# Examination Results of Leukocytes and Nitrites in the Early Detection of Urinary Tract Infection

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***Abstract*— A general issue for clinical medicine is whether to treat asymptomatic patients who present with bacteria in their urine. Because of increasing antimicrobial resistance, it is important not to treat patients with asymptomatic bacteriuria unless there is evidence of potential benefit. For this purpose, a urinalysis dipstick reagent color acquisition is important, mainly for leukocytes esterase and nitrites reagent which can be an indicator for early detection of Urinary Tract Infection (UTI). Smartphone camera can be used to help people interpreting reagent colors, rather than using expensive instrument that can only be used by professionals.**

***To accomplish that goal a system that can interpret reagent colors and can be installed on smartphone is needed. One of the main issue in developing this system is what color space and method are used, so the values extracted can represent color in the dipstick for further process to obtain reliable result . Reagent detection and acquisition system uses CIELab color space and Stepwise Linear Interpolation based method to measure the level of leukocytes esterase and nitrites reagent in urine.**

***Experimental result proves that Stepwise Linear Interpolation can determine reagent level of nitrite and leukocytes. But, black white calibration can't representing light calibration so data master can't be applied. And in some situation, a further experiment is needed for producing reliable method for determining reagent level which are not represented in the color chart.***

**Keywords— Leukocyte, Nitrite, Urinalysis**

## I. Introduction

Urinary tract infection (UTI) is an infection caused by the presence and growth of microorganisms anywhere in the urinary tract [1,2]. This infection can spread to other organs, making this disease quite dangerous. Urine culture still remains the gold standard for diagnosis of UTI. Unfortunately, appropriate investigations necessary for the diagnosis of urinary tract infection are not available in many health facilities [3]. Dipstick test is one of the qualitative diagnostic method used to detect UTI and have the advantage of being easy to perform, reliable, and can be performed in primary care giving facilities and result can be obtained immediately [4].

Dipstick reading machine has been widely used by clinical laboratories as a means to replace visual interpretation. The tool can significantly reduce reading errors caused by differences in the perception of the influence of the lighting and color in every human being. On the online trading site, dipstick reader engine reaches $ 3,000 per unit. This price is too expensive. On the other hand, check up on laboratory examination requires a high cost, so we made this application in order to support the daily control of the substance level result in the urine.

A color space is all possible color that can be made from group of colorants. Red and green can make yellow. If we reduce the green, yellow will become orange. If we add blue, the orange will become less saturated and more whitish. It is also possible to mix color with other color spaces like HSV, HSL, etc. But each color space has different strong and weakness in representing color. Determining what color space used is crucial in dipstick analysis because level in dipstick is represented by different color. A very slight error in choosing value of color can result a failure in which system interpreting another dipstick level.

In this research, we perform leukocytes and nitrite testing to determine what method and color space that can be used to interpret reagents value from dipstick image. Every color space was tested using Stepwise Linear Interpolation method to measure reagents value [5].

## II. METHODOLOGY

### A. Specimen collection

To reduce the risk of contamination, patients were instructed to wash their hands and sample taken were midstream urine samples.

The samples were collected using glass bottles, processed in the laboratory within 2 hours of collection and samples that were not processed within 2 hours were kept refrigerated at 4°C until it was processed.

### B. Scenario Taking Pictures

Further process after acquiring specimen can be seen in steps below:

1. Provided dipstick Urit 11g, chart color reagent, and urine
2. Set chart and dipstick in accordance with the template
3. Done taking photos with adequate lighting

4. Users perform crop on reagent or chart that required

Example of photo taken in step 3 can be seen in Fig 1. The photo captured using a 21MP camera.


Fig. 1. Example of photo taken with adequate lighting

### C. *Image Preprocessing*

Homogenization process was conducted by taking the mode of image RGB. This score is a color representation of a whole dipstick or chart reagent. Because the value will vary for each image reagents that taken, it is necessary to establish calibration RGB values by specifying the RGB value of the maximum and minimum in the image as the maximum value and the minimum black and white were obtained from the average of all four black and white photos. The value will be transformed into an RGB value with range from 0 to 255 so that each image reagent will have the same standards.

### D. *Color space transformation from RGB to CIELAB*

CIELAB color space is needed because it is more suited to the eye assessment [6]. From RGB value, system will transform it into a CIELAB color space. The conversion from RGB color values into CIE LAB components is implemented by converting from nonlinear RGB space into linear RGB space first, then into CIE XYZ space, and finally into CIE LAB space [7]. A system using linear interpolation to transform RGB into CIE LAB can be found in paper [8].

### E. *Color space transformation from RGB to HSV*

HSV color space distinguishes color with hue, saturation, and value (brightness). We use HSV color space value as comparison to LAB value because leukocyte has linear color level. We also extract each value in hue, saturation, and value and present it as single color space. A system to transform RGB into HSV can be found in paper [9].

### F. *Reagent Score Assessment*

Leukocyte has 4 levels for positive values and 1 level for negative value. Nitrite has 1 level for positive value and 1 level for negative value. For nitrite reagent we use Stepwise Linear Interpolation with index at last level because nitrite only has two levels. Calculation and algorithm with Euclidean Distance and Stepwise Linear Interpolation described as follows :

1. Calculate the distance between the reference data, as well as the distance between the test data with reference data, using Euclidean distance as in formula

$$\Delta E^*_{ab} = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2} \quad (1)$$

2. Find the node from data references that has the shortest distance to the test data. Variable index represents where the node is located.

   a. If the index-1 is 0, then the node is in the first level. Denote the index variable as the node "B" and the variable index + 1 as node "C", shown by Fig 2.

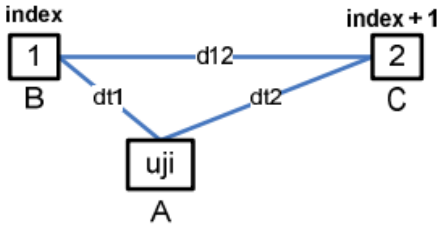


Fig. 2. Index at first level

Proceed to step 3.

   b. If the index + 1 has more value than the amount of reference data in a reagent, means the node is at the last level. Denote the index variable as node "C" and the variable index – 1 as the node "B", as shown by Fig 3.

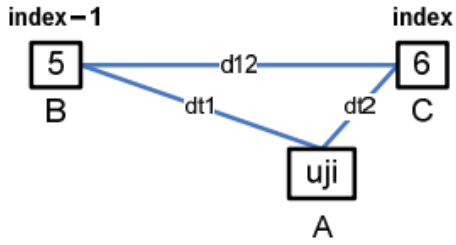


Fig. 3. Index at last level

Proceed to step 3.

   c. If not both, then the node is between two nodes. Illustrations shown by Fig 4.

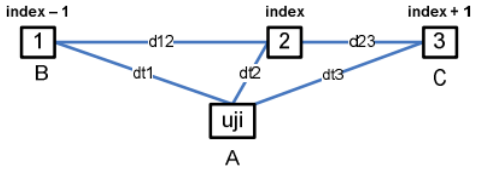


Fig. 4. Index between two levels

Proceed to step 4.

3. If the distance between the test data to the node "B" is longer than the distance between the node "B" and the

node “C”, and the distance between the test data to the node “C” is longer than the distance between the node “B” to the node “C “, then do the assessment of test data as a data outlier. Proceed to step 5.

4. Calculate the distance between the test data to the node index – 1 and the distance of the test data to index + 1. Find the shortest distance and record the node.

5. Determine the method of interpretation in accordance with the reagents being processed.

# III. Result And Analysis

## *A. Interpretation of Leukocytes substance*

We perform transformation to several color spaces to determine what color space performs better to interpret value for leukocyte. Our hypothesis is using HSV because the HSV space usually performs better to distinguish linear color level. The color spaces we tested are HSV, HSL, LAB, RGB, and Gray. We also testing every value of H, S, V, S, and L. Result value for every color level can be seen in Table 1. We took 36 data from 36 patients in total. Table 1 to Table 4 presents 1 data randomly taken from our 36 data.

Table 1. Result values for RGB, LAB, HSV, HSL, Gray color spaces (Leukocyte)

| | *Dipstick* | Chart 0 | Chart 1 | Chart 2 | Chart 3 | Chart 4 |
|---|---|---|---|---|---|---|
| R | 41 | 109 | 104 | 99 | 83 | 66 |
| G | 26 | 114 | 93 | 80 | 66 | 46 |
| B | 33 | 90 | 81 | 71 | 66 | 45 |
| L | 11.4 | 47.0 | 40.1 | 35.6 | 29.7 | 21.2 |
| A | 8.8 | -6.4 | 2.2 | 6.3 | 7.3 | 9.0 |
| B | -1.8 | 12.6 | 8.5 | 8.2 | 2.7 | 4.2 |
| H | 332 | 73 | 31 | 19 | 0 | 3 |
| S | 37 | 21 | 22 | 28 | 20 | 32 |
| V | 16 | 45 | 41 | 39 | 33 | 26 |
| H | 332 | 73 | 31 | 19 | 0 | 3 |
| S | 22 | 12 | 12 | 16 | 11 | 19 |
| L | 13 | 40 | 36 | 33 | 29 | 22 |
| Gray | 113.63 | 33.42 | 20.41 | 18.83 | 9.76 | 14.55 |

Table 2 shows value for Euclidean distance from reagent to every chart levels. Euclidean distance used for every color space.

Table 2. Distance between reagent to color chart

| | Chart 0 | Chart 1 | Chart 2 | Chart 3 | Chart 4 |
|---|---|---|---|---|---|
| RGB | 124.9 | 103.7 | 87.8 | 66.7 | 34.1 |
| LAB | 41.3 | 31.2 | 26.4 | 18.9 | 11.5 |
| HSV | 261.1 | 302.4 | 313.9 | 332.8 | 329.1 |
| HSV (H) | 259 | 301 | 313 | 332 | 329 |
| HSV (S) | 16 | 15 | 9 | 17 | 5 |
| HSV (V) | 29 | 25 | 23 | 17 | 10 |
| HSL | 260.5 | 302.0 | 313.6 | 332.5 | 329.1 |
| HSL (S) | 10 | 10 | 6 | 11 | 3 |
| HSL (L) | 27 | 23 | 20 | 16 | 9 |
| Grayscale | 80.2 | 93.2 | 94.7 | 103.8 | 99.0 |

After getting every value for every color space tested, we use Stepwise Linear Interpolation for determining the reagent level. The result can be seen in Table 3 and Table 4.

Table 3. Comparation between method result and dipstick reader

| | Method Result | Dipstick Reader | TRUE/FALSE |
|---|---|---|---|
| RGB | 4 | 4 | TRUE |
| LAB | 4 | 4 | TRUE |
| HSV | 0 | 4 | FALSE |
| HSV (H) | 0 | 4 | FALSE |
| HSV (S) | 4 | 4 | TRUE |
| HSV (V) | 4 | 4 | TRUE |
| HSL | 0 | 4 | FALSE |
| HSL (S) | 4 | 4 | TRUE |
| HSL (L) | 4 | 4 | TRUE |
| Grayscale | 0 | 4 | FALSE |

Table 4. Distance between two closest color

| | Chart 0 - 1 | Chart 1 - 2 | Chart 2 - 3 | Chart 3 – 4 |
|---|---|---|---|---|
| RGB | 23.38 | 17.146 | 21.840 | 33.615 |
| LAB | 11.83 | 6.1169 | 8.1668 | 8.8145 |
| HSV | 42.20 | 13.564 | 21.470 | 14.212 |
| HSV (H) | 42 | 12 | 19 | 3 |
| HSV (S) | 1 | 6 | 8 | 12 |
| HSV (V) | 4 | 2 | 6 | 7 |
| HSL | 42.19 | 13 | 20.049 | 11.045 |
| HSL (S) | 0 | 4 | 5 | 8 |
| HSL (L) | 4 | 3 | 4 | 7 |
| Grayscale | 13.00 | 1.5808 | 9.0701 | 4.7947 |

Table 5. Accuracy of each color space when tested at 36 data

| | Amount of data | Amount of correct data | Accuracy |
|---|---|---|---|
| RGB | 36 | 16 | 44% |
| LAB | 36 | 30 | 83% |
| HSV | 36 | 15 | 42% |
| HSV (H) | 36 | 14 | 39% |
| HSV (S) | 36 | 6 | 17% |
| HSV (V) | 36 | 13 | 36% |
| HSL | 36 | 15 | 42% |
| HSL (S) | 36 | 5 | 14% |
| HSL (L) | 36 | 13 | 36% |
| Grayscale | 36 | 18 | 50% |

We use two scoring method to earn more reliable result. We took accuracy and sensitivity/ specificity of 36

data compared with dipstick reader as gold truth. Accuracy is evaluated to determine which color space performed better. Sensitivity and specificity are evaluated for determining whether the data obtained have enough variety. From Table 5, we can see that LAB color space has highest accuracy from any other color spaces.

Table 6. Sensitivity and specificity of each color space when tested at 36 data

| | Sensitivity (%) | Specificity (%) |
|---|---|---|
| RGB | 36.37 | 71.42 |
| LAB | 71.42 | 90.91 |
| HSV | 42.86 | 80 |
| HSV (H) | 42.10 | 76.47 |
| HSV (S) | 20.69 | 14.29 |
| HSV (V) | 26.32 | 58.82 |
| HSL | 42.86 | 80 |
| HSL (S) | 17.86 | 12.5 |
| HSL (L) | 26.09 | 53.85 |
| Grayscale | 57.14 | 72.41 |

*B. Interpretation of Nitrite substance*

For nitrite reagent our hypothesis is LAB color chart performs better than any other color space. Value of each color space can be seen in Table 7.

Table 7. Result values for RGB, LAB, HSV, HSL, Gray color spaces (Nitrite)

| | *Dipstick* | Chart 0 | Chart 1 |
|---|---|---|---|
| R | 123 | 152 | 150 |
| G | 26 | 154 | 141 |
| B | 75 | 133 | 134 |
| L | 28.00097887 | 62.91080888 | 59.20963086 |
| A | 44.86103052 | -4.54199146 | 2.074704176 |
| B | -4.98673284 | 10.78857236 | 4.922268592 |
| H | 330 | 66 | 26 |
| S | 79 | 14 | 11 |
| V | 48 | 60 | 59 |
| H | 330 | 66 | 26 |
| S | 65 | 9 | 7 |
| L | 29 | 56 | 56 |
| Gray | 140.098 | 31.3944 | 18.2644 |

Table 8 shows Euclidean distance value from reagent to respective color chart levels. Nitrite only has two levels, which is white and any pink coloration for positive level.

Table 8. Distance between reagent to color chart

| | Chart 0 | Chart 1 |
|---|---|---|
| RGB | 143.4886 | 132.0416 |
| LAB | 62.51571 | 53.87799 |
| HSV | 272.1488 | 311.7065 |
| HSV (H) | 264 | 304 |
| HSV (S) | 65 | 68 |
| HSV (V) | 12 | 11 |
| HSL | 271.2213 | 310.6589 |
| HSL (S) | 56 | 58 |
| HSL (L) | 27 | 27 |
| Grayscale | 108.7036 | 121.8336 |

After getting every value for every color space tested, we use Stepwise Linear Interpolation for determining the reagent level. The result can be seen in Table 9 and Table 10.

Table 9. Comparation between method result and dipstick reader

| | Method Result | Dipstick Reader | True/False |
|---|---|---|---|
| RGB | 1 | 1 | TRUE |
| LAB | 1 | 1 | TRUE |
| HSV | 0 | 1 | FALSE |
| HSV (H) | 0 | 1 | FALSE |
| HSV (S) | 0 | 1 | FALSE |
| HSV (V) | 1 | 1 | TRUE |
| HSL | 0 | 1 | FALSE |
| HSL (S) | 0 | 1 | FALSE |
| HSL (L) | 0 | 1 | FALSE |
| Grayscale | 0 | 1 | FALSE |

Table 10. Distance between two closest color chart

| | Chart 0 - 1 |
|---|---|
| RGB | 13.19090596 |
| LAB | 9.586078441 |
| HSV | 40.1248053 |
| HSV (H) | 40 |
| HSV (S) | 3 |
| HSV (V) | 1 |
| HSL | 40.04996879 |
| HSL (S) | 2 |
| HSL (L) | 0 |
| Grayscale | 13.13 |

Table 11. Accuracy of each color space when tested at 36 data

| | Amount of data | Amount of correct data | Accuracy |
|---|---|---|---|
| RGB | 36 | 26 | 72% |
| LAB | 36 | 36 | 100% |
| HSV | 36 | 17 | 47% |
| HSV (H) | 36 | 14 | 39% |
| HSV (S) | 36 | 20 | 56% |
| HSV (V) | 36 | 25 | 69% |
| HSL | 36 | 15 | 42% |
| HSL (S) | 36 | 20 | 56% |
| HSL (L) | 36 | 15 | 42% |
| Grayscale | 36 | 22 | 61% |

We use two scoring method to earn more reliable result. We took accuracy and sensitivity/ specificity of 36 data

compared with dipstick reader as gold truth. Accuracy is evaluated to determine which color space performed better. Sensitivity and specificity are evaluated for determining whether the data obtained have enough variety.

Table 12. Sensitivity and specificity of each color space when tested at 36 data

| | Sensitivity (%) | Specificity (%) |
|---|---|---|
| RGB | 88.89 | 96.30 |
| LAB | 100 | 100 |
| HSV | 33.33 | 77.78 |
| HSV (H) | 23.08 | 73.91 |
| HSV (S) | 0 | 74.29 |
| HSV (V) | 66.67 | 88.89 |
| HSL | 25 | 75 |
| HSL (S) | 0 | 74.29 |
| HSL (L) | 20 | 71.42 |
| Grayscale | 75 | 81.25 |

# IV. Conclusion

Positive value in nitrite indicated by pink color is difficult to achieve because the color distance between white and pink somewhat is close. Better algorithm to distinguish any pink color from white can be proposed. For leukocytes the proposed algorithm performed well, although it is still hard to recognize spotted reagent box. For leukocytes and nitrites, CIELAB color space which is suited better for eye assessment was performed better than any other color space..

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