Classification Of Rice Leaf Color Into Leaf Color Chart Using LAB Color Space

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Abstract

Leaf Color Chart (LCC) is a measurement tool that can be used to measure the color intensity of rice leaves. The function of these measurements is to find out how many doses of fertilizer are needed by rice plants. However, readings made by human vision have a high level of subjectivity and risk of error. Therefore we need a method that can minimize errors and the level of subjectivity. One method that can be done is to classify the green color of rice leaves using LAB color space. Rice leaf image taken using a smartphone device is then extracted in RGB format. The color is then converted to LAB color space and then compared to the standard green color in the LCC. The comparison results are then used to classify the colors. The testing results show that the method has the value of accuracy, average precision, and average recall of 54.74%, 54.44%, and 51.16% respectively. Therefore the method can only classify correctly half of the data testing.

Keywords— *classification, LAB color space, Leaf Color Chart, rice leaf*

1. INTRODUCTION

Optimization of rice crop yields is a must for rice farmers to make their crops meet their needs. This is important to do especially in areas where the main food is rice such as Indonesia [1]. This optimization can certainly be done by maintaining the quality of rice plants so that during the planting period it remains in its best condition. One effort to achieve this is to provide fertilizer to rice plants at the right dose or under the conditions of growth.

The fertilizer needs for rice plants varies for each growth condition. One consideration is the need for the Nitrogen (N) element in these rice plants. If Nitrogen needs are met, rice tends to grow well. But on the contrary, if Nitrogen is not met, rice usually will grow abnormally and even die [2].

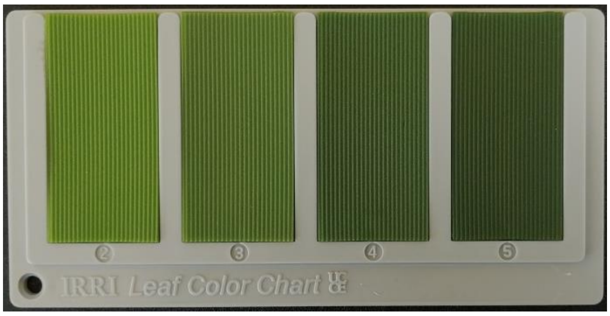

Figure 1. Leaf Color Chart

To find out the condition of the nitrogen element in rice, farmers usually use green color on rice leaves as an indicator. Nitrogen-deficient rice plants are usually followed by a reduction in the green color of the leaves [2]. Thus the gradation of green color on rice leaves can indicate the conditions of nitrogen demand in these plants.

Gradation of leaf green that shows the condition of Nitrogen content in rice plants has been standardized. The standardization is in the form of a measuring instrument called the Leaf Color Chart (LCC). This measuring instrument was developed by Furuya since 1987 in the form of 4 green leaf panels with different intensities [3]. This tool has been used by many countries in measuring Nitrogen levels in plants.

In the 4-panel of LCC (Figure 1), the leaf green intensity is grouped into 4 color levels. The lightest green color is placed on panel number 2, while the darkest one is placed on panel number 5. The color of rice leaves is measured as green which is between level 2-3, level 3-4, or level 4-5. From these measurements, farmers can estimate the fertilizer dosage requirements that must be given following the established standards.

However, measurements using LCC relying solely on human eye vision have a high degree of subjectivity and the potential for reading errors. Therefore, researchers try to use computer vision to reduce the level of subjectivity and reading errors. Several methods related to measuring leaf color into the LCC by utilizing digital devices have also been carried out.

Intaravanne and Sumriddetchkajorn [4] proposed the Color Visibility Index (CV) method to measure the intensity of leaf green color. In this method, the RGB value of the measured leaf image is compared to the reference color, which is the white color of the paper used as the background while capturing the leaf image. The CV value is obtained by calculating the average percentage comparison of the leaf image RGB value with the reference color RGB value. The CV value of the leaf image is then compared with the CV value of each LCC panel to detect the color level.

Adhiwibawa, et al [5] proposed an improvement in the CV method called the Enhance Color Visibility Index (ECV) method. In this method, the RGB value of the paper color as a reference is added to the formula used as a color correction. The color correction is intended to overcome the illumination problem produced on the image.

Prilianti, et al [6] also proposed a method to measure the intensity of leaf green color by utilizing the fuzzy logic approach. In this method, the Citrus Color Index (CCI) value is used as the input variable. This value is obtained by changing the color space of the image from RGB to LAB and then processed with a special formulation. The variable is then used on 4 fuzzy sets that represent 4 LCC panels. In the end, the leaf color level is determined based on the generated fuzzy value from the sets.

The CV and ECV methods have relatively fast computing time, but use RGB color space in their formulations. The color space is widely used in digital devices, but not designed according to human vision [6]. Therefore there are perception differences in color processing between computers and humans if they continue to use RGB color space.

Color space designed to approach human vision is the LAB color space. The color space was invented by the International Commission on Illumination (CIE) and claimed to contain all colors that can be seen by the human eye and do not depend on devices [7]. The fuzzy logic approach proposed by Prilianti et al [6] has used this color space in their formula. However, the computational time required in the method is relatively long. Therefore a simpler approach to measuring the rice leaf green color into LCC is needed.

In this paper, we proposed a method to classify the rice leaf green color into 4-panel LCC using LAB color space. In contrast to previous studies, in this paper, the distance of the average rice leaf green color and the green color of each LCC panels that have been converted into LAB color space is utilized. The leaf color then classified into 2 closest color panels.

2. RESEARCH METHODS

Our proposed method for classifying leaf colors into 4 LCC panels consists of the image preprocessing, color space conversion, and classification stages as shown in the flowchart in Figure 2.

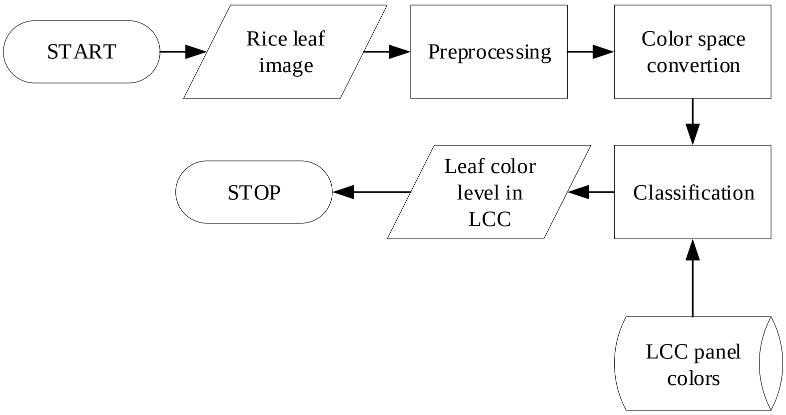

Figure 2. Proposed Method Flowchart

2.1 Preprocessing

Rice leaf images obtained from data collection using a camera or smartphone may contain non-rice leaf objects. At this image preprocessing stage, the image is first cropped into sizes 300 x 300 pixels manually (Figure 3). From these cropping, non-rice leaf objects are eliminated and leave only the surface of the rice leaf. This cropping needs to be done so that when the image pixel values are processed, only the pixels that store the leaf color are used.

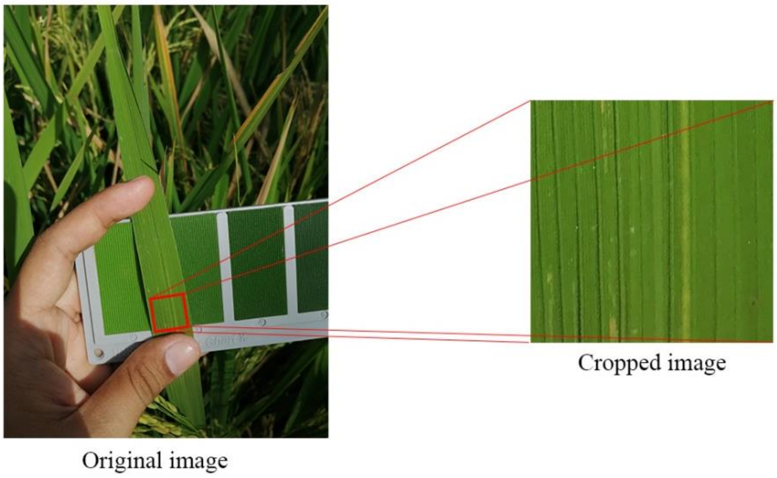

Figure 3. Manually Cropping on Rice Leaf Image

2.2 Color Space Conversion

The cropped image (I_{RGB}^{leaf}) still uses RGB color space. Therefore at this stage, we convert the color space of the image into a LAB color space (I_{Lab}^{leaf}). LAB color space itself consists of three channels, i.e. L, A, and B. L channel is a channel that stores the lightness or luminosity value of the image. The channel has a range of values from 0 (dark) to 100 (light). Meanwhile, A and B channels are channels that store color values. A channel stores the color ratio from red to green, while B channel stores the color ratio from yellow to blue. Both channels have values ranging from -128 to 127 [8].

Converting images from RGB to LAB has been described by Connolly and Fliess [9]. The conversion is done by first converting the pixel image values from RGB to CIE-XYZ. After that, the pixel values are changed from CIE-XYZ to LAB.

To convert pixel values from RGB to CIE-XYZ, the values of the R, G, and B channels are scaled into the range 0-100 first using Equation 1:

$$\gamma_s = 100\left(\frac{\gamma}{255}\right), \gamma \in \{R, G, B\} \tag{1}$$

After that Connolly and Fliess [9] describe that to get the CIE-XYZ value from RGB, it can be done using matrix multiplication as shown by Equation 2:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0{,}4303 & 0{,}3416 & 0{,}1784 \\ 0{,}2219 & 0{,}7068 & 0{,}0713 \\ 0{,}0202 & 0{,}1296 & 0{,}9393 \end{bmatrix} \begin{bmatrix} R_s \\ G_s \\ B_s \end{bmatrix} \tag{2}$$

Whereas the conversion of CIE-XYZ to LAB is done using Equation 3-5:

$$L = 116 f\left(\frac{Y}{Y_0}\right) - 16 \tag{3}$$

$$a = 500\left[f\left(\frac{X}{X_0}\right) - f\left(\frac{Y}{Y_0}\right)\right] \tag{4}$$

$$b = 200\left[f\left(\frac{Y}{Y_0}\right) - f\left(\frac{Z}{Z_0}\right)\right] \quad (5)$$

where

$$f(\beta) = \begin{cases} \sqrt[3]{\beta}, & \beta > 0{,}008856 \\ 7{,}787\beta + \frac{4}{29}, & \beta \leq 0{,}008856 \end{cases} \quad (6)$$

where X_0, Y_0, and Z_0 are tristimulus values of illuminant D65 which values are 95.047, 100, and 108.883, respectively [9].

2.3 Classification

The preprocessing and color space conversion stages are not only applied to cropped images of rice leaves but also the 4 LCC color panel images. Thus in addition to getting the image of rice leaves in the LAB format (I_{Lab}^{leaf}), we also get the 4 LCC panel color values in the LAB format (I_{Lab}^{LCC2}, I_{Lab}^{LCC3}, I_{Lab}^{LCC4}, and I_{Lab}^{LCC5}) stored in the database.

To classify the rice leaf color into LCC, we calculate the average value of all pixels in I_{Lab}^{leaf} for each channel using Equation 7:

$$I_{avg}^{\alpha} = \left[\frac{\sum L}{N}, \frac{\sum a}{N}, \frac{\sum b}{N}\right], \alpha \in \{leaf, LCC2, LCC3, LCC4, LCC5\} \quad (7)$$

where $\sum L$, $\sum a$, and $\sum b$ each represent the sum of pixel values in each channel, and N is the total number of image pixels. Calculation of the average pixel value is also performed on I_{Lab}^{LCC2}, I_{Lab}^{LCC3}, I_{Lab}^{LCC4}, and I_{Lab}^{LCC5}. The average value becomes the representative color for each image.

Using these representative colors, the similarity between the leaf color with the colors of each LCC panel can be known. The similarity is obtained based on the distance between the leaf color and the LCC panel color ($\Delta\left(I_{avg}^{leaf}, I_{avg}^{LCC}\right)$) which is calculated using the Euclidean Distance in Equation 8:

$$\Delta\left(I_{avg}^{leaf}, I_{avg}^{LCC}\right) = \sqrt{\left(L_{avg}^{leaf} - L_{avg}^{LCC}\right)^2 + \left(a_{avg}^{leaf} - a_{avg}^{LCC}\right)^2 + \left(b_{avg}^{leaf} - b_{avg}^{LCC}\right)^2} \quad (8)$$

A smaller distance value indicates that the two colors have a higher degree of similarity. The higher the similarity degree of leaf color with an LCC panel, the more possibility it is to be classified into the color level on that panel. In this paper, the colors of rice leaves are classified into the two most similar LCC panels. Thus, it is possible to obtain the leaf color classified into pairs of levels 2-3, 3-4, or 4-5 according to the standards used by the LCC.

3. RESULTS AND DISCUSSION

To test our proposed method, we have collected the rice leaf image dataset. Data collection was carried out in the Badean area in the Banyuwangi region, East Java from May to June 2019. Rice leaf images were obtained by randomly photographing rice leaves from several different rice fields using a smartphone device. Data is collected around the morning or evening when sunlight is not at its peak.

When taking the images, we also measured the color of rice leaves using LCC manually. From these activities we manually classified each rice leaves into three classes, i.e. rice leaves with colors at levels 2-3, 3-4, and 4-5. The image data then revalidated by experts to ensure data validity. In our tests, we used 190 images of rice leaves with its color manually classified as level 2-3, 281 images manually classified as level 3-4, and 88 images manually classified as level 4-5.

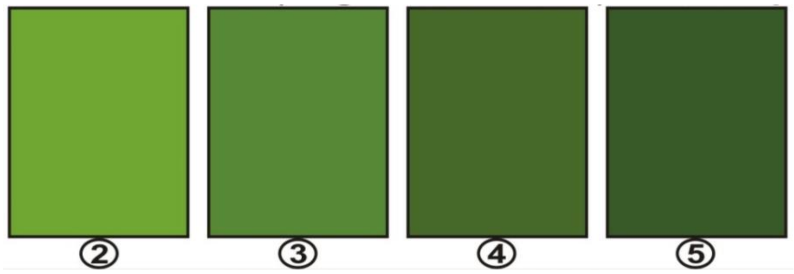

Figure 4. The Standard Color of LCC

For the standards of the LCC panel color, we use the LCC image from Gani [10] shown in Figure 4. Preprocessing and color space conversion in each LCC panel produce representative color values in the LAB color space as presented in Table 1.

Table 1 . Representatif Color Values of Each LCC Panel in LAB Color Space

Panel No.	Representative Color Values		
	L	a	b
2	80.4224	-26.5839	39.3775
3	74.0466	-24.1137	28.8432
4	66.7799	-21.1867	27.1825
5	62.4548	-20.8061	22.0496

Each of the rice leaf images that we have collected goes through the preprocessing and color space conversion stages to get their representative color in the LAB color space. The distance between the representative color and the representative color of each LCC panel in Table 1 is then measured. The two LCC panels whose color representative is closest to the color representative of the leaf image are selected as the color level or class. The results of the testing and classification for 559 images are presented by the convolution matrix in Table 2.

Table 2. Convolution Matrix of Testing Results

		Actual Class		
		2-3	3-4	4-5
Classification Result	2-3	**51**	41	1
	3-4	130	**209**	41
	4-5	9	31	**46**

From the test results in Table 2, it can be seen that 306 of 559 data can be classified precisely into their actual class. It means that the test obtained an accuracy of 54.74%. This value indicates that the proposed method is only able to correctly classify half of the data.

It can also be seen that there are 51 out of 93 data on the level 2-3 classification results that correctly classify colors to level 2-3. It shows that the proposed method gives a precision value of 54.84% for color in level 2-3. The results also showed that there are 209 out of 380 data on the level 3-4 classification results that classify colors correctly to level 3-4. It means that the proposed method has a precision value of 55% for level 3-4. In addition, from 86 data classification results to level 4-5, only 46 data are classified correctly. It means that the precision value for the 4-5 level is 53.49%. From these results, it can be said that the proposed method has an average precision value of 54.44%.

We also knew that only 51 out of 190 level 2-3 leaf color data that can be classified correctly. It means that the recall value for level 2-3 is 26.84%. For level 3-4, there are 209 out of 281 data that can be classified correctly. It means that the recall value for level 3-4 is 74.38%. While for level 4-5 only 46 out of 88 data that can be classified correctly, which means that the recall value for the level is 52.27%. Thus from these results, it can be said that the proposed method has an average recall value of 51.16%.

From these results, it can be said that the performance of the proposed method in classifying the rice leaf color to LCC is not very good. The opportunity for misclassification is still quite large. It is caused by the light variations received by the rice leaves when its image was taken. The variations can be light that hits the rice leaves too bright or even too dark because it is covered by other objects. The light causes the color of the rice leaves to turn lighter or darker than normal conditions. These changes cause a shift in the color of the leaves when compared to the color of the static LCC panel.

These results also indicate that the adaptation of the LCC panel color to variations in lighting conditions needs to be done. The dynamic and adaptive LCC panel color values based on the lighting conditions of the area where rice grows is expected to improve the performance of the classification method. It will be our future work in this research.

4. CONCLUSION

This paper proposes a method for classifying the colors of rice leaves into LCC by utilizing the LAB color space. Simply stated, the proposed method measures the similarity of representative colors of rice leaves with each representative color of 4 panels on the LCC. Leaf colors are then classified into two levels of color with the highest similarity.

From testing conducted on 559 rice leaf image data, the proposed method is only able to produce an accuracy of 54.74%. In addition, the proposed method is also only able to produce an average precision and recall values of 54.44% and 51.16%, respectively. These values indicate that the performance of the proposed method in classifying leaf colors into LCC is still not very good.

Some reasons that cause these deficiencies are the differences in light that affects the rice leaves when its image is taken. The light causes a shift in the color of the rice leaf from its normal condition compared to the static color of the LCC panel. Rice leaves can become lighter or darker due to the light and cause misclassification.

5. SUGGESTED

Our work shows that the classification of leaf color into LCC is influenced by the light conditions received by rice leaves. It shows that the color adaptation of the LCC to the lighting conditions also needs to be done. Therefore, for future work, it can be carried out research related to the LCC panel colors that are dynamic and adaptive to changes in the light.

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