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Analysis of RGB range value on fingernail image for detecting diabetes mellitus risk

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ABSTRACT

Introduction: Fingernail has various colors related to the organ's body condition, such as the pancreas, indicated by diabetes mellitus. The study aims to determine and compare the RGB range value on the fingernail image to detect diabetes mellitus risk in fasting and non-fasting conditions.
Methods: The study was a true experimental study using fasting and non-fasting respondents. Data were obtained by blood glucose level testing and fingernail image capturing. The result of blood glucose levels was classified into normal, prediabetes, or diabetes, and fingernail images were followed according to their categories. The histogram determined the RGB values of fingernail images, and calculated the maximum value of color intensity based on the height peak appeared. The distribution frequency of each group was used to get a range of RGB fingernail images in each category.
Results: Based on the results, it showed a comparison of RGB range value between fasting and non-fasting condition, including range value differences in red and blue, but any slightly overlapped in green range value. In a future study, we will use ordinal logistic regression to determine the prediction program of diabetes mellitus risk. Furthermore, we will develop a program by adding some features to improve the analysis system of the fingernail image for diabetes mellitus risk detection.
Conclusion: There was a comparison of RGB range value on fingernail image between fasting and non-fasting condition.

Keywords: diabetes mellitus, RGB, Fingernail image, blood glucose, color feature.
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INTRODUCTION

The nail could be used as a healthcare diagnosis to detect disease by identifying its color. When fingernail has dominant pink color defined as a "healthy", but another color defined as a "sick". The faded color of the nail could be identified as anemia, heart failure, malnutrition, and liver disease. White color on the nail with dark edges is a sign of liver disease such as hepatitis. The yellow color on the nail indicates a fungus infection, thyroid disease, lung disease, diabetes, or psoriasis. While blue color on the nail indicates pneumonia or heart abnormalities.[1] Any change in the color of nails could not be detected using human eyes due to insensitivity to realize small changes in characteristics such as intensity, color, or texture of the object. Therefore, an efficient and effective image segmentation method is needed to gather information from images.

The image segmentation is initial and most important in image analysis to gather necessary information. Image pixels are grouped according to any characteristic of the image.[2,3] Image analysis will be focused on gathering information according to color information. Image analysis will be focused on gathering information according to color information. As for color information, color space is a mathematical model to represent color information as three or four different color components.[4] One of the color spaces was RGB color space. Three-dimensional Cartesian coordinate systems represent RGB color space by three values red, green, and blue. RGB color space representation is addictive in nature.[5] RGB color space is selected because the simplicity of image-based feature extraction is adequately acceptable, low complexity in computation, and effective in characterizing the distribution of color in an image.[6]

The study has focused on nail color information that could be used to detect diabetes mellitus risk. Hyperglycemia is a typical sign of diabetes mellitus due to blood glucose exceeding the normal range (over 200 mg/dl). World Health Organization (WHO) predicts an increase in the number of people with diabetes mellitus, one of the global health threats. WHO predicts an increase in diabetes mellitus patients in Indonesia from 8.4 million in 2000 to around 21.3 million in 2030. This report shows that the number of people with diabetes mellitus is 2-3 times in 2035. Whereas the International Diabetes Federation (IDF) predicts an increase in the number of people with diabetes mellitus in Indonesia from 9.1 million in 2014 it became 14.1 million in 2035.[7]

Some researchers have studied early detection of diabetes mellitus by using image color such as iris structure for predicting human health, which is mentioned as iridology. Dr. Bernard Jensen's Chart of Iris is shown that pancreas activity was shown on Iris in right eyes at direction 07.15 – 07.45 hour.[8,9] Pancreas abnormalities could be indicated by diabetes mellitus. But, the other researcher used energy rates of fingernails image to predict Pancreas condition. Pancreas condition could be predicted in the third step on the right fingernails and the sixth

step on the left fingernails. When those steps have a depletion of energy rate, it might be a suspect of diabetes mellitus.[10] Researchers have been conducted on the fingernail. Fingernail could be used for biometric authentication. Fingernail shows a high degree of distinctiveness, even in the case of identical twins or even between different fingernails of an individual.[11]

This study used fingernail images that were taken by a digital camera. The image would be classified into two categories. The first category was a condition of the respondent when retrieval data was carried out such as fasting condition and non-fasting condition. The second category was grouping based on the blood glucose levels of the respondent at that time. According to International Diabetes Federation, blood glucose levels were divided into three groups such as normal, prediabetes, and diabetes.[7] Because of two conditions of the respondent, data provided in six groups data i.e. fasting condition consist of normal data, prediabetes data, and diabetes data, otherwise not fasting condition consist of normal data, prediabetes data, and diabetes data.

The study aims to determine and compare RGB range value on fingernail images to detect diabetes mellitus risk on fasting and non-fasting conditions. The study is preliminary research about fingernail image analysis based on RGB color to detect Diabetes Mellitus risk and still need to develop various features to gain the quality program as Diabetes Mellitus risk detection.

METHODS

Study Design

The study was a true experimental study with a cross-sectional design. Respondents total was 165 respondents with 1650 captured fingernail images. There were four stages conducted, including blood glucose level testing of fasting and non-fasting respondents and categorizing data into normal, prediabetes, and diabetes according to fasting and non-fasting conditions, capturing fingernail images of respondents, determining RGB value, and analyzing data.

Data Collection

Blood glucose levels were obtained using Point of Care Testing (POCT) methods, detailing materials, namely Autocheck strip glucose, Autocheck GCU 3 in 1, auto click set, alcohol swab, blood lancet, and sterile cotton. The method of obtaining blood glucose levels consists of some steps. The first step was wiping the finger's location that will be drawn with an alcohol swab. The second step was wiping the finger with sterile dry cotton. The third step was putting the blood lancet to auto click. The fourth step was taking a blood sample. The fifth step was to place the strip to the auto-check POCT, which was followed by dropping the blood sample to the end of the auto-check strip. Blood glucose levels data were categorized based on International Diabetes Federation. On non-fasting conditions, normal status is shown by blood glucose levels below 90 mmol / L, prediabetes status is shown when blood glucose levels are between 90 mmol / L until 199 mmol / L, and diabetes status was shown when blood glucose levels are above 200 mmol / L. Meanwhile, on fasting condition, blood glucose levels below 90 mmol / L are included in normal status, blood glucose levels around 90 mmol / L until 99 mmol / L are included in Prediabetes status and above 100 mmol / L is included in diabetes status.[7]

In the second stage, fingernail images were taken by digital camera with a toolbox as a place for fingernail images captured. The toolbox was designed with a lighting source inside, which was considered for getting clear images. A camera place was provided on the top side to take a picture. The third stage, RGB determination obtained by using a MATLAB program. Each image was imported to the algorithm until a red, green, and blue histogram were achieved. RGB histogram could describe maximum intensity color according to peak height.

Data Analysis

The fourth stage was statistically analyzed by grouping frequency distribution to determine the RGB range value. Grouping frequency distribution is a method to provide grouping categories when the range of data was too large and more than one unit in width. Number data was classified into symbol *n*; class number data was classified into *k* equivalence as *Struges' formula* in Equation 1. The maximum value (*t*) was followed by the minimum value (*r*) and class interval was counted by using equation 2. Afterward, grouping data was determined according to suitable data classes, and the class with the highest number showed the range of R, G, B values.[12]

$$k = 1 + 3.3 \log n \quad (1)$$

$$i = (t-r) / k \quad (2)$$

RESULTS

Fingernail Images

Data in this research was fingernail images. Data was obtained from digital camera of the fingernail. The total of images was 1650. Data have inclusion criteria such as free from the presence of fingernail dyes and clear images like non-blurred images, no failure texture nail due to ages or trauma. After the inclusion process, data is reduced to 1516 images. Data were divided into fasting conditions image and non-fasting conditions image based on the respondent's condition while the image is taken. Data on fasting conditions about 661 images consist of 390 images as normal data, 171 images as prediabetes data, and 100 images as diabetes data. Data images on non-fasting conditions about 885 images consist of 362 images as normal data, 385 as prediabetes data, and 108 as diabetes data. Data fingernail images are shown in Figure 1.

Determination of RGB Value

This step has aim to obtain the determination of the RGB value. The program is built using MATLAB script. The interface of MATLAB program is shown in Figure 2. Figure 2 shows three interfaces: red histogram data, green histogram data, and blue histogram data. There were six buttons, two images, and one table in each interface. Six tables were open button, reset button, process button, save histogram button, save table button, and exit button. The open button has a function to open or retrieve images stored on the computer for processing in the program. The reset button works for resets or clears the display of images, histograms, and tables in the GUI so that the program is ready reused for the next image. The

process button is the button used to determine the image's histogram that gives rise to the histogram and histogram data on the table. The save histogram button is a button to save histogram into the device, while the save table button is a button to save the table in program into device as excel file. The last button, the exit button, is used to exit the program if the process has been completed have done it.

The output of program was red histogram, green histogram, and blue histogram. All histogram is shown in Figure 3. Based on Figure 3, the RGB histogram consists of x-axis representing color intensity from 0 to 255 and the y-axis represented the frequency of image intensity. The highest frequency was determined by paying attention to the peak of the histogram and ignoring the frequency of color intensity about 255 due to it was known as a background image, white color. RGB histogram could not accurately determine intensity with the highest frequency of each color. Therefore, it needs to export RGB histogram data to table data. Afterward, RGB table data was used to determine intensity with the highest frequency by utilizing the maximum function in the table with intensity from 0 to 254. Furthermore, recap data was needed to analyze statically at the next stages.

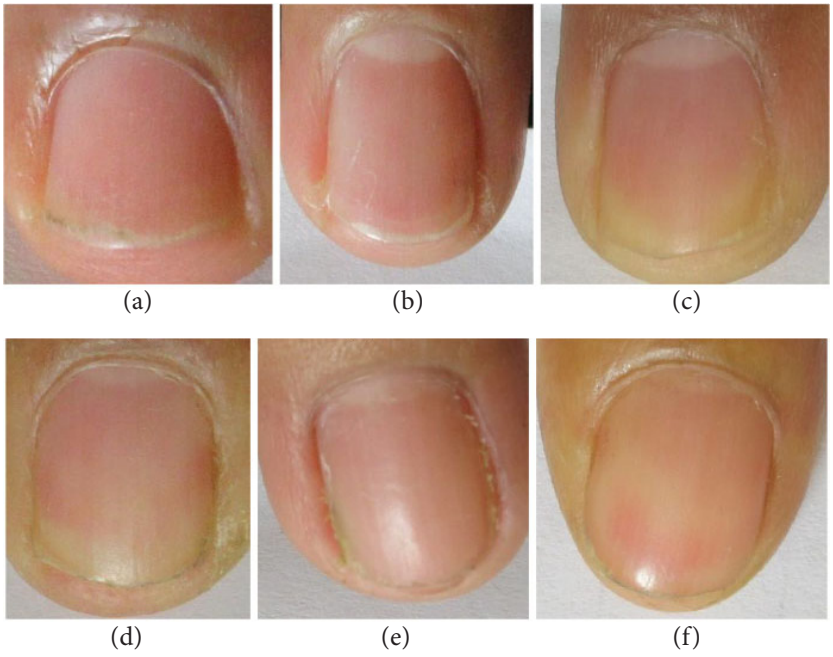


Figure 1. Image of fingernail in fasting condition (a) normal data (b) prediabetes data (c) diabetes data and not fasting condition (d) normal data (e) prediabetes data (f) diabetes data.

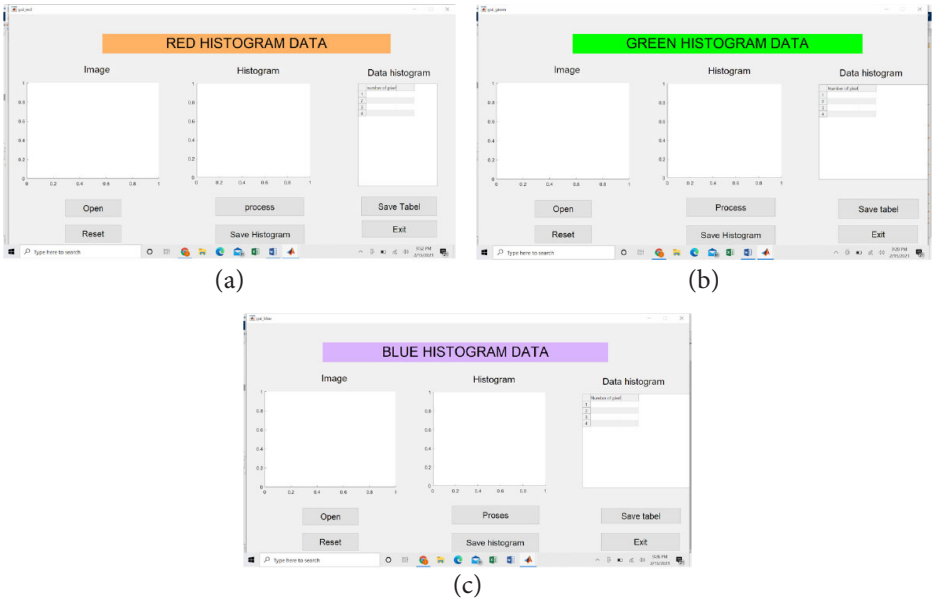


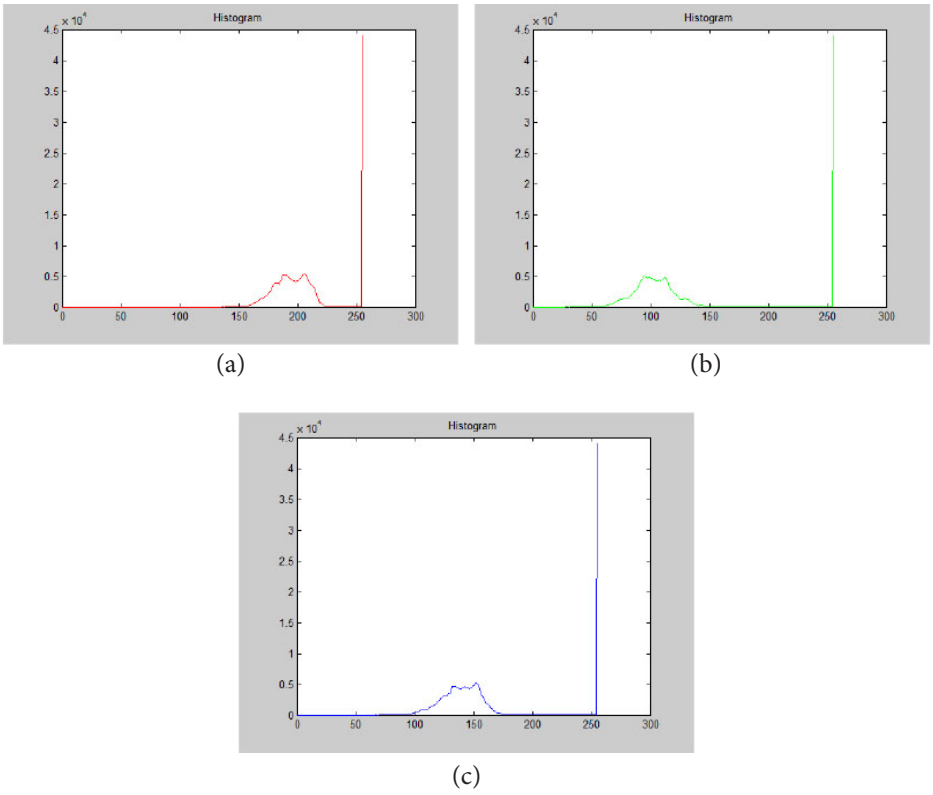
Figure 2. The interface of program (a) red histogram data, (b) green histogram data, (c) blue histogram data.

Data in this research consist of two types: data in fasting condition and data in non-fasting condition. In fasting condition, Analysis process of grouping frequency RGB components in all categories were shown in Table 1. The process was begun by determining the data number in n, maximum, and minimum values. By using Equation 1 and Equation 2, number and interval class could be determined. Therefore, RGB range value could be obtained and seen in Figure 4. Based on Figure 4 showed that any overlapped intensity data in all color components. Red component had overlapped intensity in all categories at 152-160. Green component had overlapped intensity at 103-113 in all categories. Meanwhile the blue component had overlapped intensity only in normal and prediabetes data, particularly at 17-30. The comparison in RGB components showed that any slightly different among data in fasting condition.

In non-fasting condition, Analysis results of RGB components in fingernail image of non-fasting respondents were successively shown in Table 2. Meanwhile, the RGB intensity graph comparison in all categories was shown in Figure 5 which explained any overlapping data in all color components. Red components overlapped data at 170-181, green components overlapped intensity at 100-119, and blue components overlapped intensity at 97-110.

For the second comparison of RGB range value between on the same color and same category in the different conditions is shown in Figure 6, Figure 7 and Figure 8. Figure 6 and Figure 7 shows that there was different range in red and blue on normal data and prediabetes data. But in green color, there was overlapping in color

intensity of 107 – 119 on normal data and 103-114 on prediabetes data. And for diabetes data, in red color, there was different range of value between diabetes data on fasting and not fasting condition. But in green color and blue color, there was overlapping around 100-113 for green and 93- 99 for blue.



(a) (b) (c)

Figure 3. RGB histogram of fingernail images. (a) red histogram, (b)green histogram, (c) blue histogram.

Table 1. Analysis data in fasting condition.

Detail	Component of RGB		
	red	green	Blue
Normal data			
Number of data (n)		390	
Number of class (k)		9.5 ≈ 10	
Maximum value	230	181	165
Minimum value	52	18	0
Interval class	18,73 ≈ 19	17,1 ≈ 17	17,3 ≈ 17
Range of value	146 - 164	103 - 119	17 – 33
Prediabetes data			
Number of data (n)		171	
Number of class (k)		9	
Maximum value	211	177	153
Minimum value	62	25	15
Interval class	17,8 ≈ 18	18,1 ≈ 18	16,4 ≈ 16
Range of value	152 - 169	97 - 114	15 – 30
Diabetes data			
Number of data (n)		100	
Number of class (k)		7,6 ≈ 8	
Maximum value	201	158	146
Minimum value	81	24	10
Interval class	15,7 ≈ 16	17,6 ≈ 18	17,9 ≈ 18
Range of value	145 - 160	96 – 113	82 - 99

DISCUSSION

According to all comparisons between fasting and non-fasting condition, data were showing that red, green, and blue (RGB) in fingernail images had a relation with diabetes mellitus even though any overlapped in several categories. According to this study, in fasting conditions and non-fasting conditions, the overlapping intensity data can be found in all color components. Overlapping data happened due to several factors such as enlighten power in data retrieval procedure and unclear nails condition of respondents. Lighting also gave effect to image captured reflection.[13]

According to Kurniastuti (2019), overlapping in RGB may be occurred due to lighting intensity that affects the image of fingernails so it might change the quality of fingernails' color. The RGB consists of three primary colors, which also represent brightness. The brightness might be changed if the surroundings light changes as well.[14]

This research could be a preliminary study about fingernail image as early detection of diabetes mellitus risk. This research also proves that color features especially RGB could be used as a feature in the next research like classification fingernail image as detection diabetes mellitus risk. Diabetes Mellitus risk detection based on RGB color analysis on fingernail image was still not optimum due to any overlapped RGB intensity in several categories. Therefore, it needs to develop by adding some feature of the fingernail image.

CONCLUSION

In conclusion, fingernail images can be extracted into RGB color space as information of the image. RGB range value consists of two conditions such as fasting condition and non-fasting condition. RGB range value on fasting condition showed that normal data consist of red color intensity around 146-164, green color intensity around 103 - 119, blue color intensity around 17-33, prediabetes data consisted of red color

intensity around 152-169, the green color intensity around 97-114, the blue color around 15-30, diabetes data consisted of red color intensity around 145-160, the green color intensity around 96-113, the blue color intensity around 82-99. RGB value on non-fasting condition showed that normal data consisted of red color intensity around 165-183, the green color intensity around 107-129, the blue color around 97-117, prediabetes data consisted of red color intensity around 170-185, green color intensity around 103-123, blue color intensity around 90-110, diabetes consisted of red color intensity around 160-181, green color intensity around 100-119, blue color intensity around 93-113. The comparison of RGB range value between fasting and non-fasting condition were including range value differences in red and blue, but any slightly overlapped

Figure 4. Comparison graph of RGB components on nail images of fasting respondents (a) red (b) green (c) blue.

Figure 5. Comparison graph of RGB component in non-fasting conditions (a) red (b) green (c) blue.

Figure 6. comparison graph of RGB in normal data of fasting and not fasting condition (a) red (b) green (c) blue.

Figure 7. comparison graph of RGB in prediabetes data of fasting and not fasting condition (a) red (b) green (c) blue.

(a) (b) (c)

Figure 8. Comparison graph of RGB in diabetes data of fasting and not fasting condition (a) red (b) green (c) blue.

Table 2. Analysis data in non-fasting condition.

Detail	Component of RGB		
	red	green	Blue
Normal data			
Number of data (n)		362	
Number of class (k)		9.6 ≈ 10	
Maximum value	247	229	214
Minimum value	70	15	13
Interval class	18,7 ≈ 19	22,6 ≈ 23	21,2 ≈ 21
Range of value	165 - 183	107 - 129	97 - 117
Prediabetes data			
Number of data (n)		385	
Number of class (k)		9,6 ≈ 10	
Maximum value	241	219	204
Minimum value	90	19	6
Interval class	15,8 ≈ 16	20,9 ≈ 21	20,8 ≈ 21
Range of value	170 - 185	103 – 123	90 – 110
Diabetes data			
Number of data (n)		108	
Number of class (k)		7,7 ≈ 8	
Maximum value	241	210	190
Minimum value	118	60	30
Interval class	15,9 ≈ 16	20	21
Range of value	160 - 181	100 – 119	93 - 113

in green range value. Future studies with better study design are required to obtain further explanation and minimize the study limitations about the topics.

DISCLOSURE

Author Contribution

All authors have contributed to this research process, including conception and design, analysis and interpretation of the data, drafting of the article, critical revision of the article for important intellectual content, final approval of the article, collection and assembly of data.

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Conflict of Interest

Threre is no conflict of interest for this manuscript.

Ethical Consideration

This research was approved by the Health Research Ethics Committee of Economy Business and Digital Technology Department, Universitas Nahdlatul Ulama Surabaya. Letter of exemption Ref. No. 241/EC.KEPK/UNUSA/2020.

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