Comparison of image segmentation of lungs using methods: connected threshold, neighborhood connected, and threshold level set segmentation

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Abstract. The aim of this research is to compare some image segmentation methods for lungs based on performance evaluation parameter (Mean Square Error (MSE) and Peak Signal Noise to Ratio (PSNR)). In this study, the methods compared were connected threshold, neighborhood connected, and the threshold level set segmentation on the image of the lungs. These three methods require one important parameter, i.e the threshold. The threshold interval was obtained from the histogram of the original image. The software used to segment the image here was InsightToolkit-4.7.0 (ITK). This research used 5 lung images to be analyzed. Then, the results were compared using the performance evaluation parameter determined by using MATLAB. The segmentation method is said to have a good quality if it has the smallest MSE value and the highest PSNR. The results show that four sample images match the criteria of connected threshold, while one sample refers to the threshold level set segmentation. Therefore, it can be concluded that connected threshold method is better than the other two methods for these cases.

1. Introduction

Along the time, medical imaging systems have become more frequently used by health experts to diagnose a disease suffered by a patient. To be able to produce a medical image, modality of an image is needed, for example, CT-scan. The image generated by imaging modalities needs to be processed first in order to get the image quality as expected. One of the image processing is segmentation.

Segmentation is a technique to partition an image into areas that are more meaningful for a particular purpose; it is one of the first steps to analyze and interpret the image [1]. In the medical world, segmentation itself is often used to make it easier to analyze the shape, size, and borders of the target or region of interest (ROI) of the patient. But, segmentation is not easy; there are some issues that need to be considered when doing this process, such as: highlights, shadows, transparency, and object occlusion [2]. Then, to facilitate it, segmentation methods are divided into two basics, i.e. segmentation based on similarity and based on discontinuity. One method that is based on similarity is region growing, while the method based on the discontinuity is level set.

This study used the image of the lungs as the object of segmentation. The lung is an organ that is quite difficult to define in term of its limits. Therefore, it is necessary to facilitate the segmentation technique to analyze the results of the lung image. The accuracy of the identification of lung disorders depends on the efficiency of the lung segmentation techniques [3].

The image that has been successful in the segmentation needs to be evaluated in order to determine a better method that can segment the image appropriately. In the medical world there are some parameters that can be used to evaluate the image, such as: signal noise to ratio (SNR), peak signal noise to ratio (PSNR), timing run, histograms, mean square error (MSE), accuracy, sensitivity, specificity, etc. This research will use the evaluation parameters of MSE and PSNR. MSE [4] and PSNR [5] equation is as follows.

$$MSE = \frac{1}{NM}\sum_{i=1}^{N}\sum_{j=1}^{M}(f(i,j) - \hat{f}(i,j))^2 \tag{1.1}$$

$$PSNR = 10\log_{10}\frac{L^2}{MSE} \tag{1.2}$$

Therefore, the purpose of this study is to compare the results of the image segmentation of lungs using several methods of segmentation with performance evaluation parameters: MSE and PSNR. Analysis on the segmentation results is used to determine the best method for this case.

2. Methods and material

In this research, segmentation process will be carried out using Insight Toolkit software or commonly referred to ITK. The methods used are connected threshold, neighborhood connected, and threshold level set segmentation.

2.1. Connected threshold

Connected threshold includes the part of region growing method. This technique is done by evaluating the intensity values at predetermined intervals by two threshold values (threshold value) or can be written as follows [6]:

$$I(x) \in [lower, upper] \tag{2.1}$$

That is, only the pixels nearby that have an intensity which is in the range of lower limit and upper limit that can be segmented. Those beyond that range will be considered as background.

The initial step of this process is to determine seed x and seed y manually; after the seed is determined and put in, the next step is to read the histogram to determine the upper and lower threshold. Then, the segmentation process begins. This process continues to spread to the nearest neighboring pixels until no pixels have similarities. The segmentation process in this method is very quick.

2.2. Neighbourhood connected

The next method is neighborhood connected, one of the region growing methods. This method is similar to connected threshold, only this method will add in the nearest neighboring pixels when pixels are included in the measurement defined at the beginning of the process. The main reason to evaluate the neighborhood of each pixel is to make even smaller structures [7]. Because there is a requirement of pixel size and intensity range that must be qualified, the neighborhood connected method is not suitable for segmentation of small-sized organ.

The working steps of neighborhood connected method are the same as those of connected threshold. It's just that there is a specified radius. Because this study uses ITK software, the large radius has been pre-determined and cannot be changed.

2.3. Threshold level set segmentation

The basic techniques of this method is discontinuity, but with an additional threshold parameter. The limit of the intensity used is the lower threshold and upper threshold. For the pixels belonging to the intensity range, the equation level set is applied where the connected components bounded surface evolution, which is commonly called the propagation [7]. The following equations were used.

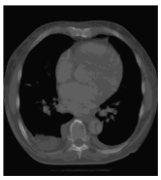
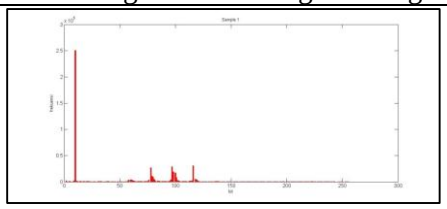
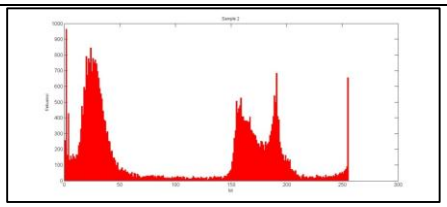
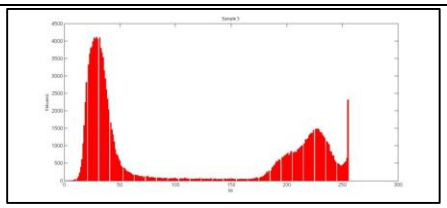
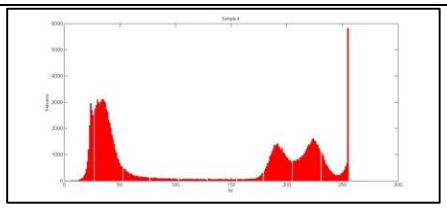
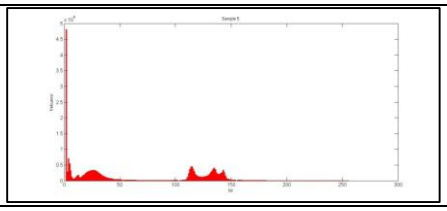
$$P(x) = \begin{cases} g(x) - L, if \quad g(x) < \dfrac{(U-L)}{2} - L \\ U - g(x), \quad others \end{cases} \tag{2.2}$$

Where P is the propagation, g (x) the function of the image, U is the upper threshold, and L is those below the threshold limit.

3. Results and discussion

In this study, the segmentation process begins by inserting the image of the lungs with a format of DICOM files. This research uses five samples of lung images with different pixel dimensions. Five sample images and histograms of each original image can be seen in table 1 below.

Table 1. Input image of the lungs of sample 1, sample 2, sample 3, sample 4, sample 5 and histograms of each sample.

Lungs	The histogram of the original image
	
	
	
	
	

The histogram above shows the upper and lower thresholds of each image, where the threshold is indicated by the valleys of the histogram. Errors in determining the threshold range would affect the results of image segmentation in which the closer the distance of the threshold interval, the smaller the

segmented region. However, when conducted excessively, the segmented region would be superfluous. After determining the location of the seed, threshold, and initial distance, the importance of the new image that has been segmented is as in table 2 below.

Table 2. Segmentation results obtained from each method on five samples.

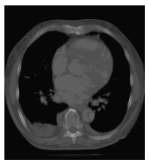
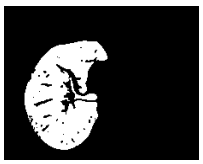
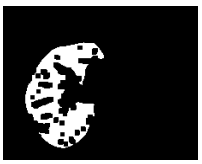
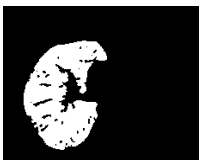
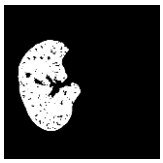
Sample	Connected Threshold	Neighborhood Connected	Threshold Level set Segmentation	Parameter
				Dimension : 686 × 753 Seed : 170 388 Threshold : 0 13 Initial Distance: 1.0
				Dimension : 228 × 183 Seed : 45 86 Threshold : 5 46 Initial Distance: 5.0
				Dimension : 388 × 388 Seed : 82 201 Threshold : 13 69 Initial Distance: 5.0
				Dimension : 448 × 329 Seed : 127 147 Threshold : 15 81 Initial Distance: 5.0
				Dimension : 496 × 494 Seed : 150 200 Threshold : 0 51 Initial Distance: 1.0

Table 3 below the MSE and PSNR values obtained from each method in the fifth sample, where the smaller value of MSE and the higher value of PSNR have a good level of similarity with the original image.

Table 3. Result of MSE and PSNR

M / S	MSE			PSNR (MATLAB)			PSNR (PhotoDefiner)		
	C	N	T	C	N	T	C	N	T
P1	39602,71	40206,65	39599,86	2,154	2,088	2,154	2,154	2,088	2,154
P2	21294,41	24639,94	21748,66	4,848	4,214	4,756	4,848	4,214	4,756
P3	19060,19	20827,44	19217,22	5,330	4,944	5,294	5,330	4,944	5,294
P4	17422,36	19107,11	17446,22	5,720	5,319	5,714	5,720	5,319	5,714

P5	33869,14	34889,08	33942,95	2,833	2,704	2,823	2,833	2,704	2,823

In table 3 above, it can be seen that for sample two to sample five, the smallest MSE and PSNR value is highest in the connected threshold method; whereas, in sample one, there are the best values in the threshold level set segmentation method. In this case, by looking at the values above, the connected threshold method is deemed better than the other two methods.

4. Conclusion

After doing research on segmentation of five sample images that have different dimensions, it can be concluded as follows:

- After doing some research on this case, it can be concluded that the connected threshold method is superior to the other two methods. It is based on the faster time required for the segmentation process; MSE and PSNR show this method is superior, and it takes only the parameters of seed location and threshold range.

References

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