Automated color classification of urine dipstick image in urine examination

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Abstract. Urine examination using urine dipstick has long been used to determine the health status of a person. The economical and convenient use of urine dipstick is one of the reasons urine dipstick is still used to check people health status. The real-life implementation of urine dipstick is done manually, in general, that is by comparing it with the reference color visually. This resulted perception differences in the color reading of the examination results. In this research, authors used a scanner to obtain the urine dipstick color image. The use of scanner can be one of the solutions in reading the result of urine dipstick because the light produced is consistent. A method is required to overcome the problems of urine dipstick color matching and the test reference color that have been conducted manually. The method proposed by authors is Euclidean Distance, Otsu along with RGB color feature extraction method to match the colors on the urine dipstick with the standard reference color of urine examination. The result shows that the proposed approach was able to classify the colors on a urine dipstick with an accuracy of 95.45%. The accuracy of color classification on urine dipstick against the standard reference color is influenced by the level of scanner resolution used, the higher the scanner resolution level, the higher the accuracy.

1. Introduction

Health is one of the essential essences of human life. Performing an early examination of the symptoms of an illness that appears is recommended to receive proper medical treatment from the medical staff, especially. The result of initial examination of the symptoms of an illness considerably affects the subsequent doctor action against a patient. Therefore, precise and accurate of an early examination result is needed in order to obtain the right result of early diagnosis or screening test.

The symptoms of an illness can be detected through various examinations performed on the body or from the results of human excretion such as examination through urine called urinalysis.

Urinalysis is an integral part of the early evaluation of kidney disease and urinary tract infections [1]. Urine examination using urine dipstick is performed to determine some chemical substances contained in the urine like proteins, glucose, ketones, hemoglobin, bilirubin, urobilinogen, acetone, nitrites, and leucocytes as well as pH testing and its density [2].

Urine examination using dipstick urine can be accomplished by matching the color change on the reagent paper that has been dipped into the urine sample with the standard color chart of urine
examination. This is done to determine the level of elements content contained in the urine [3]. Color matching between reagent papers and standard color chart of urine examination is still done manually using the eyes, causing differences in color perception that may affect urine examination results using a urine dipstick.

In this research, Euclidean Distance is proposed to resolve differences in color perception that occurs in urine examination using a dipstick urine, i.e., at the time of performing color matching between reagent paper with a standard color chart of urine examination.

2. Problem identification
Content test of chemical elements in the urine examination using a urine dipstick has been used by doctors and health practitioners as a screening test (early diagnosis) to determine the potential of the disease suffered by a person before further testing. The result of urine examination using urine dipstick is still read manually using naked eyes by comparing reagent paper with a standard color chart of urine examination. This resulted perception differences in the color reading of the examination results. Therefore, an approach to classifying the color on the urine dipstick image is required so that the results of urine examination become more accurate.

3. Previous research
Several other types of research are talking about digital image processing on urine dipstick. For example, research conducted by Wijaya (2013) which discussed the color blend of Sa*b* elements on urine dipstick analysis of smartphone camera images using Backpropagation neural network. The color blend of Sa*b* elements is a combination of the color space of HSV and La* b*. Backpropagation neural network was used to obtain the most optimal value for each unit of the Sa * b * value. From the test results conducted on the color blend of Sa * b * elements on urine dipstick analysis of the smartphone camera images using Backpropagation neural network has proven to produce a better level of color matching accuracy compared to the color space of La*b* optimized and HSV [4].

Next research was conducted by Shanty (2014) using color interpretation method of urine dipstick test results in quantitative and qualitative methods. Stepwise linear interpolation with color distance trigonometric approach has proposed a method to determine the proportional position of test data. The proposed method can be used to assess the substance of test data quantitatively. Qualitative assessment of the test data is performed by initializing threshold with a round to nearest and round to down from a proportional position of specified test data. The research used the images of the smartphone camera [5]. Another study was conducted by Selvarasu (2010) using Euclidean Distance to calculate the proximity of RGB colors on the thermal image of the skin temperature or thermographic [6].

4. Methodology
The proposed method to conduct the color classification of urine dipstick images in this research consists of several steps. The steps are as follows: image acquisition of urine dipstick using scanner; image cropping; RGB feature extraction for color images; Otsu threshold for textured images; and Euclidean Distance calculation. After all the steps are performed, will obtain the color classification result of urine dipstick image. The general architecture of this system can be seen in Fig 1.

4.1. Image Acquisition
Image acquisition is the initial step to obtain digital images. Image acquisition is performed to achieve the desired image so that can be prepared in the next step. In this step, digital image acquisition will be performed on urine dipstick that has been dipped into a urine sample using a scanner with a resolution of 4800 x 1200 dpi and stored in a joint photographic group (.jpg) format.
4.2. Dataset

4.2.1. Urine dipstick image. Dataset used in this research is urine dipstick images that have been dipped into 120 urine sample from the General Hospital Haji Medan. The scanning result of urine dipstick images used in this research can be seen in Fig 2 and Fig 3.

4.2.2. Color chart of urine dipstick. Color chart of urine dipstick is a chart that contains information in the form of urine examination indicator, rine examination time and the value of urine examination indicator that is interpreted in colors to be used as a reference for the urine examination using urine dipstick [7]. Color chart of urine dipstick can be seen in Fig 4.
4.3. **Image pre-processing**

Image pre-processing is a process performed to prepare the images before to be processed in further image processing. In this research, the image pre-processing performed is image cutting or cropping. Image pre-processing is a process performed to prepare the images before to be processed in further image processing. In this research, the image pre-processing performed is image cutting or cropping.

4.3.1. **Cropping.** Urine dipstick image required for the next step is the part attached to the celluloid pad. For that the bottom of the urine dipstick is discarded since it is not needed for the following process. Cropping result of urine dipstick image can be seen in Fig 5.

4.4. **RGB color feature extraction**

RGB color feature extraction step is performed to obtain the characteristic of the color of inputted urine dipstick images so that the result of the feature extraction can be compared with the reference data. Steps performed in RGB color feature extraction for this research are as follows:

1) Determine each of the three values of red, green and blue that most appear in a single urban dipstick indicator.
After the three most common RGB values are specified, then the mean value of each RGB value will be determined [9]. To determine the mean of the RGB value is used equation 1 to equation 3 as follows:

\[
R = \frac{R_1 + R_2 + R_3}{3} \quad (1)
\]
\[
G = \frac{G_1 + G_2 + G_3}{3} \quad (2)
\]
\[
B = \frac{B_1 + B_2 + B_3}{3} \quad (3)
\]

The result of the calculation using equation 1 to equation 3 obtained a new RGB value which is the mean of the RGB value of the inputted image. This RGB value will be set as the RGB value to be equal to the reference image.

4.5. Otsu Threshold

Usually, universal thresholding will convert a grayscale image into a black and white image [10]. However, we used Otsu thresholding in this case to distinguished blood spots. Otsu method in this research was used for blood indicator with values of 5-10 and 50 Ery / μL. Because in the blood indicator, there are dots that indicate the presence of blood spots on the urine sample examined. Otsu method used in this research will separate the foreground and background of the blood indicator image. Where the dots in the image of blood indicator are defined as the foreground and are white, while the background of the image is black. Otsu method is applied to the blood indicator image with values of 5-10, and 50 Ery / μL can be seen in Figure 6 and Figure 7.

![Figure 6. indicator with values of 5-10 and 50 Ery / μL.](image)

![Figure 7. The result of Otsu method on blood indicator image with values of 5-10.](image)

Calculation of foreground and background areas can be calculated using equation 4 below.

\[
L = \frac{\text{Foreground area}}{\text{background area}} \times 100\% \quad (4)
\]

4.6. Classification using Euclidean Distance

After feature extraction on urine dipstick urine image performed, the next step is classification. Classification using Euclidean Distance is performed by matching the color distance using the calculation of red, green and blue (RGB) color-coded differences in the corresponding pixel. Then the distance difference is calculated using Euclidean distance equation as in the following equation 5 [8].

\[
d_{xy} = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 + (x_3 - y_3)^2 + \cdots + (x_n - y_n)^2} \quad (5)
\]

After calculating Euclidean Distance using equation 5 is performed, then will obtain the smallest RGB value difference. The RGB value with the smallest difference is the value closest to the RGB value of the reference color.
5. Result and analysis
The testing is performed to determine the ability of the system in color classification of urine dipstick image. System testing was done with 120 urine samples. Urine samples used in this research were obtained from RSU Haji Medan.

5.1. Urine dipstick image testing
In the system testing process, the thing that affects the classification result of urine dipstick image is the resolution of the scanner tool used when scanning the image. Testing was performed by using two different scanner resolutions which are 4800 x 1200 dpi and 600 x 600 dpi.

The result of the accuracy of each urine examination indicator using 4800x1200 dpi scanner can be seen in Table 1.

**Table 1. Image testing accuracy using 4800 X 1200 dpi scanner**

| No. | Indicator | Testing result | Accuracy rate (%) |
|-----|-----------|----------------|-------------------|
|     |           | Succeed | Failed |                        |
| 1   | LEU       | 119     | 1      | 99                       |
| 2   | NIT       | 120     | 0      | 100                      |
| 3   | URO       | 118     | 2      | 98                       |
| 4   | PRO       | 101     | 19     | 84                       |
| 5   | pH        | 119     | 1      | 99                       |
| 6   | BLO       | 119     | 1      | 99                       |
| 7   | SG        | 120     | 0      | 100                      |
| 8   | KET       | 117     | 3      | 97.5                     |
| 9   | BIL       | 113     | 7      | 94                       |
| 10  | GLU       | 119     | 1      | 99                       |

From Table 1 can be calculated the average accuracy rate in classifying the data resulted from urine examination using the proposed method using equation 6 as follows:

\[
\bar{\lambda} = \frac{99+100+98+99+99+100+97.5+94+99}{10} = 95.45\%
\]

(6)

5.2. Image testing with lower scanner resolution
The lower scanner resolution used to test the image in this research is 600 x 600 dpi. The test was performed using ten urine samples taken at a lower resolution. Based on the image testing, the accuracy rate of each urine examination indicator can be seen in Table 2.

**Table 2. Image testing accuracy using 600 X 600 dpi scanner**

| No. | Indicator | Testing result | Accuracy rate (%) |
|-----|-----------|----------------|-------------------|
|     |           | Succeed | Failed |                        |
| 1   | LEU       | 9       | 1      | 90                       |
| 2   | NIT       | 9       | 1      | 90                       |
| 3   | URO       | 9       | 1      | 90                       |
| 4   | PRO       | 6       | 4      | 60                       |
| 5   | pH        | 10      | 0      | 100                      |
| 6   | BLO       | 9       | 1      | 90                       |
| 7   | SG        | 8       | 2      | 80                       |
5.3. Textured image (blood indicator) testing
We used urine samples with artificial blood spots for image testing for blood indicator. This resulted due to the unavailability of urine samples that has blood spots to be tested. The test using samples with artificial blood spotting is performed only to determine the ability of the proposed Otsu method to classify the textured image that existed in blood indicator. Testing result of textured images for blood indicator can be seen in Table 3 below.

| No | Image name | Blood image | Otsu image | Result (Ery/µL) | Notes |
|----|------------|-------------|------------|----------------|-------|
| 1  | DUT1       | ![Blood image](image1) | ![Otsu image](image2) | 5-10 | Succeed |
| 2  | DUT2       | ![Blood image](image3) | ![Otsu image](image4) | 5-10 | Succeed |
| 3  | DUT3       | ![Blood image](image5) | ![Otsu image](image6) | 50   | Succeed |

The test result performed in Table 3 shows that the Otsu method proposed in this research was able to classify the textured image on the blood indicator into 5-10 and 50 Ery/µL values.

6. Conclusion and future research
Based on the system testing of color classification on urine dipstick images, obtained several conclusions which are the proposed method in this research is able to classify the color of urine dipstick images to determine the concentration level of chemical elements in urine samples tested. Resolution on the scanner used when taking urine dipstick images can affect the result of image classification. The accuracy rate using the images taken by a scanner with 4800 x 1200 is higher at 95.45%, compared to images taken by a scanner with lower resolution that is at 83%.

Further research can perform the process of image cropping on urine dipstick image automatically so that the urine dipstick image can be directly processed to the next step. In order to improve the analysis result of the color similarity on the digital image can be applied methods of measuring distance between other colors.

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