Dragon Fruit Maturity Detection Based-HSV Space Color Using Naive Bayes Classifier Method

I S Khisanudin¹, Murinto¹,*
¹Department of Informatics Engineering, Universitas Ahmad Dahlan Yogyakarta, Indonesia

¹irfansoudry@gmail.com, *murintokusno@tif.uad.ac.id.

Abstract. Color is one of the elements to determine the level of maturity of the fruit because each level of maturity of the fruit has a different color level. At present, the dragon fruit is only classified based on a visual analysis of the skin color of the human eye. This study aims to classify dragon fruit using image processing with the naïve Bayes method based on HSV color space. The color feature used in this study is RGB which has been converted to an HSV value, after getting an HSV value then classified using the naïve Bayes method. Image data used amounted to 120 training images and 30 test images. The results of the classification of dragon fruit using the naïve Bayes method based on HSV color space can show an accuracy rate of 86.6%.

1. Introduction

Red flesh dragon fruit (Hylocereus polyrhizus) is a type of cactus plant or in the family Cactaceae and subfamily hylocereanea that grows in many American regions but many are also cultivated in the Asian region. Dragon fruit, in general, contains water nutrients, carbohydrates, phosphorus, vitamin C, calcium, and specifically for red fleshy dragon fruit also contains beta carotene which functions as an antioxidant. In Indonesia, dragon fruit is planted on a small scale (household) or on a large scale (garden), dragon fruit can be said to be old enough to be harvested when it is ± 50 days after the flowers bloom perfectly. In fruit harvesting, it is necessary to consider the level of fruit maturity, because this is one of the factors in determining the quality of the dragon fruit. If the fruit is harvested when it is still not ripe even though the color has started to red, the result is that the fruit will have a less sweet taste. Likewise, when the fruit is harvested in conditions for too long it will produce a sweet taste but the fruit also has a short shelf life because it rots quickly.

Image processing is one technique that can be used in processing images by manipulating them into image data to obtain the desired information. Transforming the system from color space is one of the methods used in image processing. The basic basis of color composition is RGB or red, green, blue, which is also good for displaying color information from images but there are also some image processing applications that are not suitable. To overcome these deficiencies, one way to display image information is by converting the RGB value of the image into an HSV value.

The use of image processing technology is expected to help improve accuracy in the classification of fruit maturity levels. The condition of fruit maturity can be observed through the color of the image when taken against a background that contrasts with the object of study. This is what underlies the conduct of this research so that there are thoughts to build an image processing application to predict the maturity of dragon fruit based on the dragon fruit skin color features. The application of fruit maturity detection previously investigated include star fruit [1], banana [2], apple [3], manga [4], persimmon [5], palm oil [6], and there are also applications used in image processing for beef eligibility classification.
[7], human skin recognition [8], and email spam classification based on text and images [9], classification tanning of leather [10].

2. Method

In this study the data obtained through the study of literature, observation and interviews. A literature study is one of the information gathering techniques related to the theme of image processing and detection of maturity based on fruit skin to support the theoretical basis of the research conducted by referring to research that has previously been done. An interview is a technique of collecting information directly from sources or experts that are useful for the design of the image processing system model. Furthermore, there are observations where we make observations directly on the object to get information and then it will be processed by the system.

Based on the image data of the red dragon fruit taken using a smartphone camera, we can obtain information values and the maturity classification of the dragon fruit based on their skin color. Dragon fruit which is still green means the dragon fruit is still unripe if it is reddish-green, it can be categorized as half-ripe, and dragon fruit can be said to be ripe when it is red. In Table I can be shown the level of maturity of the dragon fruit based on changes in color.

| Table 1. Maturity Level of Dragon Fruit |
|----------------------------------------|
| Color Index | Fruit picture | Fruit Feature |
| 1 | ![Image of Dragon Fruit 1](image1.png) | The entire surface of the skin is green and has a red color on the tip of the fruit scales |
| 2 | ![Image of Dragon Fruit 2](image2.png) | The skin is purple mixed with yellow and green, the fruit is a little hard |
| 3 | ![Image of Dragon Fruit 3](image3.png) | The surface of the skin is red and has a soft texture on the skin |

The implementation of the dragon fruit maturity detection system based on skin color in the HSV color space with classification using the naïve Bayes method is shown in Figure 1.

Figure 1. Flowchart of maturity determination program based on HSV color space
The steps taken in the program are:
1. Displays the original image taken from the file directory.
2. Propping the original image into the desired area to facilitate the classification process.
3. Calculate the average value of each RGB component of the cropped image
4. Transform the average RGB value into the HSV value by calculating the value of equation (1) first and then looking for the value of $H$ by using equation (2), the value of $S$ is calculated using equation (3), and the value of $V$ is calculated using equation (4)\[10].

$$r = \frac{R}{R+G+B}, g = \frac{G}{R+G+B}, b = \frac{B}{R+G+B}$$  \hspace{1cm} (1)

$$H = \begin{cases} 
0 & \text{jika } S = 0 \\
\frac{60 + (g-b)}{S+V} & \text{jika } V = r \\
60 \times \left[2 + \frac{b-r}{S+V}\right] & \text{jika } V = g \\
60 \times \left[4 + \frac{r-g}{S+V}\right] & \text{jika } V = b 
\end{cases}$$  \hspace{1cm} (2)

$$S = \begin{cases} 
\theta & \text{jika } V = 0 \\
1 - \frac{\min(r,g,b)}{V}, & V > 0 
\end{cases}$$  \hspace{1cm} (3)

$$V = \frac{R+G+B}{3}$$  \hspace{1cm} (4)

5. Calculate the maximum and minimum average values of $H$, $S$, and $V$ from the results of trials of 10 samples of unripe dragon fruit, 10 samples of half-cooked dragon fruit, and 10 samples of ripe dragon fruit.
6. Classify the maturity level of the dragon fruit based on skin color using the naïve Bayes method using equation (5)\[12].

$$f(x) = \frac{1}{\sqrt{(2\pi)^d \det(\Sigma)}} \ast \exp\left(-\frac{1}{2}(x - \mu)^T \Sigma^{-1}(x - \mu)\right)$$  \hspace{1cm} (5)

3. Result and Discussion
The system testing phase in this study was carried out by processing 30 images with *. Jpeg, *. Jpeg and *.bmp extensions with 10 images divided by 10 unripe images, 10 half-cooked images, and 10 ripe images. The image is cropped on the skin where you want to calculate the average RGB histogram value which is then transformed into the HSV color space. After obtaining the average value of HSV from the image, classification is done using the naïve Bayes method. Table II shows the values of $H$ (hue), $S$ (saturation) and $V$ (value).
### Table 2. Range of HSV values of unripe dragon fruit

| Test Image Data | Hue     | Saturation | Value     |
|-----------------|---------|------------|-----------|
| 1               | 0.22425 | 0.85481    | 0.44024   |
| 2               | 0.21237 | 0.83432    | 0.63619   |
| 3               | 0.25027 | 0.32475    | 0.71868   |
| 4               | 0.20195 | 0.84625    | 0.66707   |
| 5               | 0.25828 | 0.51748    | 0.68915   |
| 6               | 0.20992 | 0.70125    | 0.42190   |
| 7               | 0.19355 | 0.72828    | 0.55938   |
| 8               | 0.19683 | 0.81568    | 0.67465   |
| 9               | 0.20561 | 0.72721    | 0.67178   |
| 10              | 0.20894 | 0.63579    | 0.70850   |
| Total           | 2.16197 | 6.98582    | 6.18754   |
| Average         | 0.21620 | 0.69858    | 0.61875   |
| Min             | 0.19355 | 0.32475    | 0.42190   |
| Max             | 0.25828 | 0.85481    | 0.71868   |

### Table 3. Range of half-ripe dragon fruit HSV values

| Test Image Data | Hue     | Saturation | Value     |
|-----------------|---------|------------|-----------|
| 1               | 0.27505 | 0.48658    | 0.90462   |
| 2               | 0.55273 | 0.35087    | 0.60747   |
| 3               | 0.36432 | 0.31128    | 0.54466   |
| 4               | 0.25564 | 0.46469    | 0.84682   |
| 5               | 0.27481 | 0.54343    | 0.62916   |
| 6               | 0.31326 | 0.26961    | 0.69397   |
| 7               | 0.34182 | 0.47223    | 0.80405   |
| 8               | 0.29003 | 0.35765    | 0.78002   |
| 9               | 0.34182 | 0.47223    | 0.80405   |
| 10              | 0.16776 | 0.33256    | 0.61703   |
| Total           | 3.19556 | 3.99220    | 7.29543   |
| Average         | 0.31956 | 0.39922    | 0.72954   |
| Min             | 0.16776 | 0.26961    | 0.54466   |
| Max             | 0.55273 | 0.54343    | 0.90462   |

### Table 4. Range of HSV values of ripe dragon fruit

| Test Image Data | Hue     | Saturation | Value     |
|-----------------|---------|------------|-----------|
| 1               | 0.85200 | 0.56615    | 0.94806   |
| 2               | 0.91995 | 0.56648    | 0.96886   |
| 3               | 0.93848 | 0.58993    | 0.98491   |
| 4               | 0.89152 | 0.44855    | 0.97257   |
| 5               | 0.87888 | 0.53696    | 0.97311   |
| 6               | 0.86429 | 0.57267    | 0.93820   |
| 7               | 0.91878 | 0.70491    | 0.91073   |
| 8               | 0.82015 | 0.62398    | 0.96775   |
| 9               | 0.80875 | 0.54576    | 0.97071   |
| 10              | 0.83701 | 0.58775    | 0.96600   |
| Total           | 8.72981 | 5.74314    | 9.60090   |
| Average         | 0.87298 | 0.57431    | 0.96009   |
| Min             | 0.80875 | 0.44855    | 0.91073   |
| Max             | 0.93848 | 0.70491    | 0.98491   |

### Table 5. Range of minimum and maximum HSV values based on the level of maturity

| Hue     | Saturation | Value     | Note     |
|---------|------------|-----------|----------|
| Min     | 0.1935     | 0.51748   | 0.4219   | Unripe   |
| Max     | 0.2748     | 0.85481   | 0.7085   | Unripe   |
| Min     | 0.1677     | 0.26961   | 0.5446   | Half Ripe|
| Max     | 0.8201     | 0.62398   | 0.9677   | Half Ripe|
| Min     | 0.5527     | 0.35087   | 0.6074   | Ripe     |
| Max     | 0.9384     | 0.70491   | 0.9849   | Ripe     |

### Table 6. Result of classification maturity level red dragon fruit

| No | Test Data | Expert Judgment | Average Value | System Test Results | Conclusion |
|----|-----------|-----------------|---------------|----------------------|------------|
| 1  | Citra 1   | Unripe          | 0.22425       | 0.85481 0.44024     | Unripe     |
| 2  | Citra 2   | Unripe          | 0.21237       | 0.83432 0.63619      | Unripe     |
| 3  | Citra 3   | Unripe          | 0.25027       | 0.32475 0.71868      | Half ripe  |
| 4  | Citra 4   | Unripe          | 0.20195       | 0.84625 0.66707      | Unripe     |
Based on Table 2 it can be seen that the range of HSV values in every level of Nature for the Unripe category is minimum (0.19355; 0.51748; 0.42190) and maximal (0.27481; 0.85481; 0.70850), Half-ripe minimum (0.16776; 0.26961; 0.54466) and maximal (0.82015; 0.62398; 0.96775), as well as minimal Ripe (0.55273; 0.35087; 0.60747) and maximal (0.93848; 0.70491; 0.98491).

After analyzing the results of testing the level of maturity of the dragon fruit conducted by the system and also the Expert Judgment, the results show that the overall image of the dragon fruit has a match between the system and Expert Judgment. Where the value of N is the sum of all dragon fruit test images, 30 images consisting of 10 unripe images, 10 half-cooked images, and 10 ripe images.

Then the accuracy of the system can be calculated in a way:

\[
\text{Accuracy} = \frac{26}{30} \times 100\% = 86.6\%
\]  

(6)
4. Conclusion

Based on the results of research conducted it can be concluded that:

1. The level of maturity of the dragon fruit we can know besides the manual way can also automatically use a computer system

2. Detection results performed by the image processing system using the naïve Bayes method based on the HSV color space have an accuracy rate of 86.6% with a test data of 10 images in each category.

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