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Image Extraction of Lettuce Leaves using Fast Fourier Transform Method and Color Moments

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ABSTRACT

Lettuce (Lactuca sativa L.) is a seasonal leaf vegetable with high nutritional content which is usually fresh for consumption. Typical harvest age for lettuce is 45 days. Lettuce which is harvested more than 45 days will affect the taste of the lettuce. In addition to the lettuce's age, there are several things that can affect taste of the lettuce, including room temperature, harvest time, and thickness of the leaf color. In this study, Fast Fourier transform (FFT) was used as feature extraction by changing the spatial domain in frequency domain image of the lettuce leaves, while the color moment method was used as the extraction of lettuce leaves. With this digital image processing, it can automatically identify the maturity level of lettuce leaves. The classification process uses the Naïve Bayes method with the Weka application. The obtained results of texture and color extraction using the FFT method and the color moment using the Naïve Bayes classification method in the Weka application work well. From the results of the age classification of lettuce based on its leaf color, the average percentage of total accuracy was 94.4%. The correlation of color and taste using the correlation test performed by SPSS, and it was found that there is positive relationship between color and taste with sig. (1-tailed) < 0.05.

1. Introduction

Lettuce (Lactuca sativa L.) is an annual leaf vegetable plant that belongs to family of compositae [1] which is generally eaten raw as fresh vegetables or salads. Put simply, farmers use estimates or instinct to estimate the maturity of lettuce. One of them is by observing the leaf color change that occurs when plants begin to develop. At the plant lettuce leaf color changes greatly affect the quality of the harvest and the quality of the taste. The maturity level of lettuce can be identified by the color that appears on the lettuce leaf. However, if it performs the identification manually can lead to differences of opinion in determining the maturity level of lettuce.

The color space of RGB (Red, Green, Blue) produced by common camera can be used as an alternative solution in color comparison [2]. Each color element in the RGB color space is interpreted in 8-bit, thus color shades of 224 or 16777216 can be formed. By applying digital image processing, lettuce can be identified in computational manner by recognizing color features using range of the RGB value [3]. In this research, RGB images were converted into HSV (Hue, Saturation, Value) images for image extraction using color moments, because HSV has a color space very similar to the color seen by the human eye [4][5]. The color moment is a fairly good technique in identifying color features. Color moment is a method applied to extract images using a color basis by assuming that the color distribution in each image be able to be expressed as a distribution of opportunities [6][7]. This color moment method uses three main moments of image color distribution, namely mean, standard deviation, and skewness [8]. Therefore, this method might generate three values for each color component. Therefore, the accuracy generated by the color moment is constant even supposing the image size changed [9].

Based on this background, this study was using the FFT (Fast Fourier Transform) method and color moment as methods for frequency feature (F) and color extraction. The FFT method is a method used to minimize memory consumption in digital images, and the extent to which the quality of a digital image can be deteriorated and its file size if a compression mechanism is applied using the FFT method [10]. FFT is used tremendously for image convolution [11]. As for the correlation of color and flavor, questionnaire was used in the test sample. The purpose of this study was to analyze the features of texture, color and the correlation between color and flavor. In addition, it was also to determine the accuracy of the obtained results. This study was expected to assist in analyzing the color difference correlation lettuce with flavors resulting from any kind of color and type of lettuce for the best results.

2. The Proposed Method/Algorithm

In this study was using research methods experimental research, which in this study to design a program of image processing functions as a system for analyzing the feature extraction used by changing the spatial domain to the image of the lettuce to the frequency domain using the FFT method and the extraction of colors on the leaves of lettuce using moments of color. As for the age classification process lettuce was using Naïve Bayes method. After that is the process of testing the correlation source data came from questionnaire data using statistical analyzer application. With a datasheet as many as 90 data that consists of three age levels (40 days, 45 days, and 50 days), which each age level as much as 30 data. Meanwhile, the image was taken directly during the day at a hydroponic plantation in Kediri.

Table 1. Datasheet

No.	Lettuce Age Levels	Amount of Data
1	40 days old	30
2	45 days old	30
3	50 days old	30
	Total	***90***

3. Method

After performing image acquisition of lettuce leaves in the form of an RGB image, the image was then converted into HSV image. Besides converting RGB to HSV image, resize image of lettuce was performed into a 250x250 pixel so the processed data to be lighter.

Extraction of features used in this study was the change in the spatial domain images of lettuce to frequency domain. The conversion was done using 2D Fourier transformation, i.e. using FFT. FFT is image representation as the number of complex exponential with different magnitude, frequency, and phase. FFT has an important role in variety of image processing applications, including enhancement, analysis, restoration, and compression. In 2D image, FFT could be calculated using Equations (1) [12].

$$F(u,v) = \sum_{x=0}^{M-1}\sum_{y=0}^{N-1} f(x,y)e^{-j2\pi\left(\left(\frac{ux}{M}+\frac{vy}{N}\right)\right)} \quad (1)$$

Where F(u,v) = data in frequency domain u and v where u = 0, 1, 2,…, M-1 and v = 0, 1, 2,…, N-1, F(x,y) = data in spatial domain on the x and y axes coordinates, M = image height (number of row pixels), N = image width (number of column pixels). Advantages of using the FFT that is capable of displaying the content of frequency contained in a signal, and is capable of displaying multiple frequency components contained in the cue.

For extraction of color feature in this study using Color moment, which is a technique used to select the image based on the color feature. The basis of this method used assumption that the color distribution of an image could be expressed as probability distribution. Therefore, the obtained accuracy was constant although the size of the image was changed. This study was using three main

moments to get 3 color feature values, among others Moment Mean, Standard Deviation, and Skewness.

Moment Mean might be considered as the average value of an image. The mean moments can be calculated using Equations (2).

$$E_i = \sum_N^{j=1} \frac{1}{N} P_{ij} \quad (2)$$

Moment Standard Deviation is square root of the variance in the distribution or spread coverage data from mean. Standard Deviation moment could be calculated using Equations (3).

$$\sigma_i = \sqrt{(\frac{1}{N} \sum_N^{j=1} (P_{ij} - E_i)^2)} \quad (3)$$

Moment Skewness is a data value that is not symmetrical about the mean. If the moment Skewness has negative value, then the data is more spread out on right side of the mean than on left side of the mean or vice versa. The value of normal distribution Skewness Moment is zero. Skewness moment might be calculated using Equations (4).

$$S_i = \sqrt[3]{\frac{1}{N} \sum_N^{j=1} (P_{ij} - E_i))^3} \quad (4)$$

Where E represents Mean, σ is Standard deviation, S is Skewness, N is Number of pixels, I is Current color component index (e.g.: 1 represents H, 2 represents S, 3 represents V), j is Pixel order, Pij Defines the i-th value of the color component in the j-th of the image pixel, r represents Number of channels (e.g. 3) [13].

After processing extraction of texture and color features age classification, and then performed using a lettuce leaf Naïve Bayes method. Naïve Bayes Classifier (NBC) is a method used to perform statistical data classification [14]. NBC could be used to predict probability of class members which have owned [15]. Generally, the calculation method was presented by NBC 5 the following equation [16].

$$P(H|X) = \frac{P(X|H)P(H)}{P(X)} \quad (5)$$

The Naïve Bayes algorithm used in this study was Gaussian Naïve Bayes. Gaussian Naïve Bayes was used in this study for the reason that the data used has sustainable nature. Steps taken to find the Naïve Bayes value was by finding the mean value at each feature. Equation 6 was the used formula to find the mean, while equation 7 was used to find the value of standard deviation.

$$\mu = \frac{\sum_i^n = 1 x_i}{n} \quad (6)$$

$$\sigma = \sqrt{\frac{\sum_i^n = 1 (xi - \mu)^2}{n-1}} \quad (7)$$

Having obtained the mean and standard deviation, then observed classification with continuous data using Gaussian density equation (Equation 8).

$$P(Xi = xi|Y = yj) = \frac{1}{\sqrt{2\pi\sigma ij}} e^{\frac{(xi - \mu ij)}{2\sigma^2 ij}} \quad (8)$$

To find out how accurate a system within the classification correct data, it is necessary to test the classification results. It might not be denied that the ability of classifier in a system could work perfectly. Confusion matrix is a table which commonly used to record or measure the performance of classifiers as shown in Table 2 as follows [17].

Table 2. Confusion Matrix

Original Data		Prediction Results	
		Positive	***Negative***
	Positive	True[a]	False[b]
	Negative	False[b]	True[a]

a. True = The original data were recognized correctly
b. False = The original data were identified incorrectly

In classification, accuracy is the percentage of data recording precision that is classified correctly after testing the classification results. Accuracy was calculated using equation 9 as follows. The higher level of accuracy could be alleged the more effective that the classification algorithm models with a range of percentages as follows: Accuracy percentage of 90-100% = Excellent; Accuracy percentage of 80-90% = Good; Percentage accuracy 70 – 80% = Good Enough; Accuracy percentage of 60-70% = Bad; Accuracy percentage of 50-60% = Failed [17].

$$Accuration = \frac{\sum Correct\ Data}{Total\ Data}\ x\ 100\% \quad (9)$$

To determine the relationship between color and taste of lettuce's leaves, the correlation test was used. Correlation was a number that states the direction and strength of the relationship between variables or more. Relationships between variables expressed as a positive or negative relationship, while the strength of the relationship indicated by the correlation coefficient.

The relationship between two or more variables was stated to be positive. If the value of one variable was increased, it would increase the other variables. And vice versa, if the value of one variable was lowered it would decrease the other variables. For example, there is a positive relationship between height and running speed, this means that the taller the person, the faster they run, and the shorter the person, the slower they run [18]. At the correlation stage was using questionnaire data that had been distributed to 10 respondents and then the results of the questionnaire would be processed using a statistical analyzer application with several trials. The trials which included were Data Analysis Test (Validity Test, Reliability Test); Analysis Prerequisite Test (Normality Test, Linearity Test, and Homogeneity Test); and Correlation Test.

4. Results and Discussion

4.1. Datasheet Impplementation

Table 3. Results of obtained lettuce leaves data

Lettuces' Age	Image Result	Comments
40 Days		Lettuce leaves' age 40 days old with pale green color.
45 Days		Lettuce leaves' age 45 days old with light green color.

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Lettuces' Age	Image Result	Comments
50 Days		Lettuce leaves' age 50 days old with dark green color.

Lettuce leaf image data retrieval was done in a span of 50 days. The data was taken at the age of lettuce 40 days, 45 days and 50 days. The pixel size used in this study was 250 × 250 pixels.

4.2. FFT Test Results

Table 4. FFT Trial Results

Image of Origin	Lettuces' Age	Frequency (F)	Period (T)
	40 days	0.509803922	0.411979789
	45 days	0.525490196	0.422315798
	50 days	0.28627451	0.251750063

The trial results FFT method to get the value of extraction such as the frequency and period of the image of the lettuce at the age of 40 days, 45 days and 50 days were presented by Table 4.

4.3. Color Moment Test Result

At the moment the color test method to determine the results of the analysis of the image color feature extraction lettuce at the age of 40 days, 45 days and 50 days for the mean value, standard deviation, and skewness were shown by Table 5.

Table 5. The Results of Data Collection of HVS's Lettuce Leaves

Image of Origin	Lettuce's Age	Color Component	Color Value Extract		
			Mean	*Standard deviation*	*Skewness*
	40 days	***Hue***	0.3092	0.1890	0.1342
		Saturation	0.3110	0.1482	2.3948
		Value	0.3110	0.1348	1.0414

Image of Origin	Lettuce's Age	Color Component	Color Value Extract		
			Mean	*Standard deviation*	*Skewness*
	45 days	***Hue***	0.3203	0.2129	0.3012
		Saturation	0.2946	0.1461	2.6121
		Value	0.0257	0.1160	1.0736
	50 days	***Hue***	0.5640	0.4293	-0.0518
		Saturation	0.4300	0.0851	1.1838
		Value	0.1339	0.0903	1.1838

From table 5 above, it was obtained that the value of color feature extraction varies in each image based on its age, so it could be alleged that the extraction of color features using color moments can identify the age of lettuce leaves based on their color.

4.4. Classification Results

Classification of the age of lettuce leaves based on the value of texture and color feature extraction using FFT and color moment using the NBC method obtained the results of the confusion matrix as shown in Table 6.

Table 6. Results of Confusion Matrix of Lettuce Age Classification using the NBC Method

Lettuce Actually	Classified		
	Lettuce 40 Days	***Lettuce 45 Days***	***Lettuce 50 Days***
Lettuce 40 Days	28	2	0
Lettuce 45 Days	3	27	0
Lettuce 50 Days	0	0	30

Average percentage of accuracy of NBC method based on the extraction of frequency and color features using FFT and color moment which calculated using the equation 9 was presented in Table 7.

Table 7. FFT Results

Lettuces' Age	Total Data	Correct Data	Incorrect Data	Accuracy (%)
40 Days	30	28	2	93.3
45 Days	30	27	3	90.0
50 Days	30	30	0	100
Total Data	90	76	5	
Mean Percentage/Total Accuracy				**94,4**

Based on the results of the total accuracy of the combined classification accuracy of the color moment color and FFT method above it could be seen that the NBC method has an average percentage of overall accuracy was done well with value 94.4%. Thus, the accuracy of results obtained from the merger of the two methods of color moment and FFT with NBC method might be assumed in the excellent category.

4.5. Correlation Results

On the results of correlation test was used to determine how the relationship between the color of lettuce with a taste produced by lettuce. Similarly, the test data and test requirements analysis, at this late stage trial was using statistical processing applications for the value results

investigation. The standard formulation of the correlation test was acceptance of H0 or rejection of H0 according to the sig. value (1-tailed). If the sig. (1-tailed) value was > 0.05 then H0 was accepted and H1 was rejected, meaning that there was no positive relationship between the independent variable (lettuce leaves color) and the dependent variable (lettuce flavor). If the sig. (1-tailed) value was < 0.05, then H0 was rejected and H1 was accepted, meaning that there was positive relationship between the independent variable (lettuce leaf color) and the dependent variable (lettuce flavor).

Table 8. Correlations results

	Color	**Taste**	
Color	1	0.551	Pearson Correlation
		0.099	Sig.(2-tailed)
	10.900	6.200	Sum of Squares and Cross-products
	1.211	0.689	Covariance
	10	10	N
Taste	0.551	1	Pearson Correlation
	0.099		Sig.(2-tailed)
	6.200	11.600	Sum of Squares and Cross-products
	0.689	1.289	Covariance
	10	10	N

Based on the correlation data (Table 8) shows the correlation coefficients between the lettuces' color with the lettuces' flavor (Pearson Correlation) was 0.551 with sig. (2-tailed) 0.099. Because the hypothesis was a hypothesis in one direction, to obtain sig. (1-tailed) then sig. (2-tailed) was necessity to be divided by 2 to become 0.0495. Because sig. (1-tailed) less than 0.05 (a significance level benchmark data), therefore H0 was rejected (hypothesis of no effect) so that it preserve to concluded that there was positive relationship between the color and the taste of lettuce.

5. Conclusion

The use of the FFT method and moment of color might produce values that vary in extracting features of an image and the classification results using the method of NBC was obtaining accuracy of 94.4%. Therefore the accuracy results obtained from the feature extraction of both color and FFT moment method by classifying using NBC method might assumed that the results were in excellent category. The correlation between color and taste might be concluded that for lettuce age of 40 days had a pale green color with a bland taste. As for the lettuce age of 45 days had a bright green color with a sweet taste, and for lettuce age of 50 days had a dark green color with a bitter taste. In addition, the correlation between the color and sense of lettuce had positive relationship. From the interpretation of color imaging, it can be inferred that the most appropriate imaging time that is starts from the age of 45 days.

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