



VOLUME ESTIMATION OF LUNG CANCER USING IMAGE-J FOR CT-SCAN IMAGE

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ABSTRACT

Lung cancer is a malignant tumor that develops in the lower respiratory system, including cells in the walls of the bronchi and bronchioles. Lung cancer originates from genetic changes in cells in the lungs. Improper treatment of lung cancer can cause the cancer to spread to other nearby tissues around the lungs. Early detection of lung cancer will help patients get appropriate treatment. One of the medical instruments used to detect lung cancer is the CT-Scan. This instrument can provide information about the location, size, and characteristics of the tumor, lymph node spread, and tissue infiltration into the surroundings, thus helping to determine the clinical stage of lung cancer. Organ size determination is one of the analyses of pulmonary images for diagnostic and therapeutic purposes. The study estimated lung cancer volume based on CT scan images using Image-J software. The edge detection method determines information on the edges of the lungs affected by cancer. The results show that the Image-J software can provide a clear picture of the edges of cancer and obtain accurate cancer volume at each image slice. Based on calculations obtained for the 1st, 2nd, and 3rd patients have volume of 128 cm³, 447 cm³, and 335 cm³, respectively.

Keywords: CT scan image; lung cancer; edge detection; volume analysis; Image-J.

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INTRODUCTION

The lung organ is vital for the respiratory system to exchange oxygen with carbon dioxide along with hemoglobin in the blood. The lung organ is located inside the chest cavity and protected by the collarbone along with two walls called pleura. The two layers (collarbone and pleural wall) are separated by an air layer, i.e., the pleural cavity that contains fluid. The slightest damage to the lungs will impact the body's performance. Lung cancer is a malignant tumor that develops in the respiratory system and includes cells in the walls of the bronchi and bronchioles. The risk of lung cancer has been evaluated in adults with a pack-year of 20 and the first 15 years in the United America ^[1]. Lung cancer remains the leading cause of cancer deaths among both men and women ^[2]. American Lung Association reported that four in five patients diagnosed with lung cancer will die. However, the survival rate increased from 13% to 22.6% ^[3]. Lung cancer begins with genetic changes in the cells that form lung organs. Lung cancer for men ranks second after prostate cancer, and for women, lung cancer ranks third after breast cancer and colorectal cancer ^[4]. Less rapid treatment of lung cancer can cause spread to other tissue organs closest to the lungs. Early detection efforts for lung cancer are very effective for patients to get fast and appropriate treatment. One of the medical instruments used to detect lung cancer is to perform a

computed tomography scanning (CT-Scan) examination ^[5]. The CT-Scan examination will provide an overview of the presence of cancer, how large the cancer is, how physically characteristic the tumor is, information on the area of lymph node spread, and the possibility of tissue infiltration in the nearest region so that it can help estimate the clinical stage diagnosis of cancer. Determination of organ size is one of the analyses of lung images for diagnostic and therapeutic purposes.

Recently, various applications and software using computers have been developed, such as image processing, artificial intelligence in cancer imaging ^[6], a validated open-source deep-learning algorithm (Sybil) from a single low-dose chest CT ^[7], machine learning approaches ^[8], or other ways using GLCM (Gray Level Co-Occurrence Matrix) ^[9] so that medical image analysis diagnosis can perform more practically and automatically. The segmentation process on CT-Scan images is a stage to separate normal and abnormal lung areas of objects for analysis. Edge detection is one of the segmentation techniques applied. Edge detection techniques have several advantages, including being simple, fast, precise, and able to accurately mark the original edges in position according to the original image. The noise does not affect the edges because the edges of the image are marked only once. Therefore, this technique has been widely used in several studies and image analysis. Research on image edge segmentation using the active contour method ^[10-11] or canny edge detection ^[12] has been conducted. After edge detection on the cancer image, a clear outline is obtained. Thus, the next stage is to measure the volume of the cancer.

Research by Owen showed that the measurement of tumor volume or lung cancer is a better marker of patient survival than the measurement of unidimensional diameter ^[13]. Volumetry can improve diagnostic clinical decision-making for each patient and enable faster and more precise assessment of new treatments. A study in the city of Jember reveals that the average lung cancer patient in the lung hospital can survive six days ^[14]. Research on radiation dose analysis in lung cancer has also been conducted ^[15]. Research on the prevention of lung cancer using nutraceuticals has been conducted. Food ingredients from the genus *Brassicaceae* (cruciferous vegetable), garlic, beans, soybeans, vitamin D, and fish oil are mentioned as foods that can reduce the risk of lung cancer and improve quality of life ^[16]. The studies reveal that lung cancer begins with genetic changes in cells in the lungs, with an incidence of 12.9% of all cancer diagnoses and a mortality rate of 19.4%. In men, lung cancer is also the first cause of death from malignancy in the world (mortality 23.6%), and the incidence is also the first (16.8%) of all cancer diagnoses ^[4]. Medical images provide information for decision-makers (medical experts) about diseases and medical images can also be used as a medium for the diagnosis of a disease. However, if the parameters are misconduct when taking images, for example, current, voltage, position, etc., this will affect the results of the medical image. The effects on the image include colors that are too contrasting and lines that are less sharp or blurred. This effect can result in errors in interpreting the information in a medical image; therefore, other tools are needed to dig up the correct information in the image. One method is image manipulation using Image-J software ^[17].

To determine the volume of lung cancer cases, medical practitioners usually determine it by manually measuring the diameter of the CT Scan image. This method was applied because it is quite practical, simple, and easy. It is a common method applied by medical professionals to measure lung nodules. They take the maximum diameter of the image slice as a reference to determine the area and volume of the target organ, which is assumed to be a circular shape. This simple procedure can introduce errors, as shown in Ref. ^[18]. Therefore, in this paper, the authors show another approach to determining lung cancer volume using

Image-J as an alternative to estimate lung cancer size quickly and accurately through computational technology

METHOD

CT scan image data set provided by the radiology installation of one hospital in Banda Aceh. Three of lung cancer patient data set images, that have been consulted with specialists, were chosen. The image data obtained is *DICOM format, then converted into *JPG format to be analyzed using Image-J software. Image processing was done at the Laboratory of Medical Physics and Nuclear Applications Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala. The first step to perform image processing is to calibrate the scale of lung cancer images in Image-J software and then process the original image into a binary image. Segmentation and edge detection (sobel method) of lung cancer images are performed for binary data to obtain accurate outlines then, the final step is to calculate the volume of lung cancer by utilizing the plug-in measure in Image-J. Calculation of lung cancer volume based on Equation (1)

$$Volume = surface\ area \times slice\ thickness \quad (1)$$

Image Input Process

Image input is the initial stage in Image-J software. Not all image slices are processed into Image-J. We need only the image slices containing cancer to proceed to separate cancer areas and other organs (confirmed with a specialist). The data input process is done by inputting a file on the Image-J bar. The data input stage is completed, which is marked by the display of the image along with information on the number of pixels, which are the smallest elements in the form of color dots that make up an image. Image information is in the form of RGB images consisting of three primary color matrices, i.e., red (R), green (G), and blue (B), combined to obtain a certain color, and the size of the image inputted in the description of Megabyte units.

Image Calibration

This stage is the calibration of the lung cancer image scale with Image-J software with steps starting from *analyze > set scale*. Next, write down the initial scale that is already known from the hospital data. In this study, the scale is 10 mm at each slice of the image, with a pixel distance of 30.0167 and a known distance of 20 with select units in mm. Calibrated scale imagery will serve as a reference for other images of unknown initial scale by comparing pixel values close to 30.0666.

Segmentation and Edge Detection

The initial stage in segmenting images is converting the original image into a binary image called image binarization. A binary image is an image that contains only two pixel values in its cell, namely 0 (black) and 1 (white). This allows for images to have one bit to represent each pixel present. Binary images are also referred to as monochrome/B&W (Black and White) images. The threshold value is used to calculate binary images. The automatic thresholding function segmentation method is used in Image-J for the segmentation process [19]. The automatic thresholding function can divide the image into objects and backgrounds. This is done by taking a test threshold and calculating the average pixels at pixels below the threshold and pixels above the threshold. It then calculates the average of the two by increasing the threshold and repeats the process (Equation (2)). This method allows the

software to automatically determine for itself its optimal threshold value [20-22]. Figure 1(a) shows an RGB image, 1(b) 8-byte image, and 1(c) image after the thresholding applied.

$$\text{Thresholding} = \frac{\text{average background} + \text{average objects}}{2} \quad (2)$$

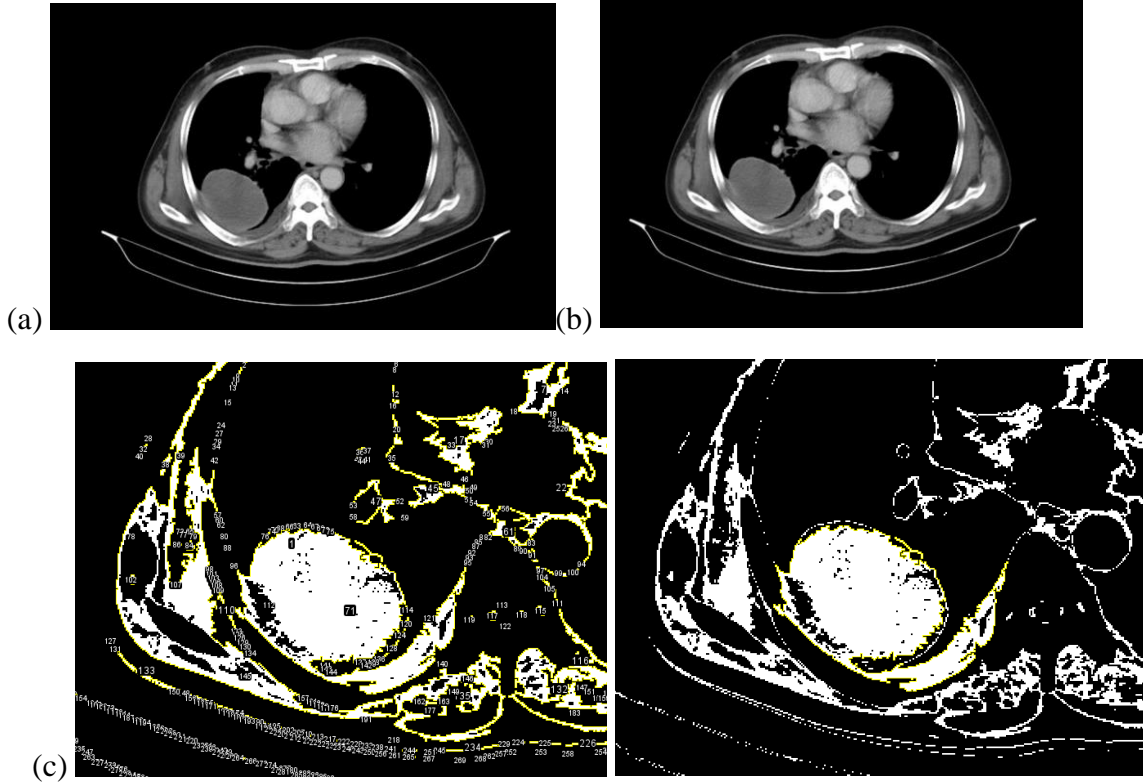


Figure 1. Processing image (a) RGB (b) 8-byte (c) Thresholding

Digital images are discrete quantities in the form of gray level integer numbers of $G \{0,1,\dots, l-1\}$, stored in a number of pixels, N , at spatial coordinates of (x,y) , so that digital images are mapping in functions of $f = N \times N \rightarrow G$. The gray level of a pixel with coordinates (x,y) is denoting as $f(x,y)$. If $t \in G$ and t are thresholds, thus the grey level coordinates $B = \{b_0, b_1\}$ with $b_0, b_1 \in G$. The result of thresholding is in the form of an f function consisting of a light object and a dark background, then the object pixels and background have intensity levels that are grouping into two domain modes [23]. One obvious way to extract objects from the background is to select the threshold (t). Any point (x,y) where $f(x,y) \geq T$ is an object point, while the other is a background point. In other words, the thresholded image $B(x,y)$ is defining in Equation (3). Threshold area number of lung cancer in this study by Image-J range between 101 to 156. There is a study for breast cancer with a threshold value of 0.00005 [24].

$$B(x,y) = \begin{cases} b_1 & \text{if } f(x,y) \geq t \\ b_0 & \text{if } f(x,y) < t \end{cases} \quad (3)$$

In a pixel, if the value is below the threshold limit it will be changed to 0, and the other will be 1. The color image is converted to grayscale (8 byte image) and then into a binary image, it is because 8-bit images have a value from 0 to 255 [24]. The way to convert an image into an 8 bit image is to operate *image > type > 8-bit* on Image-J software. If the image is already 8 bit type, then Image-J will display information on the input image. The next stage in this study is to separate the area of lung cancer (abnormal) from normal tissue and other organs

using edge detection methods by calculating the intensity value of the image. The binarization process was done with *binary steps > make binary*. The results of binary lung cancer images will show that the difference in black color has zero intensity for normal lungs, and white for abnormal lungs (lung cancer). Physically, to find out that there is cancer in the lungs without the help of a doctor, it is necessary to separate the intensity value. The separation of intensity values can be done using edge detection methods. The edge detection stage is carried out to see the outline of the image clearly by *processing > find edges*. To clarify the area of lung cancer, color is added to the cancer section using Image-J with the *image > color > color picker steps* (Figure 2).

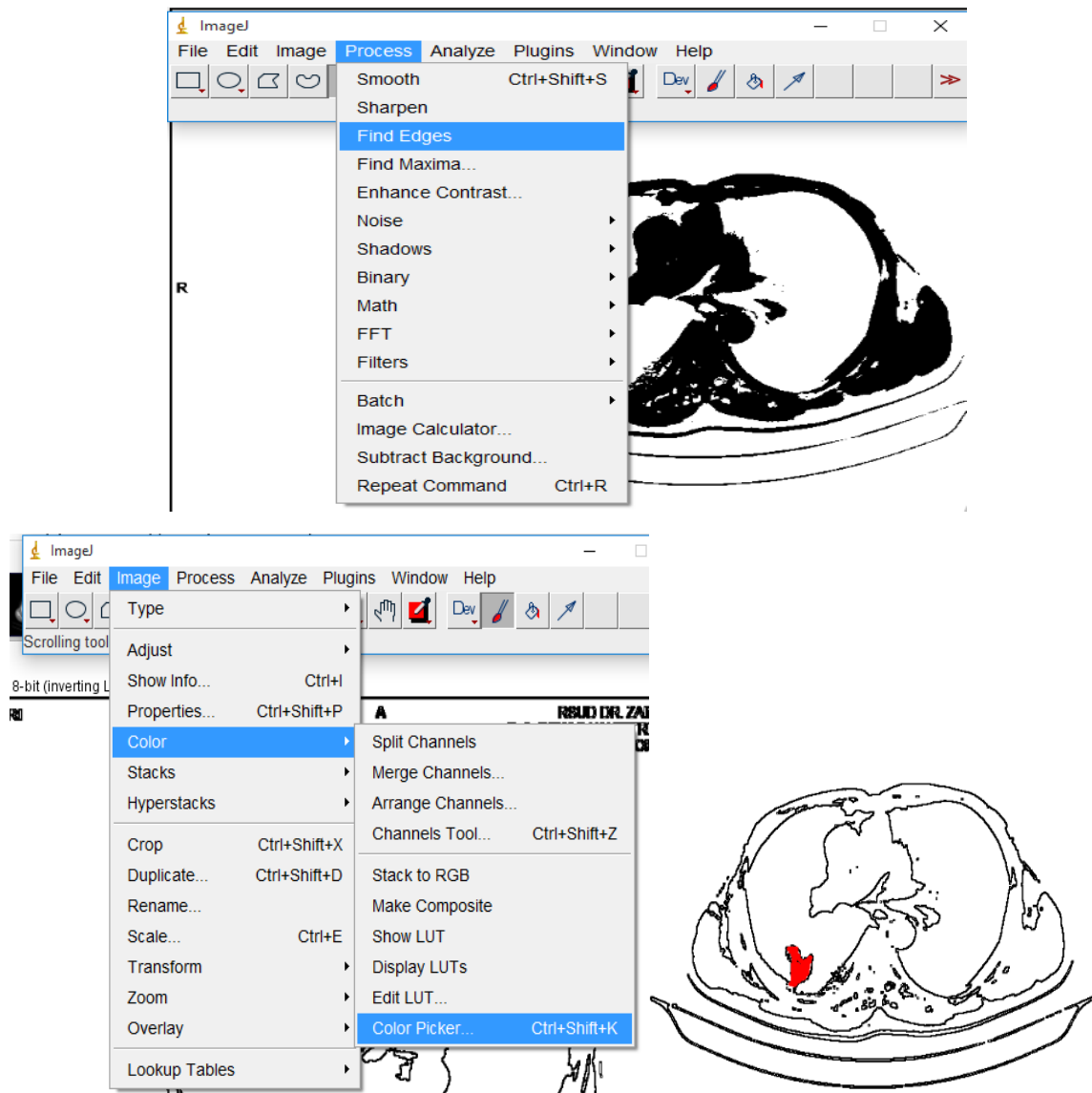


Figure 2. Edge detection stages to determine abnormal organ regions

Volume Calculation

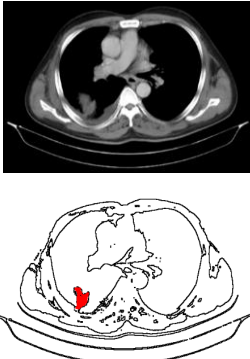
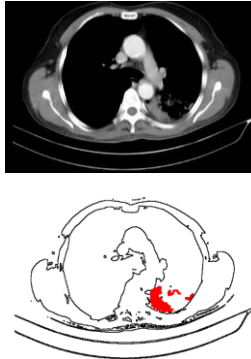
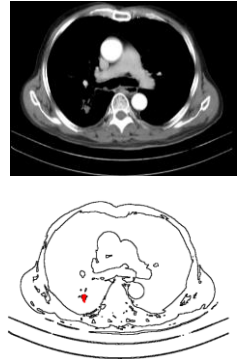
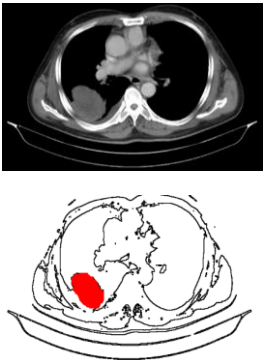
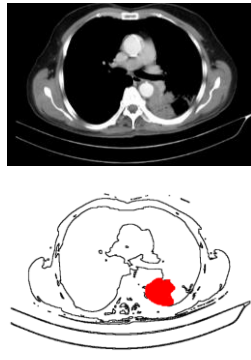
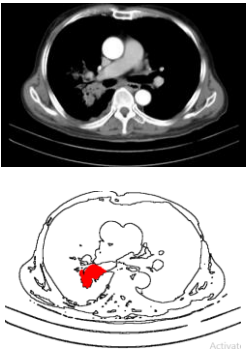
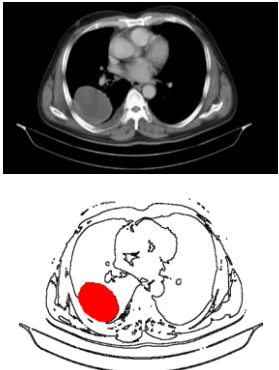
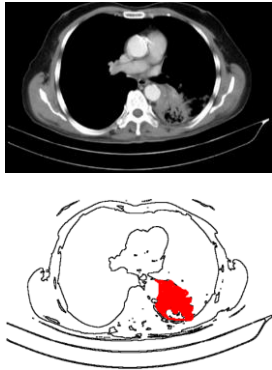
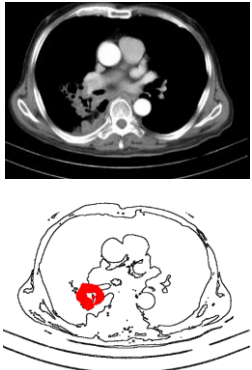
The calculation of lung cancer volume on each slice of the image data set is using Equation (1). The surface area is calculated by selecting the "Analyze" menu, then selecting "Measure" in the submenu, and the slice spacing (the thickness) of the slice is 10 mm (based on the information of the CT-scan officer of the hospital). The final step is to sum the values per slice and calculate the volume of each three-dimensional structure. The data are cubic

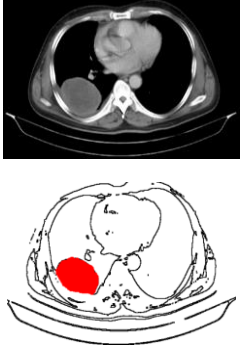
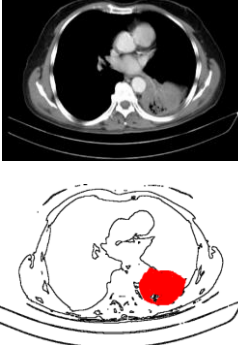
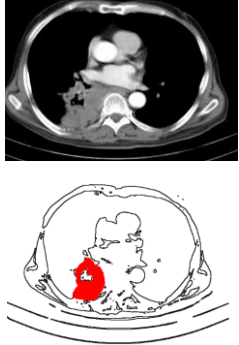
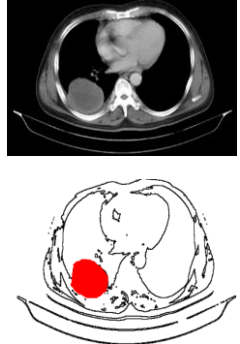
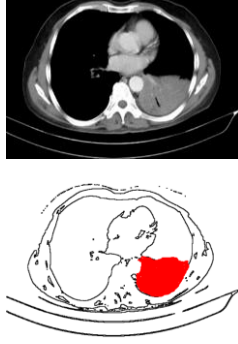
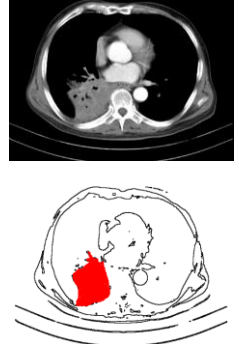
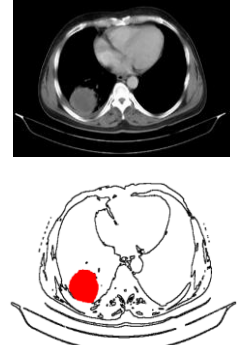





millimeters. Next, the value per slice image is added as the total volume of each three-dimensional structure [25].

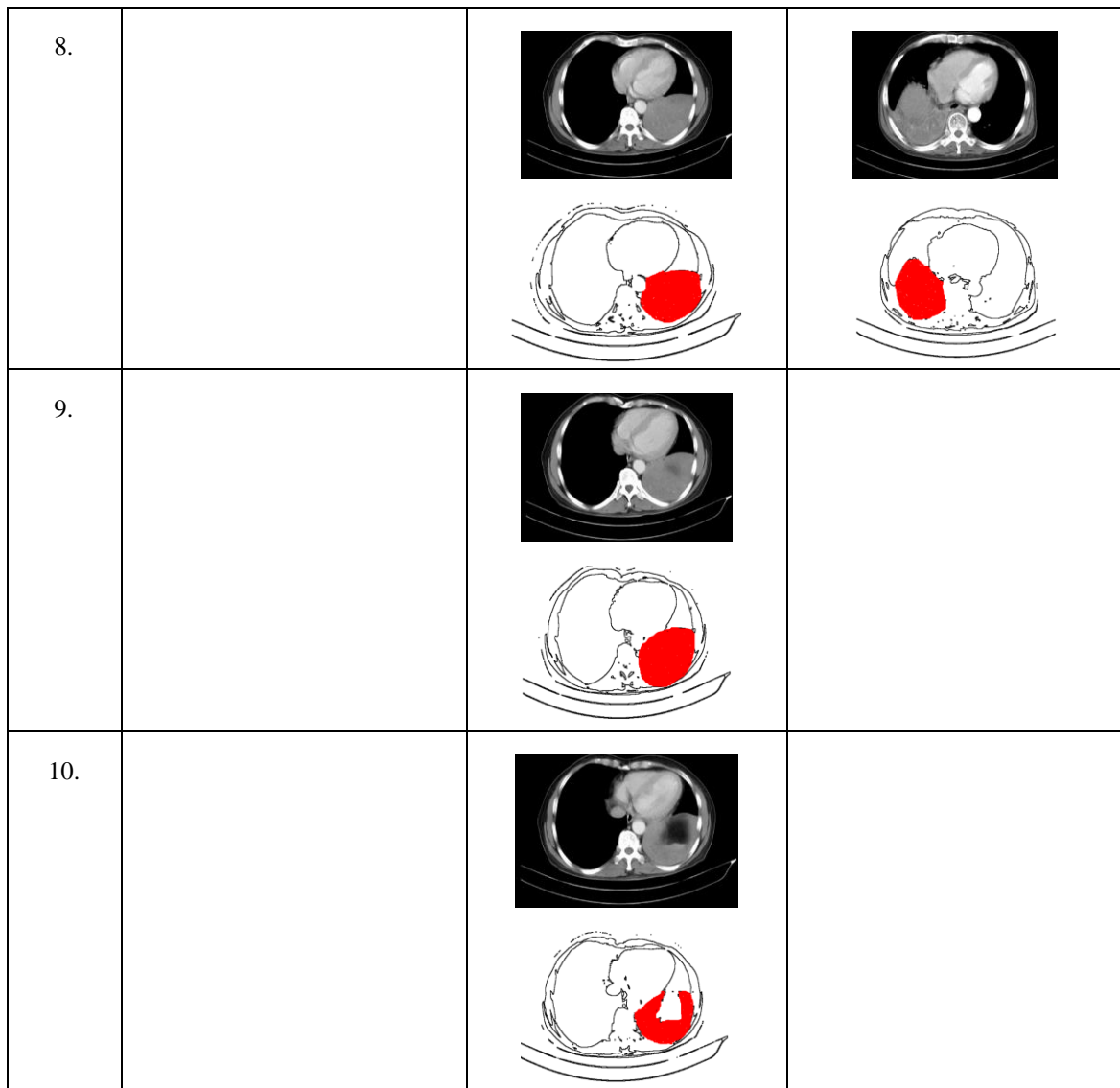
RESULTS AND DISCUSSION

We succeed in estimating the volume of the cancer area for three lung cancer patients. Table 1 shows the results of this study. The 1st patient applied seven image slices, the 2nd patient is ten image slices, and the 3rd patient is eight image slices. The image slice is taken based on the presence of abnormal images that were assumed to be cancer by a specialist in the hospital. The red mark is the edge detection result in the Image-J software as describing earlier. In this process, the results of segmentation and edge detection of abnormal parts have been consulted with a specialist and are cancer areas. Usually, the specialist will determine the diameter of cancer conventionally, this introduce errors as shown by Ref [18].

Table 1. Results of the calculation of lung cancer volume per slice for three patients

Slices number-	1st patient	2nd patient	3rd patient
1.			
2.			
3.			

4.			
5.			
6.			
7.			



Calculating the diameter of lung cancer is based on volume analysis using Image-J. Moreover, we assume that the shape of cancer is spherical, then by using Equation (4), the diameter is obtained. The volume and diameter of the present study are tabulated in Table 2.

$$volume = \frac{1}{6} \pi d^3 \quad (4)$$

Table 2. The volume and diameter of lung cancer

Patient-	Volume (cm ³)	Diameter (cm)
1.	127,90	6,23
2.	447,05	9,49
3.	334,92	8,62

By knowing the diameter of the cancer, it can classify the stage of cancer of each patient. The 1st patient has a diameter of 5-7 cm, which can be classified into stage IIB or IIIA cancer if there are metastases. The 2nd and the 3rd patient both have a diameter of >7 cm, which can be classified as stage IIIC and stage IV cancers if there are metastases [26]. Research on volume-based algorithm of lung dose optimization for esophageal cancer shows that range of the volume (V_{res}) is considered from 0 to 2230 cm³ [27]. The results method developed is assumed to be more accurate rather than the general way. By knowing the lung cancer volume, the diagnosis handled more precisely according to procedures and references for medical professionals to determine the right therapy and treatment.

CONCLUSION

This study has successfully determined the size of lung cancer volume using Image-J software. The lung cancer volume was accurately and precisely estimated on each slice of the CT scan image. The results showed that the first patient had a volume of 127.90 cm³ with a diameter of 5-7 cm so that it could be classified into stage IIB or IIIA cancer if there were metastases. The second and third patients having a volume of 447.05 cm³ and 334.92 cm³, respectively, were categorized with a diameter of more than 7 cm, which could be classified as stage IIIC and stage IV cancer if there were metastases. This method is recommended for medical professionals to analyze the volume of lung cancer patients in hospitals.

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