Mango Leaf Image Segmentation on HSV and YCbCr Color Spaces Using Otsu Thresholding

Eko Prasetyo[1], R. Dimas Adityo[2]
Department of Informatics, Engineering Faculty
University of Bhayangkara Surabaya
Jl. Ahmad Yani 114, Surabaya 60231
email: eko@ubhara.ac.id[1], dimas@ubhara.ac.id[2]

Nanik Suciati[3], Chastine Fatichah[4]
Department of Informatics, Information Technology Faculty
Institute of Technology Sepuluh Nopember (ITS)
Kampus ITS, Jl. Raya ITS, Sukolilo, Surabaya 60111
Email: naniksuciati@gmail.com[3], chastine@cs.its.ac.id[4]

***Abstract*-Research detection of mango tree type that hasn't yet-fruitful needs good result of image segmentation. This is due it use color, texture, and shape as feature. Especially shape feature, we have to produce good image segmentation result as input of feature extraction. For color and texture, we need image segmentation result to be some region of interest in the feature extraction. In this research, we use segmentation by thresholding with Otsu method. We apply Otsu thresholing on Hue, Saturation, Intensity (HSV), and Luminance, Chromaticity Blue, Chromaticity Red (YCbCr) color space for mango leaves. All components of color space are used except Luminance. Segmentation is done by converting input image Red, Green, Blue (RGB) into color space required, then use the color components required, then applying Otsu threshold method, then use several morphology steps to produce good segmentation results. Then the results are compared with ground truth images. Performance testing of color space components provides the best performance component, it is Cr, then Saturation, Cb, Intensity, and Hue respectively. We use Precision, Recall, and F-measure as performance measurement. Precision is a percentage of positive detected in detection result. The Recall is the percentage of real positive detected. While F-measure is weighted harmonic mean of Precision and Recall. The results of empirical testing on components Cr, the average performance of segmentation obtained as follows: Precision is 0.995, Recall is 0.971, and F-measure is 0.983. This performance proves Cr as the right color space component for image segmentation of mango leaves by thresholding.**

Keywords-segmentation; mango leaves; YCbCr; HSV; performance; Otsu threshold; analysis

I. INTRODUCTION

The research in the not yet-fruitful mango tree classification become an interesting research. This is because the research provides a challenge in order to identify mango tree, what kind of mango tree is, but it has not yet-fruitful. Some previous researcher conducted it by properties of the leaf [1] [2] [3] [4] [5]. This research has passed various prototype testing, and required the support of good performance in some sections in order to give accurate detection results. One stage in this work is segmentation. Classification of mango trees is conducted by processing the mango leaves image. The image contains an object of mango leaves. This image then passed through a number of processes, start from pre-processing, feature generation, until application of classification method to determine the type of mango trees.

For the generation of shape features as the leaf properties for detecting, then segmentation is very important work. Segmentation is the work of separating digital image into pieces (sets of pixels). The purpose of segmentation is to simplify and or changing the image representation into a representation that is more meaningful and easier. Generally, segmentation is used to separate the object and boundary (such as curves, lines, points, and so on) in the image [6]. The results of the work is binary image, where generally, objects and boundary are colored by white, while background is colored by black.

For image segmentation task with uniform color like leaf image, thresholding method can be an alternative to do, especially if the region of leaf is important. Generally, image segmentation is conducted on some components of multiple color spaces, such as: Hue, Saturation, Value (HSV) [7]; Luminance, Chroma Blue, Chroma Red (YCbCr) [7] [8] [9] [10]. Das and Ghosal [9] using Cb and Cr components, combine with watershed method for separating skin and not skin. This study also used calculation of gradient magnitude method and morphological operations to solve the segmentation. Shaik et al [7] perform comparisons HSV and YCbCr color space to detect skin region on the complicated image, the method used is thresholding segmentation. The threshold value used in accordance with the results of visual observation on the histogram analysis of each color space component. Research results conclude that the YCbCr provide better segmentation results. Sable and Talbar [8] using the YCbCr color space to perform face detection. YCbCr components are processed with Wavelet Packet Decomposition (WPD), PCA and Mahalanobis. The rate of recognition gained by 90.50%, 95.87% and 98.99% respectively at three, five, and ten samples of each class.

(a) (b)

Fig. 1. Mango leaf images; (a) Leaf of Gadung type; (b) Leaf of Jiwo type

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Some previous research, the utility of color space components for segmentation by thresholding method can be conducted, but the work is applied in cases such as skin detection [9], complicated image [7], and face detection [8]. So in this study the authors apply it in the case of mango leaf image.

Therefore, authors conducted research to determine the best choice of color space component in image segmentation by thresholding method for mango leaves image. We applied experiments on HSV and YCbCr color space. We use Hue, Saturation, and Intensity from HSV, Cb and Cr from YCbCr. Luminance components of YCbCr is not be used because it is a component representing the light received in the image. The authors use Otsu for thresholding method [11] [12]. The expected result is the mango leaves object can be separated accurately. The performance measurement in this study is Precision, Recall, and F-measure. The authors tested empirically at 60 mango leaves image to learn more about the performance of segmentation on Cr components.

II. RESEARCH METHODOLOGY

A. *Research Framework*

The framework for the research of classification of types of mango trees based on color, texture and shape of leaves overall is presented in Figure 2. This research is divided into several stages. They are as follow:

(1) Image acquisition

In this stage, we conducted image acquisition by phone cell camera. The resolution of image is 2592 x 1944.

(2) Pre-processing 1

Some image samples have get high light intensity, so we have to detect the region with high light intensity and discard it from interested area of texture generation. We conduct some work to improve image quality with morphological processing.

(3) Image segmentation

We need mango leaf region as the basis of feature extraction, both color and texture. So we have to segment the image to get the region of interest. Good segmentation would give good region on generated features.

(4) Pre-processing 2

This stage as the next process to get fittest quality og image and ready to go on feature extraction.

(5) Features extraction

There are three type feature that we have to generate, they are color, texture, and shape. For color feature, we would generate mean and moment of color space. For texture feature, we would generate Local Binary Pattern-based method. And for shape, we would generate Circularity and Compactness.

(6) Analysis the best features

Some features have good quality on class separability, but the others aren't. So we need to analyze and select some better feature to utilize on classification stage.

(7) Data splitting

This is special stage in our research. In this stage, we split the data to be 2 groups. One group is training data, and the other group is testing data.

(8) Training in classifier

In this stage, we conduct training to the system in order to get the best condition system to do classification.

(9) Prediction

The last step in our system is prediction of the testing data.

All stages are illustrated in Figure 2.

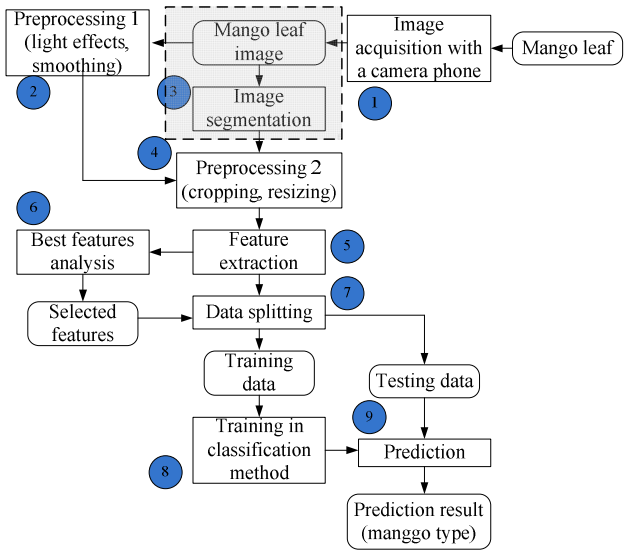

Fig. 2. Framework of mango tree type detection

The results of research presented in this paper are marked with gray color with a dotted line boundary in Figure 2. The authors segmented the mango leaves image. The assumptions used in this research paper is not using the image that has been separated from the stage that gets high intensity light as presented by Prasetyo et al [4]. The results of [4] and paper on this research will be used for features generation in the next research.

B. *Analysis of HSV Color Space in Segmentation with Threshold*

The authors analyzes component histogram of Hue, Saturation and Intensity. Hue component histogram on the image in Figure 3 (a) and (b). From the exposure by Prasad et al [4], value range which still contain green color from the mixture of Yellow-Green to Green-Cyan is from 0.169 to 0.469 or [0.169, 0.469]. These value appear as a region on histogram with dense graphic composition. These area are a region of leaf. In figure 3 (b) visible regions of solid histogram shifted more to the right than the figure 3 (a), this is due to exposure to high intensity light in the image 1 (b). Because the

Hue value in the leaf area in range [0.169, 0.469], this research use 2 fixed thresholds for Hue, T1 = 0.169, T2 = 0469.

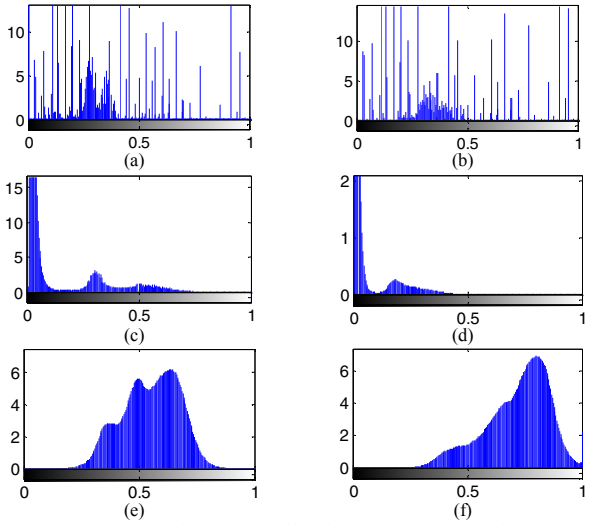

Fig. 3. HSV component histogram, all value of *y* axes multiplied by 10^4; (a), (c), (d) are histogram of Hue, Saturation, Intensity from image 1 (a) respectively; (b), (d), (e) are histogram of Hue, Saturation, Intensity from image 1 (b) respectively

Histogram of Saturation component on the image presented in Figure 3 (c) and (d). According to the figure of Saturation value in [4], the background pixels are very low range which values below 0.2. In this research, authors analyzes histogram of Saturation that Saturation value below 0.2 is background, indicated by very high graph in the chart for the low saturation value. Histogram marked as mountain areas which Saturation value > 0.2 is leaf area. Boundary between leaf area and background is uncertainly, depending on the level of light influence. Image with higher light intensity has threshold tend to be larger. To get uncertainly threshold, the authors use Otsu method [11] [12] to determine appropriate threshold.

Histogram of Intensity component on the image presented in Figure 3 (e) and (f). In the figure 3 (e), it looks like a mountain shape as much as three, a mountain on the right side is background region, while on the center and left side are leaf area. Similarly, in Figure 3 (f), the highest shape of mountain to the right end is background area and the other is leaf area. To determine appropriate threshold of Intensity components authors also use Otsu method [11] [12].

C. *Analysis of YCbCr Color Space in Segmentation with Threshold*

The author analyzes the Cb and Cr components because Cr component is a component of chromaticity as the difference between the luminance and blue color, while Cr is a component of chromaticity as the difference between the luminance and red color. While luminance component Y as a component of the light, color processing of the image is strongly influenced by light conditions [10]. The author analyzes only the Cb and Cr components as chromaticity or pure color. Component Cb, Cr and the graph of sample images are presented in Figure 4.

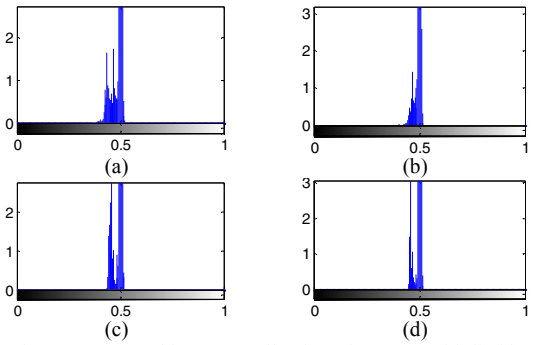

Fig. 4. YCbCr component histogram, all value of *y* axes multiplied by 10^4; (a), (c) are histogram of Cb, Cr from image 1 (a) respectively; (b), (d) are histogram of Cb, Cr from image 1 (b) respectively

The Cb histogram graph presented in Figure 4 (a) and (b) provide information that background region in the range of value > 0.47, marked on the form like very high bar in the histogram. While the leaf area in ranges of values ≤ 0.47. Uncertain threshold value like this should be calculated using Otsu method [11] [12]. Character of histograms chart provided by Cr is different, it has two bars, left and right side, as presented on Figure 4 (c) and (d). The bar on the left side is object leaves area, while the right side is background area. This threshold value is also suitable calculated using Otsu method.

D. *Segmentation Procedures*

To assure quality of feature extraction, especially shape, we have to produce the best quality on image segmentation result. For color and texture feature we need result on this research and accompany with [4] to conduct feature extraction. So, for good segmentation result, we create a segmentation procedure. It is conducted in this study, and is presented in Figure 5. The segmentation procedure is done as follows:

1. Transformation to the required color space, like HSV or YCbCr.
2. Extract he components required.
3. Using Otsu method to get the segmentation threshold.
4. Applying threshold value to obtain binary image
5. Morphological Operation filling holes to cover the results of a perforated binary image.

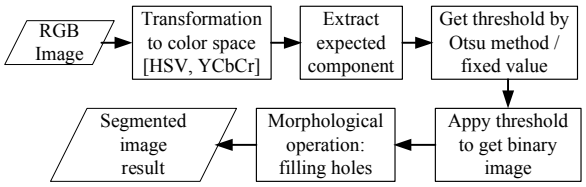

Fig. 5. Segmentation Procedures

III. RESULTS AND DISCUSSION

A. *Comparison of segmentation results on the color space components*

Testing of the segmentation quality in this study conducted by comparing the image segmentation results with ground truth images. Ground truth image give information that should

be ideal segmentation results. This image is obtained by manually marking white color on the leaves regions and black in the background region.

Comparison of the segmentation performance results of five components of image color space for two examples in Figure 1 are presented in Table I and Table II. Hue component threshold value use fixed value, two threshold, [0.169, 0.469]. While other components calculated threshold using Otsu method, this value can be different between an image with the others on same component. Segmentation performance measurement using Precision, Recall, and F-measure (Fm) [13] [14], as used in the study [15], do not use accuracy as used in [16] because accuracy don't differentiate leaf or background detected. Higher Precision value indicates that more accurate segmentation results, which they have less pixels that are not leaf is detected as leaf. While higher Recall value indicates higher number of real leaf pixels is detected as leaf. The expected performance are both to be high. Overall value performance is given by Fm.

TABLE I. COMPARISON OF SEGMENTATION PERFORMANCE OF THE IMAGE OF GADUNG MANGO LEAVES

No.	Component	Threshold	Prec.	Rec.	Fm
1	Hue	T1 = 0.169, T2 = 0.469	0.56	1.00	0.72
2	Saturation	0.23	0.99	0.99	**0.99**
3	Intensity	0.54	0.64	0.49	0.55
4	Cb	0.47	0.99	0.98	0.98
5	Cr	0.47	1.00	0.97	**0.99**

TABLE II. COMPARISON OF SEGMENTATION PERFORMANCE OF THE IMAGE OF JIWO MANGO LEAVES

No.	Component	Threshold	Prec.	Rec.	Fm
1	Hue	T1 = 0.169, T2 = 0.469	0.47	0.99	0.64
2	Saturation	0.13	0.98	0.98	0.98
3	Intensity	0.67	0.81	0.62	0.71
4	Cb	0.48	0.99	0.54	0.70
5	Cr	0.48	0.99	0.98	**0.99**

From data presented in Table I, the highest performance is given by Cr component, the value of Fm is 0.99, for both of Gadung and Jiwo mango leaves. This performance is almost same as the Saturation component, where in the Saturation performance Fm are 0.99 and 0.98 respectively for Gadung and Jiwo. Authors continue testing leaves image segmentation to 60 mango leave image on Cr component because Cr is chromaticity component, while Saturation is component representing color purity of light affected. Jiwo mango leave image as sample parts of the leaves have got exposure to high light intensity, but performance of Recall on this component remains high, 0.98, this means that only 2% of the original area of leaves are failed to detect even with the effect of high light intensity. This marks Cr component in thresholding segmentation is not affected by high intensity light. The authors continue testing at 60 mango leaves that are mostly exposed to high light intensity to prove it empirically. The segmentation result of image 1 (a) and (b) for Cr components are presented in Figure 6.

Other component segmentation performance results are less good. The Cb component has high value for Fm, 0.98 and 0.70 respectively for Gadung and Jiwo. The value 0.70 influenced by low Recall, 0.54. Hue and Intensity components also provide good performance. So from the best to the worst performance in segmentation is Cr, Saturation, Cb, Intensity, and Hue.

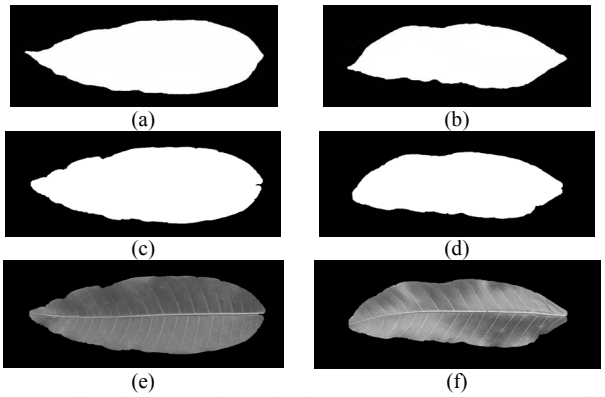

Fig. 6. Results of segmentation of using Cr components; (a) Ground truth segmentation of image 1 (a); (b) Ground truth segmentation of image 1 (b); (c) The segmentation results of image 1 (a); (d) The segmentation result of image 1 (b); (e) Segmented leaf of image 1 (a); (f) Segmented leaf of image 1 (b)

B. Analysis of segmentation results empirically

The authors continue testing segmentation using Cr components with empirically testing at 60 images of mango leaves. These images were obtained with acquisition using camera phone. When acquisition process, the spatial resolution image is 2592 x 1944. Performance testing conducted by measuring the value of Precision, Recall, and Fm. This is done when the binary image segmentation results compared with ground truth images were prepared. Summary of test results at 60 images are presented in Table 3.

TABLE III. RESULTS OF PERFORMANCE THRESHOLDING SEGMENTATION FOR CR COMPONENT

No.	Image	Threshold	Prec.	Rec.	Fm
1	Gadung	0.477	0.996	0.966	0.981
2	Jiwo	0.481	0.995	0.971	0.982
3	Manalagi	0.469	0.994	0.977	0.985
Average		**0.475**	**0.995**	**0.971**	**0.983**
Max		**0.486**	**0.999**	**0.991**	**0.993**
Min		**0.424**	**0.985**	**0.934**	**0.961**

From the segmentation performance data presented in Table 3, the average Precision value is 0.995. This value is very good for segmentation result, because the number of pixels that are not detected as leaf leaves only 0.005 or 0.5% only. In addition to good Precision, average value of Recall 0.971 is also very good with only 0.029 or 2.9% only leaves pixel that are not detected. So overall performance give Fm = 0.983. The average value of performance is supported by the min and max values that aren't much different from the average, where the smallest Fm value is 0.961, and this is also very good value. For the average value of threshold obtained 0.475, the smallest value obtained is also not too far 0.424. Overall performance thresholding segmentation method on Cr component is very good.

IV. CONCLUSIONS

The conclusions obtained from the results of research and discussion in this paper as follows:

(1) Segmentation on mango leaves image with thresholding method on the Cr component has very good performance, where the average Precision, Recall, and Fm respectively 0.995, 0.971, and 0.983. This performance proves Cr as right color space component for image segmentation mango leaves.

(2) Comparison between some components of HSV and YCbCr color space to the image of mango leaves obtained two best accuracy in the order of performance are: Cr, Saturation, Cb, Intensity, and Hue.

Feedback obtained from the results of research presented in this paper as follows:

(1) Need further comparison in the segmentation results between selected component with more number of image color space.

(2) Comparison with other color spaces like L*a*b, YUV, and other color spaces will also be necessary to provide the possibility of an alternative choice of color space or better result.

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