Automatic Counting of Chili Ripeness on Computer Vision for Industri 4.0

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Abstract: **This study aims to determine and counting the number of ripe chili on a tree. The proposed system uses images taken in gardens with a distance of 40 cm and an image resolution of 576x864. This work implements RGB2HSV color transformation, image segmentation, threshold, and image morphology, and then implements a Blob Analysis method for detecting and counting the ripe chilies on the trees. The trial results of this study provide a boundary for the blob area that will be used. Blob area less than 400 will not be labeled for the bounding box of the object detected. The accuracy of the proposed method to detect and calculate the ripe chilies on tress is 89.7%.**

Keywords—Industry 4.0, RGB2HSV, Segmentation, Image Morphology, Blob Analysis, Counting.

I. Introduction

The government of Indonesia devised a road map and strategy in the era of digital, making Indonesia 4.0. The Industrial Revolution 4.0 has fundamentally changed human life and work [1]. Industrial Revolution 4.0 encourages automation systems that can give a large impact to human life, including in agriculture [2]. One of the superior agricultural commodities is horticulture. Horticulture plants that have the potential to be developed in Indonesia is chili commodities. Chili (*Capsicum annuum L*) is a horticultural commodity that is highly needed by consumers and is one of the causes of national inflation, one of the superior commodities of chili is a big chili [3]. Chili is included in high-risk plants so that strategy and knowledge of technical and area become the important things that must be mastered. As technology developed, there are so many developments and innovations carried out for research especially on chili plants with several problems for image processing and object detection such as detection of pests in chili plants and estimation of the content of Vitamin C [4].

The availability of computer vision technology along with the increasing of the computer capability that facilitates the development of automated farming systems that are able to solve problems, increase flexibility effectively and efficiently make many fruit detection studies carried out [5].

Research conducted by Y. Song, et al. Multiple image detection and calculation with 110 image data using the Euclidean Distance for cluster, *K-means* that represents the template to find the association pixel at the cluster center, this study also uses the *Bag of Visual Words* (BoW) approach when point of interest adjacent to the detected image, then using the multiple-view algorithm to minimize errors caused by occlusion in the image to improve the fruit detection. The results of accuracy in this study were 74.2% [6].

Meanwhile, research to determine the fruit by Anisha Syal, et al. which presents a fruit counting system automatically and efficiently with computer vision techniques, using Resizing and Gaussian Low Pass Filtering and Euclidean Distance for fruit regions of input images. This study uses 25 images that are used as training data for segmentation, and the fruit is calculated based on centroid from the fruit region, the result showed that L*a*b color transformation used gave a good result [7]. P.J. Ramos, et al. conducted the process of image acquisition with a camera on a cellphone for image detection using a Machine Vision System, with the Canny Edge Detector algorithm for segmentation, Douglas and Peucker for detection, Fitzgibbon for classification, Bayes Classifier and SVM for detection, with 88% accuracy [8]. Xin Li, et al. detected strawberries in trees using HOG for feature extraction, Otsu for segmentation, SVM and CaffeNet for classification. The results showed that strawberry detection using the CafeNet method has a better accuracy of 11% than SVM, which were 95% and 84% respectively [9].

The color is an important parameter for the identification of the fruit in the process of detection of the fruit. R. Satpute et al. in their research to detect defective tomatoes, tomatoes will be inserted one by one into a box equipped with LEDs and cameras, the camera will take pictures of tomatoes, then image processing is done to get color features with RGB to YCR color conversion. The results of the study were 90% [10]. Furthermore, Yati Dandotiya et.al. in their research on taking images using Momen Method for YCbCr2HSV, YCbCr was used to select image problems in a very large database by looking for highlights from an image. The images are restored on the premise of shading and the results are taken from the coordinates of the surface shape of the separate components. This study used GCD to take color features so that these features have the same effect as YCbCr for later conversion to HSV. The proposed algorithm is better at precision for image detection as much as 88.3% [11].

The related pre-harvest process problems carried out by farmers before picking the chili fruit that will be distributed both to the local market and the industry, namely by only relying on a direct observation looking at the side of the garden whether it seems that there are many ripe or not. This manual process takes a long time and is less efficient. To increase productivity and added value in chili plants, it is necessary to use image processing automation technology in the pre-processing process to estimate how much chili is cooked.

Image processing with computer vision as a solution for more effective detection and calculation by visual human eyes will use images taken using a digital camera, then the detection process with *Red, Green, and Blue* (RGB) to Hue, Saturation, and Value (HSV) color transformation, color

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segmentation within Range technique, threshold binary image, image morphology, and blob analysis method for calculating mature chili on trees.

II. Proposed Method

In this study, Images are used as input. The images are taken using a digital camera with 18.0 MegaPixel resolutions. They are taken directly from the side of chili garden in Soppeng, South Sulawesi, Indonesia. The total data used in this study is 180 images with the size of 2880x4320 pixels.

The images are taken at a distance of 40 cm between the camera and the chili tree trunks. The distance between trees is 50 cm, and the distance from the canal dividing the trees is 1,4 meters. The scenario when taking the image data can be seen in Figure 1.

The proposed system is a system for detecting and counting the ripe chilies on trees. Images taken with a digital camera will be processed with image processing with the stages of pre-processing, segmentation, detection, and ripe chili counting process. The system design, in general, can be seen in Figure 2.

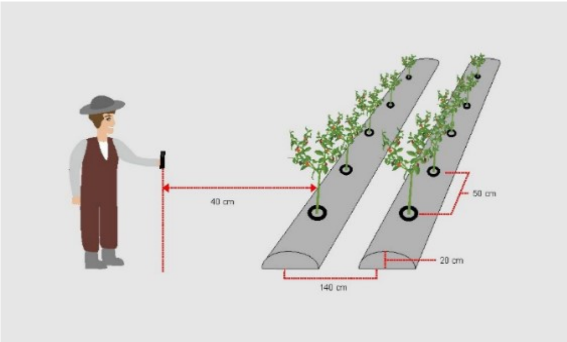


Figure 1. Scenario in Image Collection Process

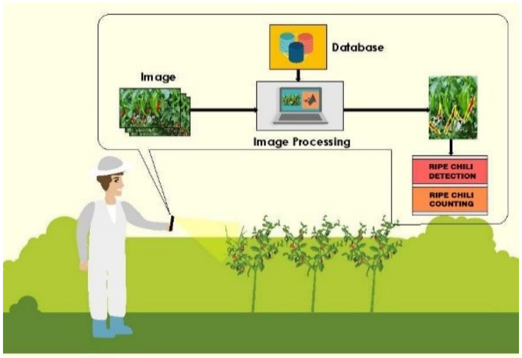


Figure 2. The Design of General System

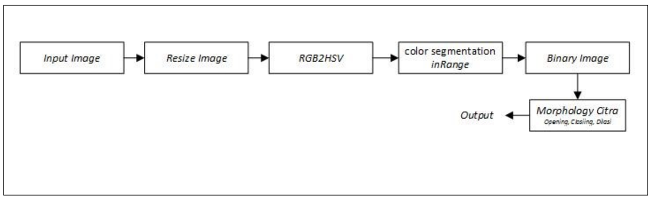


Figure 3. Pre-processing Stages

The research will be carried out in some stages such as pre-processing, RGB to HSV color transformation, color segmentation with inRange technique, threshold binary image, image morphology, and to count the ripe chili on trees blob analysis method is used. The pre-processing design can be seen in Figure 3.

The first process of image processing is the image acquisition process which is a step to collect images.

The first step is to change the image size into 576x864 pixels. RGB color transformation to HSV, where the HSV color space is a mathematical representation of three-dimensional colors. Hue represents color, Saturation represents the level of color dominance, and Value represents the level of brightness. Therefore, this method tends to detect color, the level of dominance and brightness [12].

Color transformation from RGB to HSV can be used to detect mature chili objects. Using the three parameters input R, G, B with the scale from 0-255, the normalization process can be carried out to define the value of Hue (H) using the follwing equations:

$$Nr = \frac{R}{R+G+B} \tag{1}$$

$$Ng = \frac{G}{R+G+B} \tag{2}$$

$$Nb = \frac{B}{R+G+B} \tag{3}$$

Using the normalized Nr, Ng, and Nb value, the RGB to HSV transformation can then be calculated using the following equations:

$$H = \begin{cases} 60\frac{Ng-Nb}{(V-min(Nr,Ng,Nb)} & if\ V = R \\ 120 + 60\frac{(Nb-Nr)}{V-min(Nr,Ng,Nb)} & if\ V = G \\ 240 + \frac{60(Nr-Ng)}{V-min(Nr,Ng,Nb)} & if\ V = B \end{cases} \tag{4}$$

$$S = \begin{cases} \frac{V-min(Nr,Ng,Nb)}{V} & if\ V \neq 0 \\ 0 & otherwise \end{cases} \tag{5}$$

$$V = a \tag{6}$$

Changing colors to HSV can help determine specific colors based on pixel values. Red segmentation in this study uses the pixel values of HSV images 1, 80, 100 and 10, 255, 255. So, the pixel value other than that value will be changed to 0 and the pixels that have that value will be changed to 255. The output generated from this process is a masking image of color segmentation results.

On the threshold process, pixel values that meet threshold requirements are mapped. From the process of color segmentation, the maximum and minimum values are obtained, those are 255 and 1. The threshold value used in this study is 1. So that all pixels which are less than 1 will be set to 0, while all pixels which are in the range of 1-255 will be set to 1. The process of threshold binary image can be calculated by equation [13]:

$$g(x,y) = \begin{cases} 0, f(x,y) < 1 \\ 1, f(x,y) \geq 1 \end{cases} \tag{7}$$

Image morphology process is the stage that is done after the binary image process. The opening process removes small objects around the main object. Closing process fills small holes in objects and combines adjacent objects. Meanwhile, to enlarge object segments, layers are added around the object by adding pixels to the object's boundary elements.

The process design of counting and detecting ripe chili on the tree using BLOB analysis method can be seen in Figure 4.

Blob analysis is a technique used to represent the pixel area of an image that is the focus of the detection. To determine the Blob value, the area of the data is collected to become a blob. To find contours in an image, three parameters are needed. The first parameter is the image from dilation process that its edge has to be found, the second parameter is the hierarchy between contours, and the last parameter is to compress the contour to save the memory space used.

To measure the accuracy level (A_c) of the detection and counting system of ripe chili on a tree, there are two parameters: the number of ripe chilies counted by the system (N_s) and the number of ripe chilies counted using manual counting (N_t).

$$Ac = \frac{Ns}{Nt} x\, 100 \qquad (8)$$

To calculate the error percentage of the image, the following equation can be used.

$$PEperl = \left[\frac{PC-TC}{TC}\right] * 100 \qquad (9)$$

III. Experimental and Result

The color transformation from RGB to HSV for detection of ripe chili on trees has been used on the image of chili. Image data that has been used in this study can be seen in Figure 5.

RGB value will be used in the color transformation process. To obtain the HSV value there are three parameters, those are V value, a value, and subtraction value between V and b. In this process, if the maximum and minimum values obtained are equal, then $H = 0$. The HSV result can be seen in Figure 6 and Figure 7.

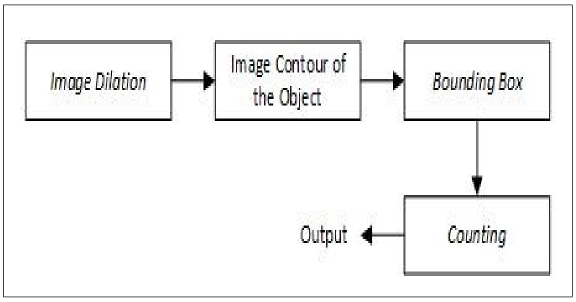
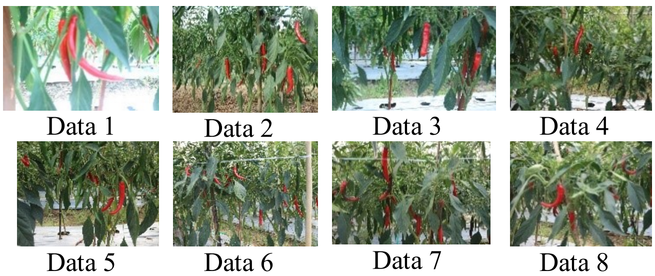


Figure 4. Blob analysis process to count ripe chilies on the tree



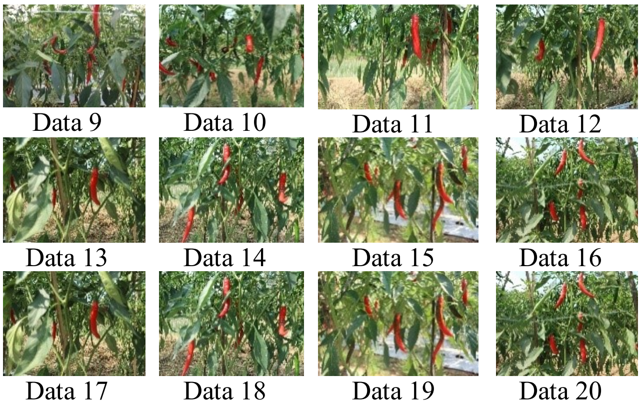


Figure. 5. Input Data

After the experiment is carried out on HSV components, H and S channels is applied to the image. The result of H and S channels can be seen in Figure 8 and Figure 9.

In this study, segmentation for the red color uses (1, 80, 100) and (10, 255, 255) pixel value of HSV image. Therefore, pixel value other than those value will be changed to 0 and the pixel with those values will be changed to 255. The output of this process is a masking image obtained from color segmentation, which can be seen in Figure 10.

Areas of the image that look a bit dark will be converted to black with an intensity value of 0, while the areas of the image that look a bit bright will be converted to white with an intensity value of 255 as the maximum value obtained from segmentation process. After the experiment is conducted threshold value of 1 will be used as the right threshold value to obtain a binary image. The result can be seen in Figure 11.

Figure. 6. The example of RGB Data 2

Figure. 7. The example of HSV Data 2

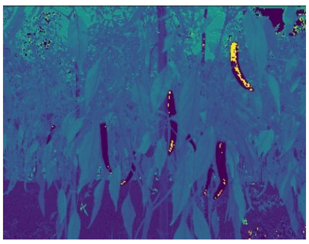


Figure. 8. The example of Channel H Data 2

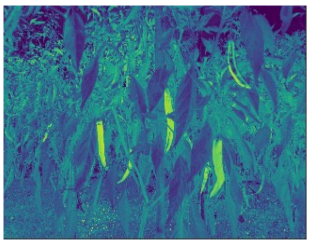


Figure. 9. The example of Channel S Data 2

Figure. 10. Segmentation Result

Figure. 11. Threshold Binary Image

Figure. 12. Opening results of Data 2

Figure. 13. Closing results of Data 2

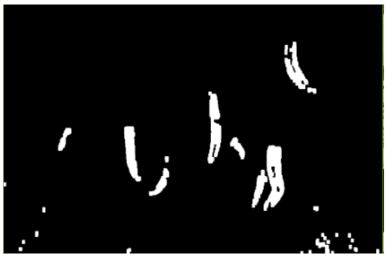


Figure. 14. The example of morphologi (Dilation)

The next step is the image morphology process which is the process of opening and closing. In the opening process, kernel (3,1) and 1 iteration are used. Experimenting with several iterations makes the object become more undetectable, so that kernel (3,1) is used with only 1 iteration. While in closing process kernel (9,9) is used with 1 iteration. The result can be seen in Figure 12 and Figure 13.

To enlarge the segment of the object, some layers are added around the object, and pixels are added to the boundary elements using the dilation process with kernel (3,3) and 3 iterations. The results of the dilation process can be seen in Figure 14.

Ripe chili can be counted after object detection using Blob Analysis has been done. The white objects formed from the dilation process will be analyzed with BLOB Analysis. Each BLOB represents an object as a group of pixels with labels as a distinction from other objects. The label is obtained by searching from the top to bottom for Y-axis coordinates of an object, and from left to right for X-axis coordinates. From this process, the blob areas value of the detected object is 311-26.376. The value of Blob area which is more than 400 will be labeled on the detected objects. The result can be seen in Figure 15 and Figure 16.

Figure. 15. Example of Blob Analysis output for Data 2

Figure. 16. *PC* is more than *RC for* data 14

Figure. 17. *PC* is less than *RC for* data 17

TABLE I. THE RESULT OF COUNTING THE NUMBER OF RIPE CHILI ON A TREE

No.	Name	Real Count	Program Count	Accuracy (%)
1	Data 1	7	6	85.7
2	Data 2	8	8	100
3	Data 3	10	12	80
4	Data 4	4	4	100
5	Data 5	9	8	88.8
6	Data 6	10	8	80
7	Data 7	12	11	91.7
8	Data 8	11	11	100
9	Data 9	10	8	80
10	Data 10	9	9	100
11	Data 11	7	7	100
12	Data 12	3	3	100
13	Data 13	3	3	100
14	Data 14	7	9	71.4
15	Data 15	10	10	100
16	Data 16	8	8	100
17	Data 17	2	1	50
18	Data 18	4	4	100
19	Data 19	3	4	66.7
20	Data 20	9	8	100
Average				**89.7**

The output from Blob analysis will be the basis to count the ripe chilies on the trees. The system will count the detected ripe chilies with blob areas more than 400. The result can be seen in Figure 15.

The testing results of the system are then compared with the results of the manual count. The result of the counting process by the system can be seen in "Figures 16 and 17":

Table 1 shows the testing result of the real count and program count. Based on Table III, there is data where program count detected more than the real count, for example in data 14 because the leaves cover the center of the ripe chili, therefore the top and bottom of the object are counted as two objects. Also, there is data which the program count is less than the real count, like in data 17, where two ripe chilies overlap with each other, therefore the program considers it as one object. The accuracy of the system conducted in this study is 89.7%.

IV. Conclusion

This study uses a dataset of chili plants with 40 cm in distance between the camera and the tree, segmentation for the red color of the objects using pixel values of (1, 80, 100) and (10, 255, 255). The threshold value 1 is used as the best threshold value to convert images to binary images. Then the image morphology process is done to remove small objects, fill the hole and enlarge the object segment using the dilation process with a kernel (3,3) and 3 iterations. After that, the BLOB analysis method is applied to detect and count the ripe chilies on the trees. The system will count the detected ripe chilies with blob areas more than 400 by applying a bounding box.

The results of the system that compared with the results of the manual count of the detected ripe chilies give an accuracy of 89.7%. For further research, another segmentation method can be tested, such as Watershed Transform.

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