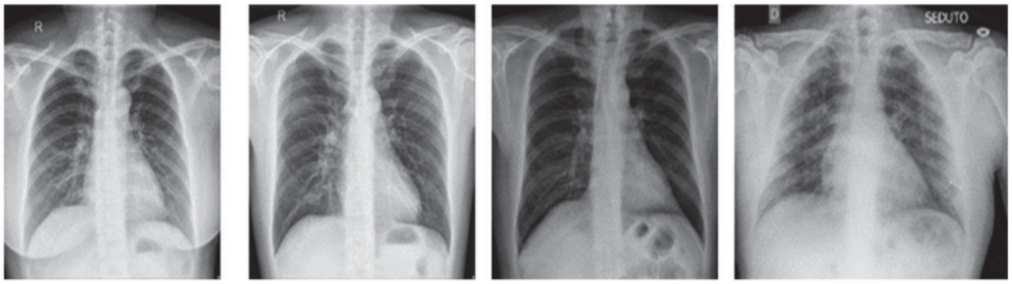


FIGURE 1. Examples of input images

Pre-Processing

Preprocessing is a process that is carried out before segmenting the image. Preprocessing is carried out to facilitate and accelerate the segmentation process that will be carried out because the original image cannot be directly segmented by the edge detection method, so that it must go through the preprocessing process first. In this experiment, we did several things, including gray scaling to change an image that has three layers or RGB into a grayscale image that has one layer, cropping to cut the desired image, thresholding, namely changing the grayscale image to a binary or black and white image and resizing it to change the image dimensions to 500x500 pixels. Gray scaling is intended to simplify and speed up the segmentation process because the grayscale image only has one channel that has a range of 0 to 255, while the RGB image has three channels, namely red or red (R), green or green (G) and blue or blue (B) each of which has a range of 0 to 255. Cropping is done to cut or remove other objects in the image. The image used in this experiment is an X-ray image of the body of both Covid-19 patients and normal patients so that the image contains the patient's lungs, sternum, and the patient's upper body. In this experiment, what is needed is an image of the lungs to segment the image, and the objects around the lungs are not needed. So cropping is done to take images of the lungs only and remove other objects. Figure 2 shows the lung area cropping process used in this experiment.

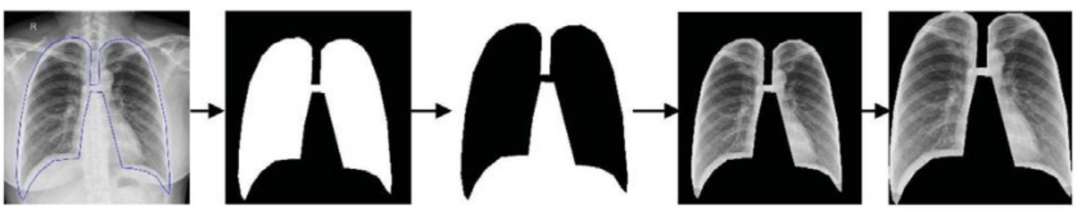


FIGURE 2. Cropping Process

Thresholding is used to convert a grayscale image into a binary or black and white image to simplify the segmentation process with edge detection because binary images only have 2-pixel values, namely 0 and 1, so that the edges of the image, in this case, the lung image will be easier to use in this experiment using adaptive thresholding because the value of the threshold used is different for each image and each edge detection method. Resize is the process of changing the pixel size in an image, usually reducing the pixel size. The purpose of image resizing is to normalize all images because each image has different sizes so that all images have the same image size and accelerate computation because the image size is reduced. In this experiment, we normalized the image size to 500x500 pixels.

Segmentation

Image segmentation is the division of the image into several parts of the object or region and can also separate particular objects from the background in the image. Segmentation is carried out on the resulting image from the previous preprocessing. The segmentation carried out in this research uses conventional edge detection methods, namely Sobel, Prewitt, Robert, and Canny, which will produce an image of the edges of the lungs. After that, dilation is done to make the line thicker on the previous edge image, look for the most significant object, and fill in the line or filling. Filtering is applied in each of these methods. By using this filter, convolution will be carried out on the preprocessed image by placing the filter or mask of the edge detection method with the X or Gx axis and Y or Gy axis into the preprocessed image, multiplying each filtered pixel by the image pixel and adding up all the multiplied images. The result of this sum will be the new pixels in the image resulting from the convolution. This process will be carried out continuously until all image pixels are multiplied by the filter pixels. The filter will shift continuously and will descend to the following line until it is finished. After image convolution with filter pixels on each edge detection method and each x-axis and y-axis, the two axes will then be combined by finding the gradient value on the two axes using Equation 1.

$$G = \sqrt{Gx^2 + Gy^2} \qquad (1)$$

G = gradient value Gx = x-axis gradient Gy = y-axis gradient

The dilation operation aims to thicken the image so that the image will be thicker so that the edges of the image will connect. Strel is a structural element that will be used for dilation—in this experiment, using a line or line with a length of 3 pixels and perpendicular to degrees 90 or vertical and degrees 0 or horizontally. Next, the structural element will be placed on the image, and perform a search for pixel 1 by tracing each image that will be performed the dilation operation. After the structural element finds pixel 1 in the image, it will add pixel 1 to the image that is dilated as big as the string used. Furthermore, after obtaining the edge image of the lung, it is filled with the edge or line to form a white lung image. A filling will fill the holes in the image. The hole, in this case, is a black pixel in the image, which is surrounded by white pixels so that the black pixel will be filled by white pixels so that the image will be intact.

Post-Processing

Post-processing is a process carried out after segmentation that aims to improve the quality of the segmented image. In this research, post-processing was only carried out on normal lung images because, in normal lungs, the edges of the filling results were not smooth or flat, so a closing morphology operation was performed. Meanwhile, the covid-19 lung image was not closed because in the lung image - Covid-19 lungs have holes and uneven edges because there is a white fog in the Covid-19 lungs so that if the closing is done, it will fill the hole and the characteristics of the image of the Covid-19 lungs will disappear, and there is no comparison with the image—normal lungs.

RESULTS AND DISCUSSIONS

We use two types of image data in the experiment, namely the lungs of COVID19 patients and normal patients. For patients with Covid-19, there are data on the characteristics of symptomatic cases that these patients have, while normal lungs have no symptomatic cases because their lungs are normal or have no previous disease history. Due to different image conditions, the threshold used for each image and the segmentation method also varies, as shown in Table 1.

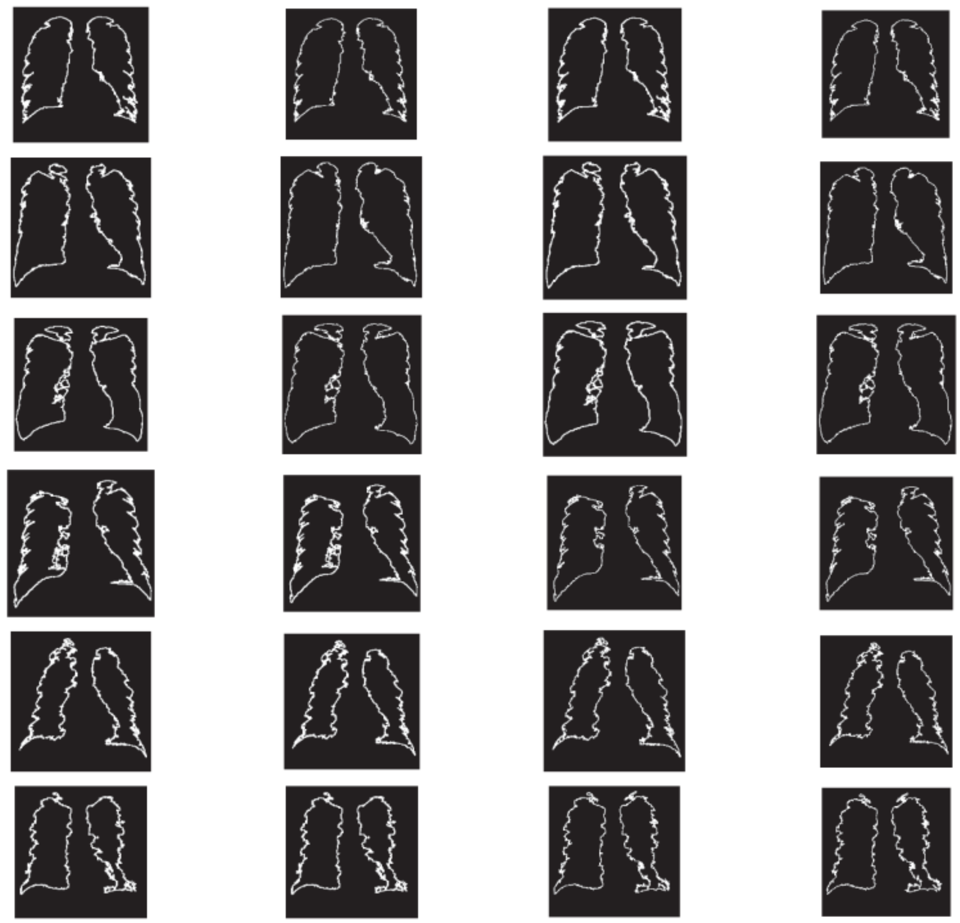
TABLE 1. Threshold sample used in this experiment

NAME	THRESHOLD VALUE			
	Sobel	**Prewitt**	**Robert**	**Canny**
Normal1	159	159	164	164
Normal 2	158	158	175	177
Normal 3	156	156	162	163
Covid 1	80	80	83	83
Covid 2	142	142	143	144
Covid 3	127	127	131	131

Table 2 is the result of edge detection performed using Sobel, Prewitt, Robert, and Canny. It can be seen that the resulting image is a binary image where only the edges are visible, namely the edges of the lungs and the edges of the cropping image.

TABLE 2. Examples of edge detection results

Sobel	Prewitt	Robert	Canny



Furthermore, after obtaining the edge image of the lung, it is filled with the edge or line to form a white lung image. The filling will fill the holes in the image; the holes, in this case, are black pixels in the image surrounded by white pixels so that the black pixels will be filled by white pixels so that the image will be intact. Table 3 shows the results obtained after filling these holes.

Furthermore, an extensive search will be carried out on the resulting image of the segmentation and how long it will take to perform the segmentation. Based on images of lungs that have been formed from the segmentation process, images of covid-19 lungs to filling, and images of normal lungs to closing. The next step is looking for the area of each lung, namely the right lung and the left lung. The search for the area of the lungs will be carried out by dividing the object based on its area by eight neighboring pixels. From the division of the area, measurements will be made in the form of properties, one of which is the area property to calculate the area of the image object. In this experiment, the object will be divided into 2, namely the right and left lungs, so that the calculation of the area will have two outputs, namely the area of the right and left lungs. After obtaining the area data from each segmentation result image, it is continued by looking for the range of that area. This range does not include images that fail to segment. The wide range of each method is shown in Table 4.

TABLE 3. Examples of edge detection of filling results

Sobel	Prewitt	Robert	Canny

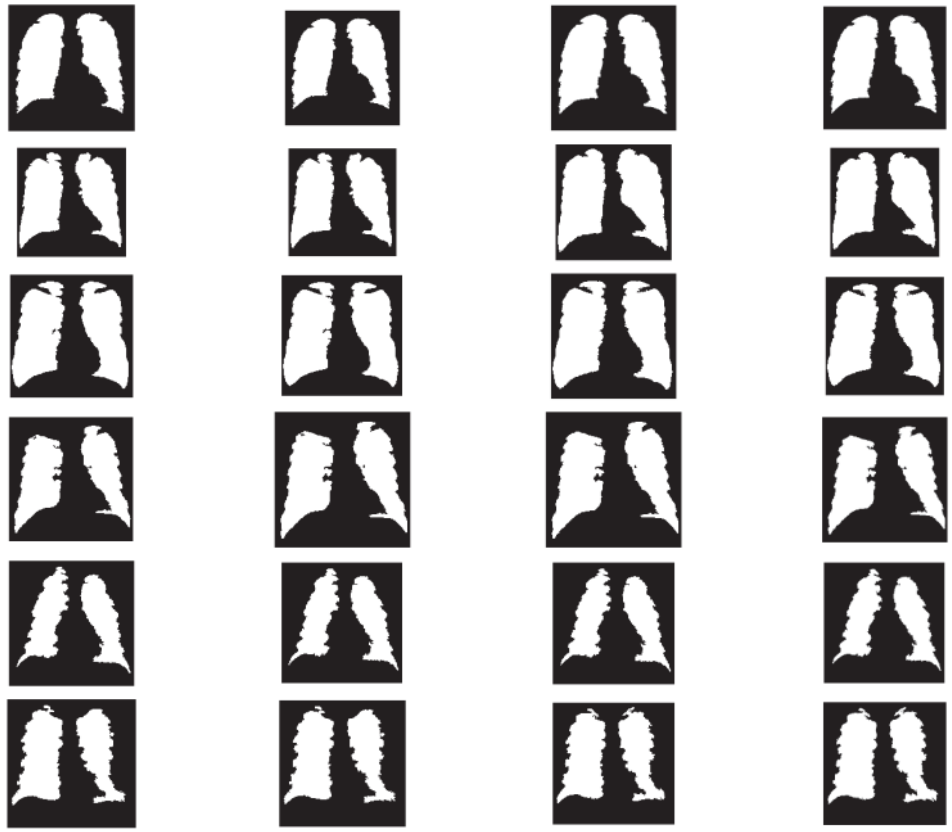


TABLE 4. An extensive range of segmented lung areas

Normal Lung				
Area	**Range**			
	Sobel	**Prewitt**	**Robert**	Canny
Right	35533 - 66646	35533 - 66646	35192 - 66562	35184 - 66437
Left	31066 - 57600	31066 - 57600	30693 - 68288	30695 - 58206
Covid Lung				
Area	**Range**			
	Sobel	**Prewitt**	**Robert**	**Canny**
Right	5607 - 59011	5607 - 59011	4452 - 61314	4896 - 65517
Left	5868 - 53751	5868 - 53751	8485 - 52961	8457 - 52923

Processing time is the time needed by the system, starting from edge detection to filling in images of normal lungs and Covid-19 sufferers. Table 5 shows the results of the processing time required for each method. The processing time is less than 1 second for all methods, so the processing time for segmenting is speedy.

TABLE 5. Examples of processing time for each method

Image	Time (in seconds)			
	Sobel	Prewitt	Robert	Canny
Normal 1	0,22	0,19	0,25	0.59
Normal 2	0,21	0,20	0,20	0.44
Normal 3	0,22	0,25	0,20	0.44
Covid 1	0,19	0,18	0,19	0.44
Covid 2	0,18	0,21	0,22	0.48
Covid 3	0,19	0,18	0,19	0.45

CONCLUSION

The performance of each of these conventional edge detection methods is almost the same so that any edge detection method can be used in the development of lung segmentation for both normal patients and COVID19 patients. In calculating the area of the lungs, from all the methods used, the normal lung image has a larger lung area than the lung area in the image of Covid-19 sufferers in both the right lung and the left lung. The processing time required is not too different.

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