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Semi automatic measurement of pleural effusion index

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Abstract
Pleural effusion index is one indicator used to determine the severity of dengue hemorrhagic fever. During this time, pleural effusion index measurements were carried out by radiologists, and there were often differences in measurement results between radiologists. This difference is due to the fact that each radiologist has a different interpretation of the width of the effusion and the width of the hemithorax that is used as the basis for calculation. In this paper we have performed pleural effusion index measurements automatically with the method of segmentation in the thoracic image of patients with dengue hemorrhagic fever in a semi-automatic manner using image processing techniques. The program design includes stages of improving image quality, segmentation, morphological operations, and finally, pleural effusion index measurements via mouse clicks on the area to be measured. The material used in this study is right lateral decubitus projection thorax image with optimal exposure factor and free from superposition. Verification is carried out by a radiologist who is an expert. From the results of the verification, it was concluded that the proposed method could measure pleural effusion index with accuracy 85 percent.

Keywords: Pleural effusion index, dengue hemorrhagic fever, thoracic image

Introduction

Dengue hemorrhagic fever (DHF) is an infectious disease caused by dengue virus, which is an endemic disease in tropical and subtropical countries [1-4] of which are Indonesia [5]. One indication of DHF is plasma leakage that leads to pleural effusion [6-8]. Pleural effusion in DHF patients will be seen on thoracic image examination with right lateral decubitus projection. Semi quantitative estimation of pleural effusion obtained from the calculation of pleural effusion index (PEI). Calculation of PEI by radiologist is still subjective, so the resulting value may differ from one radiologist to another [9-10]. To measure PEI, radiologists still rely on their visual abilities through manual measurements on thoracic images.

Radiologists often have difficulty diagnosing pleural effusion because the anatomic boundaries of the thoracic image are sometimes vague. The diagnosis of thoracic image becomes more difficult if it contains a lot of irrelevant information. To overcome these problems, we need a technology that can provide clear information as needed. One way is by digital image processing. Image segmentation is one of the stages in digital image processing that can be used [11-13].

Segmentation is grouping images into several homogeneous areas based on similarity criteria of gray levels. The resulting image will then consist of parts of the object and part of the background. The thresholding method has been used to detect lung abnormalities automatically [14]. The thresholding method can also be used to calculate the volume of pleural effusion [15]. The volume of pleural effusion is calculated from the sum of the slices in a segmented lung. In the application of medical images, thoracic image segmentation is expected to be used to calculate PEI values in DHF patients. Segmentation with the thresholding method will be carried out in the right lung as a place for accumulation of effusion fluid. Then the segmentation thresholding is combined with morphological operations to obtain more optimal results. The results of PEI calculations will be examined by a radiologist who is related to handling DHF patients. The purpose of this study was to measure PEI on a thoracic image of DHF patients through the segmentation method. In part 2 we will explain the stages of the work we are doing: eliminating noise, determining the region of interest (ROI), segmentation and calculation of PEI. We will present the experimental results in section 3 and finally the conclusions will be drawn in section 4.

Method

The purpose of this study is to get PEI semi-automatically using image processing methods. The material used in this study is a thoracic image indicated by pleural effusion from DHF patient. In this section we will explain the preprocessing method, determine the ROI semi-automatically with the click and drag technique, PEI segmentation and measurement. Examples of thoracic image indicated pleural effusion can be seen in Fig 1.

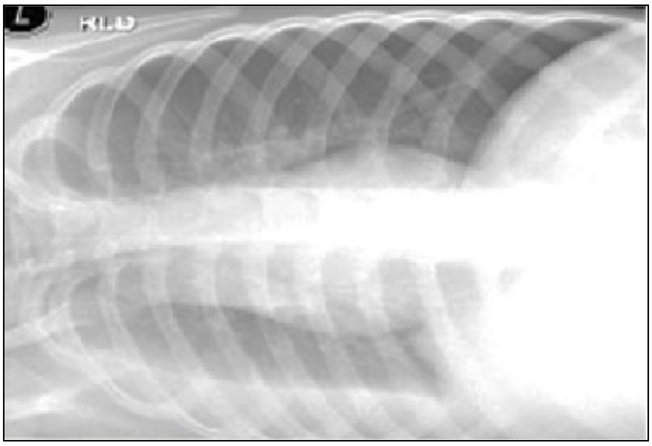


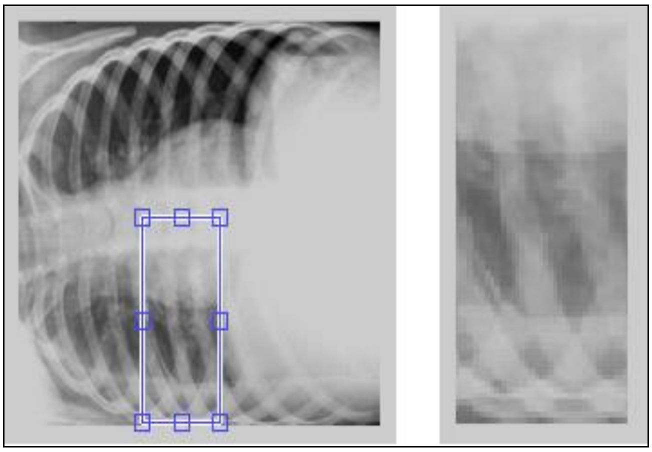
Fig 1: Examples of thoracic images indicated by pleural effusion

1. Preprocessing

Preprocessing consists of enhancement and resize. Enhancement is done to reduce the noise so that the segmentation results do not have a small hole that will affect the width of the pleural effusion. enhancement is done using a median filter. Resize is done so that the image to be processed is then 200 x 200. With resize, all input images will be made in the size of 200 x 200. By using resize, we do not need to limit the size of the image. Any size image can be used as input that can be processed in the same way.

2. Determination of ROI

The chest cavity is divided into two compartments, namely the right hemithorax (which in Fig 1 is on the bottom) and the left hemithorax (which in Fig 1 is on the top). The region of interest that can be used to measure PEI is a rectangle which is bordered by the symmetry axis (upper border), the right side of hemithorax (lower border), the middle of the lung (left border) and the end of the lung (right border). The symmetry axis is the midline between the right hemithorax and the left hemithorax. We use the click and drag technique to get the region of interest In the Matlab script. This technique can be written as follows: *im2 = imcrop (im1)*, which means we will get an im2 image which is a region of interest from the im1 image (origin image). Example of area chosen as ROI and cropping results can be seen in Fig 2.

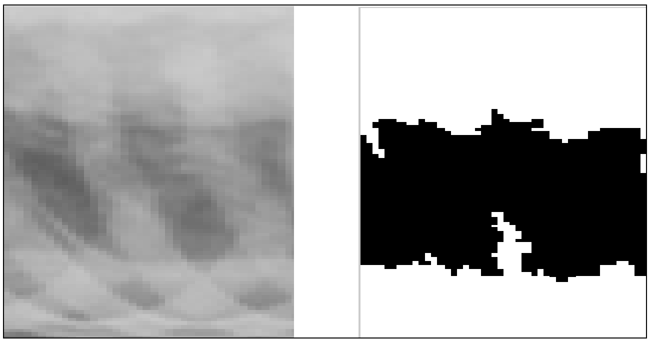


(a) (b)

Fig 2: Area selected as ROI (a) and cropping result (b).

3. Segmentation

After the ROI is determined, image segmentation is then carried out by the thresholding method. Image segmentation aims to separate objects from the background. The output of the image segmentation process is a binary image. The threshold process is done by checking the gray level of each pixel in the image and determining the threshold value. If the gray level is smaller than the threshold, the pixel is given a value of 0 (black), and if it is larger than the threshold, the pixel is given a value of 1 (white). The threshold value is determined using the Otsu method [11-13]. The Otsu method works by finding a threshold that minimizes intra-class variance of the image. Segmentation can achieve good results when image histograms have two peaks. Examples of images before and after segmentation can be seen in Fig 3.

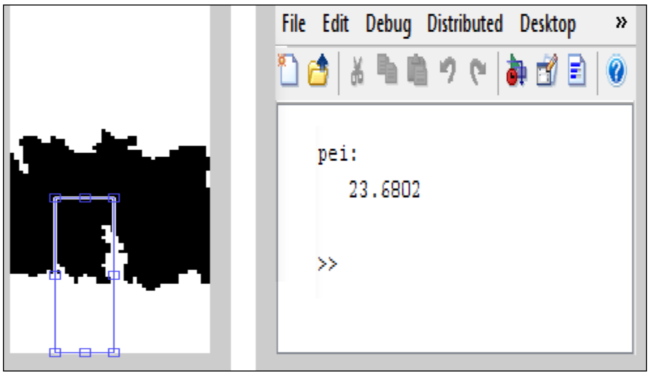


(a) (b)

Fig 3: Examples of images before segmentation (a) and after segmentation (b)

4. Measuring PEI

Before PEI calculations, morphological operations are performed which are useful for removing white spots on black areas and black spots on white areas [16, 17]. Furthermore, the PEI calculation was carried out by measuring the ratio of effusion width and hemithorax width [9]. In this ROI image, the area will be divided into 3 parts, namely the hemithorax boundary (upper part), lung (middle) and pleural effusion (bottom). The hemitorax width is the symmetrical axis boundary with the right hemithorax edge here which is the width of the ROI. The width of the effusion is sought by the click and drag technique in the area between the middle of the lung and the edge of the right hemithorax as shown in Fig 4. We chose this area because it is an area with maximum values and clear boundaries. The width of pleural effusion is calculated from the number of white pixels divided by the width of the rectangle formed when doing click and drag.



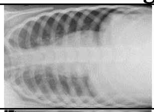
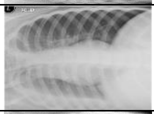
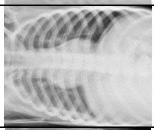
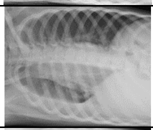
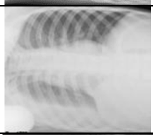
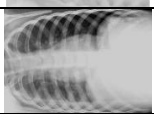
(a) (b)

Fig 4: Measurement area of PEI (a) and result of measurement (b)

Result and Discussion

Experiments were carried out using 10 thoracic images that indicated pleural effusion from DHF patients in the hospital. All image is through the preprocessing phase, determining ROI, segmentation, determining the region of interest, and measuring PEI. The results of PEI measurements based on the proposed method we compare with the measurement results manually by a radiologist. From the results of these measurements we calculated the percentage difference in measurement results using the proposed method with the measurement results manually by the radiologist. The measurement results can be seen in table 1.

Table 1: Results of PEI measurements

No	Thoracic Image	PEI according to experts	PEI according to the proposed method	Relative deviation (%)
1		29	21	27 %
2		29	30	3 %
3		19	23	21 %
4		28	29	4 %
5		32	33	3 %
6		35	28	20 %
7		35	28	20 %
8		35	39	11 %
9		25	35	40 %
10		26	26	0 %

From table 1 we can see that in each image there is a difference between the measurement results using the proposed method and the measurement results manually. The difference ranges from 0% to 40 %, which if at an average is 15 % or in other words, the accuracy is 85 %. With this small difference, the proposed method can be used as an alternative to measure PEI in patients with DHF easily and quickly. To improve accuracy, we will continue this research with morphological operations

Conclusion

Based on our study, measurement of pleural effusion can be done semi-automatically using image processing methods with click and drag techniques. The stages carried out are preprocessing, determining the region of interest, segmentation and finally the measurement of pleural effusion index. Region of interest for measuring pleural effusion is an area bounded by the symmetry axis between the right pleura and the left pleura, the right side of the pleura, the middle of the pleura and the lower end of the pleura. Pleural effusion index was measured based on the comparison between pleural effusion and hemitorax. To assess the performance of the proposed method, a radiologist who is an expert has verified it. From the results of the verification, it was concluded that the proposed method could measure pleural effusion index with accuracy 85 percent.

Acknowledgment

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