Lung X-ray Image Similarity Analysis Using RGB Pixel Comparison Method

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ABSTRACT

The high death rate caused by pneumonia and Covid-19 is still quite high. Based on data released by WHO, 14% of deaths in children under 5 years old are caused by pneumonia. One of the processes carried out to help the diagnosis process is to look at lung images using X-Ray images. To obtain information about normal lung X-Ray images, Pneumonia and Covid-19, calculations are carried out using the color difference in each pixel of the X-ray image. The calculation process will provide output in the form of numbers in units of 0 to 100. This is done to facilitate the process of identifying the similarity of each X-Ray image being compared. The research stages are carried out with stages starting from adjusting the image size, then by breaking down the pixel values of the two images being compared and the process of calculating the difference in value from each pixel with the same coordinates. After calculating a combination of 30,000 combinations using 300 x-ray images, the results obtained in the form of the level of similarity between normal x-ray images and pneumonia x-ray images are the highest with a similarity percentage of 80.06%. The combination of normal images and pneumonia images is 10,000 combinations using 100 normal x-ray images and 100 pneumonia x-ray images. Normal x-ray images and covid x-ray images have a similarity of 79.18%. The combination of normal images and covid images is 10,000 combinations. The combination uses 100 normal x-ray images and 100 covid x-ray images. Pneumonia x-ray images and covid x-ray images have the lowest similarity level of 78.87%. The combination of pneumonia x-ray images and covid x-ray images is 10,000 combinations. The data used in the combination are 100 pneumonia images and 100 covid images. From the test results, the information obtained was that Accuracy was worth 0.54, Precision was worth 0.54, Recall was worth 0.59 and F1-score was worth 0.56.

I. Introduction

Based on WHO data in 2019, pneumonia cases caused around 740,180 (14%) cases of death in children under 5 years. Pneumonia is the biggest cause of death in toddlers in Indonesia, estimated in 2018 around 19,000 children died. The decline began to occur in the last 5 years in 2020-2023. The provinces with the highest coverage of pneumonia findings in toddlers are West Papua (75%), DKI Jakarta (72.4%), and Bali (71.6%)[1], [2].

Since the first COVID-19 case was announced in Indonesia on March 2, 2020, to December 30, 2023, there have been 6,821,940 confirmed cases. In 2023, the number of confirmed cases was 101,978 cases, with the highest number of confirmed cases reported from DKI Jakarta Province (35,608), West Java (21,483), and East Java (12,715)[3]. It can be seen that the positive number of Pneumonia and Covid is still quite high, this is also followed by the high number of deaths caused by Pneumonia and Covid[4].

Health care in the medical field is certainly a fairly important priority in the health sector. The service process can be in the form of prevention efforts, diagnosis and ongoing care[5]. The right treatment and prevention process is expected to reduce cases of death in toddlers. One of the processes carried out to help the diagnosis process is to view lung images using X-Ray images. The similarity analysis process is carried out to determine the percentage value of similarity of each condition, be it normal, Pneumonia, and Covid-19[6], [7], [8], [9], [10], [11]. With the calculation of similarity, it is hoped that it will make it easier to identify Pneumonia symptoms and recognize its characteristics .

II. METHOD

A. Research Stages

The research stages are carried out in several stages starting from the image size adjustment process, then continued by breaking down the pixel values of the two images being compared. The next stage is the process of calculating the difference in value from each pixel with the same coordinates. This is done to ensure that pixels with the same coordinates are compared with pixels from the same coordinates in the comparison image.

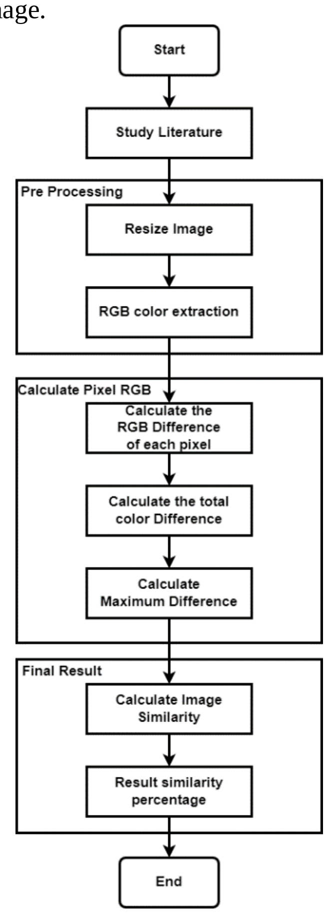

Figure 1. Research Methodology

B. Study Literature

Pneumonia and Covid-19

Pneumonia is an acute infection that attacks the tissue in the lungs (alveoli) which can be caused by microorganisms such as bacteria, viruses, fungi and parasites[12], [13], [14], [15], [16]. Coronavirus disease (Covid-19) is an infectious disease caused by a newly discovered type of coronavirus, namely Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)[17], [18], [19], [20], [21], [22], [23].

RGB Color Range

The RGB color range is a color range consisting of 3 primary colors, namely R (Red), G (Green) and B (Blue). These three primary colors form other colors in an image[24]. An image can have different colors depending on the composition of the values of each color. Each color has a value between 0 and 255[25], [26], [27]. The lowest value of the RGB color composition is black with a value composition of rgb(0, 0, 0) and the maximum value is white with a value composition of rgb(255, 255, 255)[28].

X-ray image

X-ray images are images produced from the image capture process carried out using X-ray radiation[29]. The images produced from the x-ray process are 2-dimensional images. To obtain information about normal lung X-Ray images, Pneumonia and Covid-19, calculations are carried out using the color difference in each pixel of the X-ray image. The calculation process will provide output in the form of numbers in units of 0 to 100. This is done to facilitate the process of identifying the similarity of each X-Ray image being compared[30].

C. Image Size Adjustment

Image size adjustment is done to ensure that both images have the same size. The image adjustment process uses the max Width = 100px and max Height = 100px. This process also aims to ensure that the computation/calculation process does not take too long. The maximum pixel value of an image calculated in this process is 30,000 data. The equation (1) used is as follows:

$$total\ pixel\ Width\ x\ total\ pixel\ Height\ x\ 3\ (nilai\ RGB) \tag{1}$$

Information:
total pixel width = Width of the adjusted X-ray image in pixels
total pixel Height = Length of the adjusted X-ray image in pixels
3 (RGB value) = R, G, and B values, where each has a value of 1

From equation (1) the following values are produced:

$$100\ x\ 100\ x\ 3$$

From equation (1) we also get the maximum pixel value calculated as 30,000 data.

D. RGB Color Extraction

The next stage is to break down the pixel values in an image. The breaking process is done by taking the RGB value at each pixel coordinate[31]. The coordinates start from the smallest value X0, Y0 to the largest value x99, Y99. Each color R, G, B each has a smallest value of 0 to a maximum of 255[32], [33]. Figure 2 shows the process of extracting RGB values from an image.

Figure 2. The process of extracting RGB values in pixels

E. Calculate RGB Difference of Each Image Pixel

The method used to calculate the comparison between the first and second images is done by calculating the color difference of each pixel in an image. The pixels whose differences are calculated are pixel R (Red), pixel G (green) and pixel B (Blue), and each pixel is compared according to its coordinate point[34]. The equation used looks like equation (2) below:

$$\begin{aligned} Beda\ R &= R_1 - R_2 \\ Beda\ G &= G_1 - G_2 \\ Beda\ B &= B_1 - B_2 \end{aligned} \quad (2)$$

Information:
Difference R = Difference in red pixel values (Red)
Difference G = Difference in green pixel values (Green)
Difference B = Difference in blue pixel values (Blue)
R1 = Red pixel value of image 1
G1 = Green pixel value of image 1
B1 = Blue pixel value of image 1
R2 = Red pixel value of image 2
G2 = Green pixel value of image 2
B2 = Blue pixel value of image 2

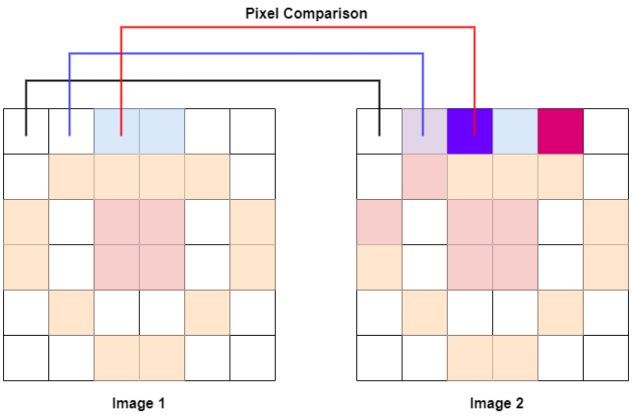

Figure 3. Compared image pixels

The pixels compared between image 1 and image 2 must have the same X and Y coordinate points. The pixels compared start from coordinates 0.0 to 100.100. The process of calculating the RGB value of each pixel being compared looks like the following image 3.

F. Calculate Total Color Difference

The next step is to calculate the total difference in color differences. All colors that have been calculated for their color differences are then calculated for their total color differences with the following equation(3):

$$Beda\ RGB = \sum (Beda\ R + Beda\ G + Beda\ B) \quad (3)$$

Information:
RGB Difference = Difference in red, green, blue pixel values (Red, Green, Blue)
Difference R = Difference in red pixel values (Red)
Difference G = Difference in green pixel values (Green)
Difference B = Difference in blue pixel values (Blue)

G. Calculate Maximum Difference

The similarity calculation process is carried out by calculating the maximum difference to measure the maximum value of the difference between the first and second images[35], [36]. The equations used include the following, equation(4):

$$Maksimal\ Perbedaan = Total\ Piksel \times 3 \times 255 \quad (4)$$

H. Calculate Image Similarity

The last step is to calculate the overall similarity of the data in the image. This step is done so that the similarity of the image is displayed in percentage units. So that the verification and analysis process becomes easier. The equations used include the following. Equation (5):

$$Kemiripan = 100 - \left(\frac{Total\ Perbedaan}{Maksimal\ Perbedaan} \times 100\right) \quad (5)$$

III. RESULTS AND DISCUSSION

Algorithm testing in this study was carried out using a public dataset[37]. There are 3 labels in the dataset used, namely Normal, Pneumonia, Covid-19. The data taken from each label is 100 images and combined, where each image is combined with other images. So that it produces a total of 30,000 combined images. From the data owned, 3 combinations are produced as in equation (6) below:

$$C(n,r) = \frac{n!}{r! \times (n-r)!} = \frac{3!}{2! \times (3-3)!} = \frac{3 \times 2 \times 1}{2 \times 1 \times 1} = 3 \quad (6)$$

Information:
n = 3 (3 categories: Normal, Pneumonia, Covid-19)
r = 2 (choose 2 of 3 categories)

The combinations resulting from equation (6) include the following:

Normal - Pneumonia:

$$Kombinasi\ Normal - Pneumonia = 100 \times 100 = 10.000$$

Normal - Covid-19:

$$Kombinasi\ Normal - Covid - 19 = 100 \times 100 = 10.000$$

Pneumonia - Covid-19:

$$Kombinasi\ Pneumonia - Covid - 19 = 100 \times 100 = 10.000$$

Total Combination :

$$Total\ Kombinasi = 10.000 + 10.000 + 10.000 = 30.000$$

The mathematical equation of the combination of each pair (Normal-Pneumonia, Normal-Covid-19, Pneumonia-Covid-19) as a whole can be written as equation (7):

$$\text{Total} = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} N_i \times N_j \quad (7)$$

Information:
n = Total number of data categories n=3 (3 categories: Normal, Pneumonia, Covid-19)
i = Index for the first category in each pair
j = Index for the second category in each pair

$$Total = (N \times P) + (N \times C) + (P \times C)$$
$$Total = 100 \times 100 + 100 \times 100 + 100 \times 100$$
$$Total = 30.000$$

The calculation of the combination data from the three categories is as follows:

$$\text{Total} = C(3,2) \times (100 \times 100)$$
$$Total = 3 \times 10.000$$
$$Total = 30.000$$

This equation illustrates that we have 3 combinations of data pairs, and each combination produces 10,000 data, so the total is 30,000.

A. *Calculate Image Similarity per Pixel*

Image similarity calculation is done by comparing 2 images from 3 existing categories. The compared images will be calculated the value of each pixel in it. An example of 2 images being compared looks like the following image 4.

Figure 4. Compared X-ray images

The process of calculating the similarity of each pixel is done using equation (5). The calculation result data is displayed in a table to make it easier to analyze the data. The calculation result data of the similarity of each image pixel that has been done looks like table 1 below.

TABLE I
RESULTS OF IMAGE PIXEL SIMILARITY CALCULATIONS

No.	Location (X, Y)	RGB Image 1	RGB Image 2	Red Difference	Green Difference	Blue Difference	Similarity Per Pixel (%)
1	(0, 0)	R: 140, G: 140, B: 140	R: 7, G: 7, B: 7	133	133	133	47.84%
2	(1, 0)	R: 90, G: 90, B: 90	R: 4, G: 4, B: 4	86	86	86	66.27%
3	(2, 0)	R: 69, G: 69, B: 69	R: 4, G: 4, B: 4	65	65	65	74.51%
4	(3, 0)	R: 62, G: 62, B: 62	R: 4, G: 4, B: 4	58	58	58	77.25%
5	(4, 0)	R: 63, G: 63, B: 63	R: 4, G: 4, B: 4	59	59	59	76.86%
6	(5, 0)	R: 63, G: 63, B: 63	R: 4, G: 4, B: 4	59	59	59	76.86%
7	(6, 0)	R: 64, G: 64, B: 64	R: 4, G: 4, B: 4	60	60	60	76.47%
8	(7, 0)	R: 64, G: 64, B: 64	R: 4, G: 4, B: 4	60	60	60	76.47%
9	(8, 0)	R: 65, G: 65, B: 65	R: 4, G: 4, B: 4	61	61	61	76.08%
10	(9, 0)	R: 65, G: 65, B: 65	R: 4, G: 4, B: 4	61	61	61	76.08%
11	(10, 0)	R: 66, G: 66, B: 66	R: 4, G: 4, B: 4	62	62	62	75.69%

The data from table 1 is also displayed in graphical form, so that the highest and lowest similarity values of each pixel of the displayed image are visible. The graph is displayed in the form of a line as seen in Figure 5.

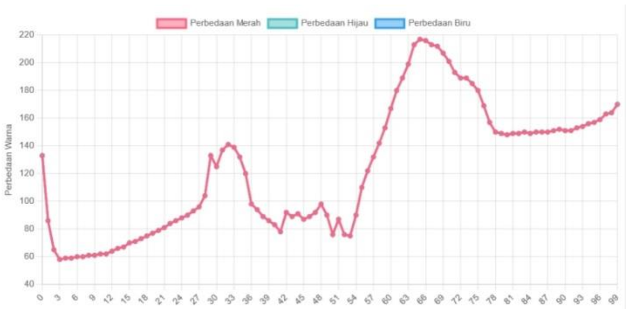

Figure 5. Similarity of RGB X-Ray values of image 1 and image 2.

A graph in the form of a bar chart is also displayed to determine the magnitude of the difference in R, G, and B values of each image pixel as seen in Figure 6.

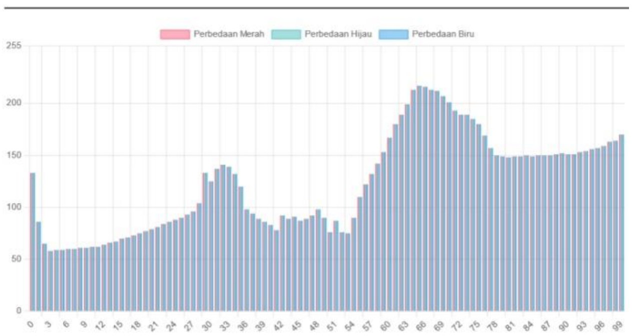

Figure 6. Similarity of RGB X-Ray values of image 1 and image 2 in the form of a bar graph.

The percentage graph of similarity of each pixel compared between image 1 and image 2 is shown in Figure 7 below.

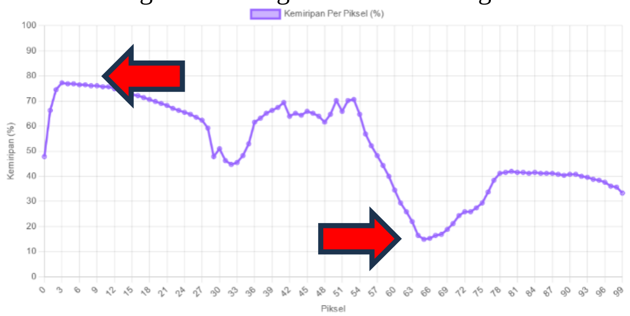

Figure 7. Highest and lowest values of image similarity.

From Figure 7, it can be seen that the highest similarity value is 77.3% and the lowest similarity value is 14.9%. This shows that there is data at certain coordinates that has a fairly high similarity. There is also data at other coordinates that has a fairly low level of similarity.

B. Image Similarity Calculation Results per Category

The results of the overall image calculation produced a similarity value with a value of 0 to 100. The higher the similarity value, the more similar the X-ray images being compared will be. The calculation results were carried out by comparing 1 image with a different category. Details of the similarity calculation carried out can be seen in table 2 below.

TABLE 2
RESULTS OF CALCULATING THE SIMILARITY OF EACH IMAGE

No	Category	Category	Image 1	Image 2	Similarities
1	normal	pneumonia	00000092_000.png	00015826_036.png	83.46%
2	normal	pneumonia	00000091_006.png	00015826_036.png	79.39%
3	normal	pneumonia	00000091_000.png	00015826_036.png	83.41%
4	normal	pneumonia	00000090_010.png	00015826_036.png	80.42%
5	normal	pneumonia	00000090_006.png	00015826_036.png	78.53%
6	covid	pneumonia	099.jpeg	00015826_036.png	83.95%
7	covid	pneumonia	098.jpeg	00015826_036.png	86.25%
8	covid	pneumonia	097.jpeg	00015826_036.png	83.93%
9	covid	pneumonia	096.jpeg	00015826_036.png	87.37%
10	covid	pneumonia	095.png	00015826_036.png	85.52%
11	covid	normal	099.jpeg	00000092_000.png	80.83%
12	covid	normal	098.jpeg	00000092_000.png	81.12%
13	covid	normal	097.jpeg	00000092_000.png	80.71%
14	covid	normal	096.jpeg	00000092_000.png	87.65%
15	covid	normal	095.png	00000092_000.png	84.05%

C. Final Result of Similarity Calculation

From the calculations that have been done with a total of 30,000 image data from the combination of 3 categories, the average value of the similarity of each combination is obtained. Details of the average similarity of each combination and the categories compared are shown in table 3.

TABLE 3
AVERAGE FINAL RESULTS OF X-RAY SIMILARITY BY CATEGORY

Category 1	Category 2	Comparative Data	Average Similarities
covid	normal	10,000	79.18 %
covid	pneumonia	10,000	78.87 %
normal	pneumonia	10,000	80.06 %

D. Algorithm performance evaluation matrix

An analysis was conducted to test the performance of the algorithm used. The researcher took the highest average similarity value of 80% from table 3 as the threshold value. The parameters used to determine the prediction value of the threshold are as follows:

If the similarity ≥ 80%, then the pair is considered similar (prediction 1).

If the similarity <80%, then it is considered not similar (prediction 0).

The classification process is based on categories, namely:

normal vs normal (label: 1).
normal vs covid (label: 0).
normal vs pneumonia (label: 0).
covid vs covid (label: 1).
covid vs pneumonia (label: 0).
pneumonia vs pneumonia (label: 1).

From determining the threshold value and classification based on categories, the parameters for the evaluation matrix[38], [39] are obtained as follows.

TP (True Positives): Similar predictions (1), and the same category (1).

FP (False Positives): Similar predictions (1), and different categories (0).

TN (True Negatives): Predictions are not similar (0), and categories are different (0).

FN (False Negatives): Predictions are not similar (0 and categories are the same (1).

TABEL 3
IMAGE TEST RESULST

Image 1	Image 2	Class Image 1	Class Image 2	Similarity (%)	Predicted Label	TP	FP	TN	FN
00000002_000.png	00000165_001.png	Normal	Pneumonia	79,58	0	0	0	1	0
00000002_000.png	00000218_001.png	Normal	Pneumonia	89,44	1	0	1	0	0
00000002_000.png	00000499_008.png	Normal	Pneumonia	79,12	0	0	0	1	0
00000002_000.png	00000583_045.png	Normal	Pneumonia	76,88	0	0	0	1	0
00000002_000.png	00000893_000.png	Normal	Pneumonia	66,06	0	0	0	1	0
00000002_000.png	001.jpeg	Normal	COVID	81,87	1	0	1	0	0
00000002_000.png	002.jpeg	Normal	COVID	84,43	1	0	1	0	0
00000002_000.png	003.jpeg	Normal	COVID	85,17	1	0	1	0	0
00000002_000.png	004.jpeg	Normal	COVID	84,15	1	0	1	0	0
00000002_000.png	005.jpeg	Normal	COVID	77,21	0	0	0	1	0
001.jpeg	00000165_001.png	COVID	Pneumonia	77,8	0	0	0	1	0
001.jpeg	00000218_001.png	COVID	Pneumonia	85,53	1	0	1	0	0
001.jpeg	00000499_008.png	COVID	Pneumonia	80,91	1	0	1	0	0
001.jpeg	00000583_045.png	COVID	Pneumonia	79,16	0	0	0	1	0
001.jpeg	00000893_000.png	COVID	Pneumonia	73,95	0	0	0	1	0

From the tests carried out in table 3, the final results of the algorithm performance test matrix were obtained as shown in table 4 below.

TABEL 4
MATRIX EVALUATION

Metric	Value
Accuracy	0,54
Precision	0,54
Recall	0,59
F1-score	0,56

IV. CONCLUSION

After calculating a combination of 30,000 combinations using 300 x-ray images, the results obtained were the highest level of similarity between normal x-ray images and pneumonia x-ray images with a similarity percentage of 80.06%. The combination of normal images and pneumonia images is 10,000 combinations using 100 normal x-ray images and 100 pneumonia x-ray images. Normal x-ray images and covid x-ray images have a similarity of 79.18%. The combination of normal images and covid images is 10,000 combinations. The combination uses 100 normal x-ray images and 100 covid x-ray images. Pneumonia x-ray images and covid x-ray images have the lowest level of similarity of 78.87%. The combination of pneumonia x-ray images and covid x-ray images is 10,000 combinations. The data used in the combination are 100 pneumonia images and 100 covid-19 images. From the algorithm performance evaluation matrix, the information obtained was that Accuracy was worth 0.54, Precision was worth 0.54, Recall was worth 0.59 and F1-score was worth 0.56.

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