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Analysis of chest X-Ray (CXR) images in COVID-19 patients based on age using the Otsu thresholding segmentation method

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Abstracts

The infection with the COVID-19 virus or better known as the Corona virus spread throughout China and other countries around the world until it was designated a pandemic by the World Health Organization (WHO). Detection of patients infected with COVID-19 in the form of RT-PCR, CT-Scan images and Chest X-Ray (CXR). This study aims to analyze CXR images of COVID-19 patients based on age using Otsu Thresholding Segmentation. The image segmentation process uses the Otsu auto-tresholding method to separate objects from the background on the CXR image. The results show that the images of COVID-19 patients have pneumonia spots that are not visible on the original CXR image. The average value of the accuracy of the Otsu Thresholding results is 95.18%. Penunomia spots are mostly found in COVID-19 patients aged 50 to 70 years and over which cause severe lung damage.

Keywords: COVID-19; segmentation; Otsu thresholding; CXR; age

1. Introduction

COVID-19 or better known as the corona virus is a new type of virus that was first identified in December 2019 in Wuhan, China [1]. Then this viral infection spread throughout China as well as other countries around the world until it was designated a pandemic by the World Health Organization (WHO). In Indonesia alone, COVID-19 was first identified on March 2, 2020 and reached 4.2 million confirmed cases in September 2021 spread across 390 regencies/ cities from 34 provinces throughout Indonesia [2]. A study in China stated that the majority of COVID-19 patients were men with an average age of 56 years with 26% requiring intensive care unit (ICU) treatment, with a mortality rate of 28% [3]. COVID-19 infection acutely attacks

the respiratory system [4]. Symptoms experienced include fever, fatigue, dry cough to shortness of breath [5].

This disease was confirmed by gene sequencing techniques in laboratory examination using Real-Time Polymerase Chain Reaction (RT-PCR) with samples taken from the upper respiratory tract (nasopharynx and oropharynx) and lower respiratory tract such as sputum, tracheal aspirate and bronchoalveolar rinses [6]. In addition, to overcome the shortage of reagents, COVID-19 sufferers can be detected using CT-Scan images. Even the chest CT-Scan screening of 51 COVID-19 positive patients has a sensitivity rate of 98% [7]. This is because, in the CT-Scan image, there are pneumonia spots that are typical of COVID-19 patients [6] and are able to provide information about COVID-19 infection [6] and able to provide information about COVID-19 infection [8]. However, radiological examination can be done using CXR at a relatively cheaper cost than RT-PCR and CT-Scan.

Imaging with CXR has a sensitivity level of 69% of 64 patients aged 19-56 years to detect COVID-19 [9]. Another study on the detection of COVID-19 patients based on CXR imagery resulted in an accuracy greater than 95% [10]. CXR is the most common and widely available diagnostic imaging technique for supporting clinical care and epidemiological studies. In rural areas most have used CXR as basic diagnostic imaging in outpatient facilities. Given that there are still many hospitals in Indonesia, especially in rural areas that do not yet have CT-Scan radiographs, this study was made using CXR to detect COVID-19.

However, because the resulting CXR image has low contrast, the resulting image needs to be processed first. Previous research using Sobel edge detection to analyze the development of COVID-19 patients resulted in object patterns and areas of Corona virus spread, there are limitations to the image that looks quite clear [11]. Another study comparing several lung segmentation methods showed that Otsu Thresholding was slightly superior to other image segmentation methods [12]. The study using the Otsu function for the evaluation of CT-Scan images in COVID-19 patients confirmed that the proposed procedure is efficient in extracting infected parts with better accuracy [13].

In this study, CXR image processing was carried out using the Otsu Thresholding Segmentation method to analyze COVID-19 patients based on age. This analysis is based on the fact that age is a risk factor for disease severity and mortality in studies of viral infection [14]. It is hoped that the CXR image segmentation with the Otsu Thresholding method can be one of the tools for the diagnosis of COVID-19 patients.

2. Experiments Procedure

The data used in this study are CXR images of confirmed COVID-19 patients diagnosed using RT-PCR. The subject's age range is 20-50 years with seven data, age 50-70 years with eleven data and age over 70 years with two data. CXR images were obtained from the open database Github.com [15]. GitHub is a project management, code versioning system, as well as a social networking platform for developers around the world.

The procedure in this study is shown in Figure 1. The processed image is the original image of the COVID-19 patient with RGB color format. The image is processed into an image in Grayscale format. Then change the image to black and white format. This image is a binary image, which is an image that has a value of 0 for black and a value of 1 for white [16]. The next stage is Otsu Thresholding Segmentation. If interpreted more deeply, Image Segmentation is the division of the image area based on the criteria for the similarity or homogeneity of the

region, the similarity of certain criteria and the gray level of one pixel with another pixel [17].

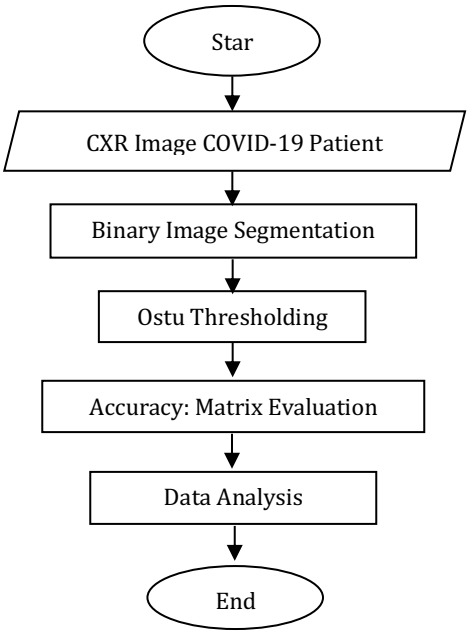

Figure 1. Experiments Procedure

Image segmentation used in this research is Otsu Thresholding. This Otsu Thresholding method performs the image segmentation process using a threshold value instantly by changing the gray color image to black and white, the comparison factor is the color threshold value of the digital pixel image [18]. The threshold value is obtained from a gray level image called k, k has a value less than or equal to one to L [19]. The total value of L is 255 [20]. The probability of each i-level pixel can be obtained by:

$$P_i = \frac{n_1}{N} \quad (1)$$

where n_1 is the number of i-level pixels and N is the total number of pixels in the image. The value of the First Comulative moment, Zeroth value and the total average value can be expressed by [21]:

$$\omega(k) = \sum_{i=0}^{k} P_i \quad (2)$$

$$\mu(k) = \sum_{i=0}^{k} i.P_i \quad (3)$$

$$\mu_T(k) = \sum_{i=0}^{L-1} i.P_i \quad (4)$$

The threshold value of k can be obtained by maximizing the following equation:

$$\sigma_B^2(k^*) = max\sigma_B^2(k) \quad (5)$$

where:

$$\sigma_B^2(k) = \frac{[\mu_T\omega(k) - \mu(k)]^2}{\omega(k)[1-\omega(k)]} \quad (6)$$

The next stage is the metric evaluation process. There are three important criteria in the process of evaluating this metric, namely accuracy, sensitivity and specificity [6]. However, in this study only the accuracy value is shown. Accuracy is obtained by using the formula [22]:

$$Accuracy = \frac{TP + TN}{TP + FN + TN + FN} \quad (6)$$

where TP, FP, TN and FN given in Equation (6) represent the number of True Positive, False Positive, True Negative and False Negative . This value is the difference in pixels between the grayscale image and the binary image.

3. Result and Discussion

The original image and the results of Otsu Thresholding segmentation on the CXR of COVID-19 patients aged 20-50 years are shown in Figure 2. The left image is the original CXR image and the right is the CXR image segmented using the Otsu Thresholding method. The image shows the presence of GGO (Ground Glass Opacities) or more commonly known as pneumonia spots, which are mostly found in the lower lung area. Spots of pneumonia are mostly only found in one area of the lung (right or left only). This indicates that the SARS-CoV-2 virus infecting the lungs of patients aged 20-50 years is relatively not too severe. In a study conducted

by Borghesi et al. revealed that patients with COVID-19 with this age group had an average x-ray lung image score of 2.5 on a scale of 0-8.5. This means that the lung damage experienced is not too severe [23].

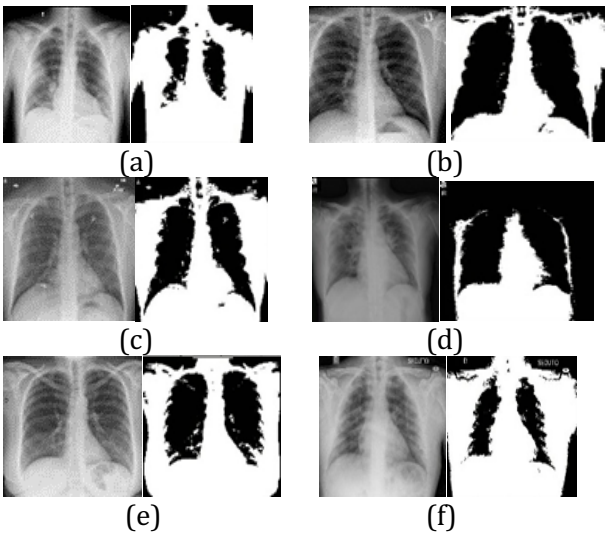

Figure 2. Original CXR image (left) and results of Otsu Thresholding segmentation (right) in COVID-19 patients aged at (a) 27 years, (b) 35 years, (c) 35 years, (d) 42 years, (e) 46 years, and (f) 45 years old

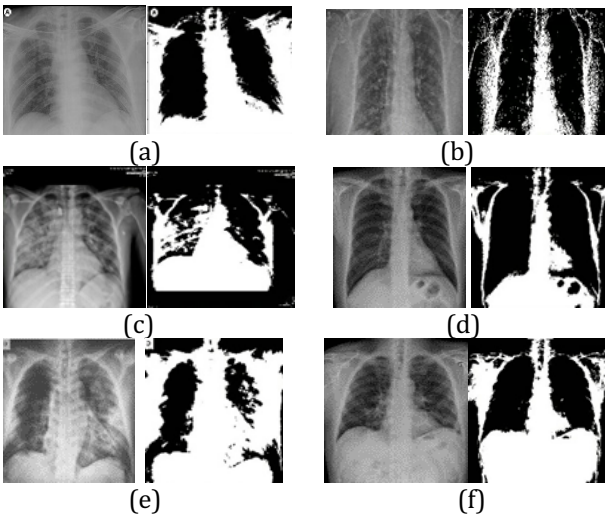

Figure 3. Original CXR image (left) and Otsu Thresholding segmentation image in COVID-19 patients aged at (a) 54 years, (b) 56 years, (c) 58 years, (d) 62 years, (e) 65 years, and (f) 67 years old

The results of the Otsu Thresholding segmentation in COVID-19 patients aged 50-70 years are shown in Figure 3. The image shows that there are many pneumonia spots on both sides of the lungs. Spots of pneumonia are mostly found in the lower part of the lungs. Previous studies conducted in this age range of patients exhibited COVID-19 typical pulmonary findings at the upper or lower margin of the scan, most commonly peripheral ground-glass opacity, followed by consolidation [24]. This characteristic is seen in the results of the Otsu Thresholding segmentation in COVID-19 patients aged 50-70 years.

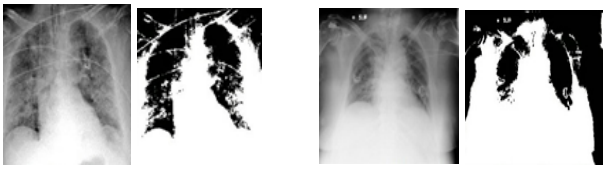

Figure 4. Original CXR image (left) and Otsu Thresholding segmentation image in COVID-19 patients aged at (a) 75 years, and (b) 78 years old

Figure 4 is the original CXR image and the results of the Otsu Thresholding segmentation in COVID-19 patients aged over 70 years. The image shows a lot of pneumonia. Almost all parts of the lungs on both sides there are patches of pneumonia. Borghesi et al revealed in a previous study that COVID-19 patients with an age range of 50-70 years and above had severe lung damage with an image score of 8 on a scale of 0-12 [23]. The results of another study conducted by Siagian also stated that the group of elderly men was a group at high risk of being infected with the COVID-19 virus [25].

CXR image segmentation in COVID-19 patients using the Otsu Thresholding method produces images that are easier to analyze. This is shown by the image of COVID-19 patients who have a lot of typical pneumonia spots, especially in patients aged 50-70 years and over. This means that patients infected with COVID-19 aged 50-70 years are more susceptible to damage to the lungs. As stated by Osturk et al.

[26] that on CXR images of patients with COVID-19 often found: Ground-glass opacities (GGO) which are areas with increased weakness in the lungs (often also referred to as pneumonia spots), merging of air spaces in the lungs, bronchovascular thickening and bronchiectasis traction.

Table 1. Accuracy of Otsu Thresholding segmentation results

No	Age (years)	Accuracy (%)
1.	27	96.42
2.	35	96.42
3.	35	94.52
4.	42	95.52
5.	46	97.60
6.	45	90.47
7.	50	90.47
8.	52	98.14
9	54	93.79
10	55	96.80
11	56	93.75
12	58	93.75
13	59	98.57
14	62	95.93
15	65	97.60
16	67	93.18
17	69	93.18
18	70	98.58
19	75	95.62
20	78	97.60
Average		95.18

It has been revealed that the type of Corona virus pneumonia attacks adults, especially people over 50 years old, regardless of gender differences [27], In addition, COVID-19 mostly attacks the middle aged and above [28]. While the majority of younger COVID-19 patients have milder cases [29]. Similar findings were also revealed by other researchers that COVID-19 patients aged at >60 years old had a higher rate of respiratory failure and required longer treatment than those aged at <60 years old [14]. These findings are in accordance with the results obtained in this study

The accuracy of the CXR image segmentation of COVID-19 patients using Otsu Thresholding is shown in Table 1. This accuracy is used to measure the percentage of the right segmented area. A good segmentation method will produce a high accuracy value. A low accuracy value indicates the dominant background area covers the main object [12]. The average accuracy of 95.18% indicates that the image is well segmented.

4. Conclusion

Image segmentation has been carried out on COVID-19 patients using the Otsu Thresholding method based on age differences. The results of CXR image segmentation based on age range show that COVID-19 infection in patients aged 50-70 years and over causes severe damage to the lungs. The Otsu Threshoding method can perform the segmentation process well with an average accuracy value of 95.18%.

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