High Detection of Hydroponic Plant Pak Choy Using Morphological Image Processing

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***Abstract*— Hydroponics is a cultivation technique that uses water without using soil by emphasizing nutrients for plants. But in monitoring the height of the plant, people who want to plant hydroponics or who are doing it at home still estimate without knowing exactly, so there are plants whose height is not well monitored. These problems created an idea to create a detection system for plant growth and development to detect height more accurately.**

Image Processing is a branch of knowledge about image processing processed digitally. The development of technology is speedy in computer vision that makes image processing not only to improve the image alone but also to detect or track an object, read barcodes, and others. The stages of image processing are acquiring images from images, preprocessing, and recognition. The method used in this system is the Morphological Image Processing method. The parameter used is to calculate the height of the Pak Choy hydroponic plant. Using this method, we obtained an accuracy of the system of 93.81% with a light intensity of 15.7 lux. During the 6 weeks of Pak Choy plant growth, the best accuracy was in the 3rd week with an accuracy of 97.24% with an average of 13.65 lux light intensity. The worst accuracy was found in the 2nd week, with an average accuracy of 86.25% at 15 lux light intensity.

Keywords— growth and development detection, computer vision, Morphological Image Processing

I. INTRODUCTION

Hydroponic cultivation techniques are currently a technique that is developing in Indonesia, especially for people who want to grow hydroponics in their homes. But with the lack of public knowledge about monitoring the growth and development of hydroponic plants, of course, will affect the yield of plants. To get good hydroponic plants, of course, it takes a routine monitoring process of the vegetable plant itself. One part of monitoring the growth and development of hydroponic plants that can be observed is the height of the hydroponic plant itself.

The application of image processing can be used to detect plant height based on variables that have been set from the type of vegetables to be detected. Therefore, the system will facilitate hydroponic farmers in detecting plant height. Furthermore, the Morphological Image Processing (MIP) method is a reasonably effective method to produce the desired output.

This research helps create a system to detect the height of hydroponic vegetable plants. Python is used to obtain the desired data using the MIP method. With research on height detection of hydroponic plants. Using the MIP method is expected to create a system that can help hydroponic farmers detect hydroponic plant height.

II. RELATED WORK

This research was conducted because height and weight measurements were still manual. In this research, a method was used in Morphological Image Processing. There are 3 processes required. The first process is image acquisition, the second process is Preprocessing in Preprocessing, there is 2 process that is required, get the grayscale image and convert it into a binary image, and the last process is Morphology Operation, in Morphology Operation, there are 2 steps that used, the first is Dilation Operation, and the second is Filling Operation. After that, the part of the image with white pixels will be counted in total pixels to get the weight and height of humans. Using the Morphological Image Processing method, the accuracy for height is 94.4 % and for bodyweight is 94.42%. This method uses a pixel ratio with the original size [1].

The second research was conducted to calculate the former tin mining area using Morphological Image Processing. The system's input uses the image from the satellite and calculates the wide-area using the comparison between pixel and the actual size. This research begins with a field survey to find coordinate points to determine the length and width of the mining area to be processed. Then, an image from a satellite that is still an RGB Image is converted to a Grayscale Image. Then, the Grayscale Image will e converted into a Binary Image to separate the front and back objects. Using Binary Image, there are 2 stages of Morphology Operation; the first is Erosion, Erosion aims to remove small objects, and the second is Dilation. Dilation aims to restore parts of the object lost by Erosion. To find out the area of the object, the number of pixels that have been calculated is multiplied by a previously known scale from the ratio between the size of 1 pixel is equal to m^2 in actual size [2].

III. RESEARCH METHODS

The research began by planting Pak Choy hydroponic plants at home as objects to be detected.

A. General Description

The picture below is a general description of the system created. It starts with image acquisition, then Rasberry Pi works as a system control center, and the image data that the camera has captured will be input data for Rasberry Pi or PC [3]. The input image does some preprocessing before

entering into morphological image processing. After doing image processing, the data obtained is sent to the Firebase Realtime Database to store the data that has been obtained. Finally, web pages serve as a container to display the detection results to facilitate users' seeing the detection results.

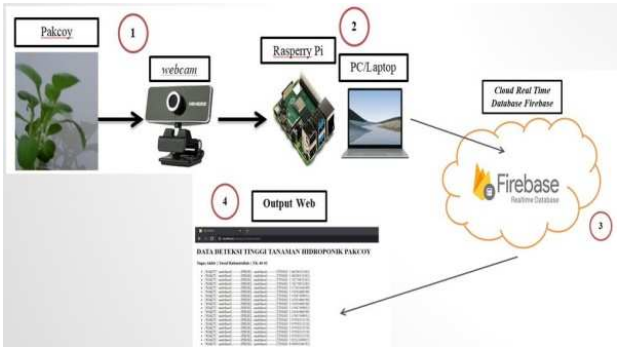

Fig. 1. General Description

The following are the stages of image processing to obtain data on Pak Choy plant height from Fig.1.

a. With a certain distance webcam capture/image acquisition of Pak Choy hydroponic plants that have been planted, so that the color image (RGB) is obtained and converted to grayscale image [4][5]. This is so that each pixel of an RGB image that has three channel values can be simplified to only one channel value in a grayscale image so that the image processing can be done more easily [6][7].

b. The grayscale image is converted to a binary image to separate the detected object from the background.

c. The result of the binary image is inverted to change the value o to 1 and vice versa.

d. Morphological Image Processing

Fig. 2. The flow of Morphological Image Processing

Fig. 2 describes that The first morphological Operation was a dilation that expanded white pixels and removed black pixels found on objects. Next, the erosion process is carried out to eliminate the white pixels outside the object to be detected. Then, white pixels are chosen to calculate the height [8].

e. Calculation of the number of pixels of an object can be easily done on eroded images. The pixels included in the calculation are pixels with an intensity value of 1(white) [9].

f. To find the height of the object image (height of Pak Choy hydroponic plants) in units of cm, the number of pixels that have been calculated is multiplied by a scale calculated at the beginning. The scale is obtained from comparing the height of the comparison object with the height of the frame capture frame so that it can be seen that a 1-pixel image is equal to how many cm in actual size [10].

After obtaining data or information desired through the Image Processing process, the data is sent to the Firebase Realtime Database and displays the results in a simple web page.

B. *Taking Scale Value*

To obtain a scale of comparison between pixels and the original size, an object is captured as a comparison. For example, the pixel size for object capture is 640:480, where the total pixel used as a comparison to measure the height is 480 (illustrated in Fig. 3).

Fig. 3. Comparison Object

$$\frac{13cm}{480\ Pixels} = 0.0264583333 \text{ cm}$$

To obtain a scale value of 1 pixel equals 0.0264583333 cm with a distance of object and webcam 30 cm.

If, X = 0.0264583333 cm

Note: X is the definition of a 1 Pixels scale

$$Height\ of\ plant = total\ of\ pixel\ height \times X. \quad (1)$$

height of plant=total of pixel height*X

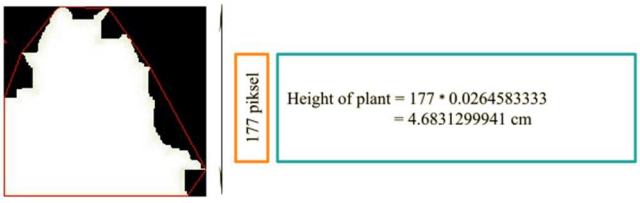

Fig. 4. Calculation Example

Fig. 4 shows the Calculation Example to obtain a scale of comparison between pixels and the original size.

C. *Image Processing Stages*

1. Fig. 5 shows the first stage is capture to obtain a

color image (RGB).

Fig. 5. RGB Image

2. Fig. 6 shows the image obtained from the capture results is divided into a grayscale image to simplify further image processing.

Fig. 6. Grayscale Image

3. Fig. 7 shows the process of converting the grayscale image to a binary image and inverting the binary image to make it easier to calculate the object's height.

Fig. 7. Binary image

4. Fig. 8 shows image processing on Pak Choy plant objects. First, morphological image processing is carried out, which is a dilation process to remove black pixels between white pixels contained in the object.

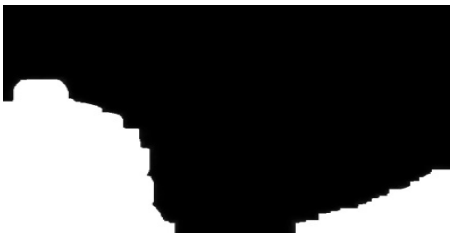

Fig. 8. Dilation Image

Fig. 9 is an erosion process followed to reduce the pixel object and return it to its original size.

Fig. 9. Erosion Image

5. Fig. 10 is a process to simplify the calculation of pixel height on objects, and cropping is carried out with the help of ConvexHull so that the object to be processed is made easier.

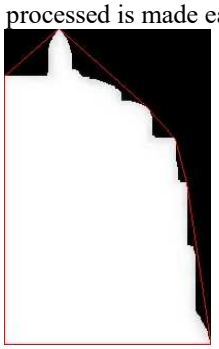

Fig. 10. Cropped image using ConvexHull

6. Fig. 11 is processed to calculate the height of the detected Pak Choy plant object. First, the total height of the white pixels obtained using the *img.shape* function is multiplied by the pre-determined scale at the start so that the height of the Pak Choy plant with the actual size is obtained.

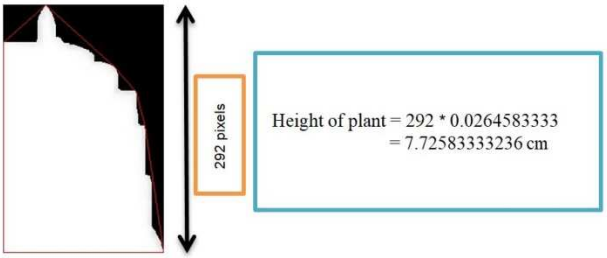

Fig. 11. Height calculation of plant

7. After obtaining the data/information results from the image processing process, the data is sent to Firebase Realtime Database in real-time (Fig. 12).

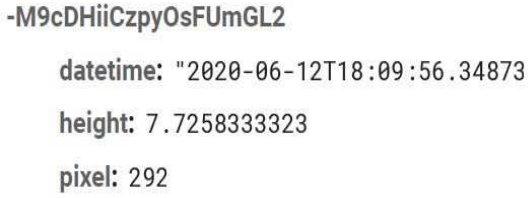

Fig. 12. Firebase Database

8. Finally, displaying the detection results in the form of a web address by retrieving data

previously stored in the Firebase Database.

IV. Results and Discussion

This study carried out testing for six weeks with 30 captures every week.

A. Capture Testing

Table I is the result of capture testing that has been carried out.

TABLE I. Capture Testing

Num	Capture Result	Capture Time
1		15_5_2020_10.12pm
2		22_5_2020_8.59pm
3		22_5_2020_9.28pm
4		22_5_2020_9.32pm
5		22_5_2020_10.10pm

Table I is the capture result for the third week and only shows 5 out of 30 captures, in which there are the original image captures and time captures. Therefore, based on the test results from Tabel I, it can be denied that the system can capture the object adequately.

B. Image Processing Testing

Table III is the result of Image Processing Testing. The Table III is an image processing test at the third week and shows only 5 processes out of 30 processes, in which there are image processing stages that have been described in the Research Methods section. Therefore, based on the test results from Table III, it can be denied that they can process the image properly.

C. Height Detection Result for 6 Weeks

Table II is the result of high detection, which has been taken for six weeks. Table II shows the detection of the height of the Pak Choy plant for 6 weeks, where it was detected 30 times each week, and the average height of each week was recorded.

In table II, there are manual measurement results, the average of light intensity when capturing the object, the average total pixels that used as a basis for measuring the height of the plant using the system that was created, and the last are the results of height detection of Pak Choy plant.

The system's detection results were compared with the height of plants manually measured using rollers to get the system's accuracy.

TABLE II. Height Detection Result for 6 Weeks

Weeks	Manual measurement (cm)	Average Light Intensity	Pixel Average	Average Measurement System (cm)
1	2	16	68	1.80
2	3	15	134	3.54
3	4	13.65	187.6	4.96
4	6	16.03	218.73	5.78
5	7	15.83	270.2	7.15
6	8	17.96	292.9	7.75

TABLE III. Image Processing Testing

N	Gray	Bin	Invert	Morph		Result
				Dil	Ero	
1						
2						
3						
4						
5						

D. System Accuracy Results

A comparison is needed to obtain the system's accuracy, namely the manual measurement results using a ruler.

The first step to obtaining the accuracy level value is to obtain an error value first. With the following calculation:

$$Error = \frac{\Delta \text{height}}{the\ highest\ measrement} \text{ x } 100\%. \quad (2)$$

Information:

1. Δheight = the difference between the system measurement height and the real measurement
2. Highest measurement = The highest measurement result between system measurement and real measurement
3. 100% = Maximum percentage

Weeks	Average Accuracy Rate (%)
1	90
2	86.25
3	97.24
4	96.36
5	96.72
6	96.29
An average of 1 harvest	93.81

$$Accuracy = \ 100\% - Error. \quad (3)$$

Information:
1. 100%= Maximum percentage
2. Error=error value obtained previously

Manual height measurement	Weekly height (cm)	Total vertical pixels	System height measurement (cm)	Accuracy (%)
	2	68	1.8	90

TABLE IV. SYSTEM ACCURACY RESULTS

Based on the table IV, it can be concluded that the average of 6 weeks of testing accuracy is 93.81%.

TABLE V. SYSTEM EXPERIMENT

The test is done by comparing the actual data with the measurement of the first week of 2 cm. The test was carried out one-time capture with a light intensity of 16 lux so that the plant height measured by the system was 1.8 cm.

Based on these results, the system's accuracy in the second week is 90%.

Based on Fig. 13, the best accuracy occurs in the third week with 97.2%, and the worst happens in the second week with 86.25%.

This website displays the detection results done by showing data previously stored in the Firebase database. On this website, some information can be obtained, including the date of the detection, the time of the detection, the total pixels of the captured object, and the height of the Pak Choy plant detected (Fig. 14).

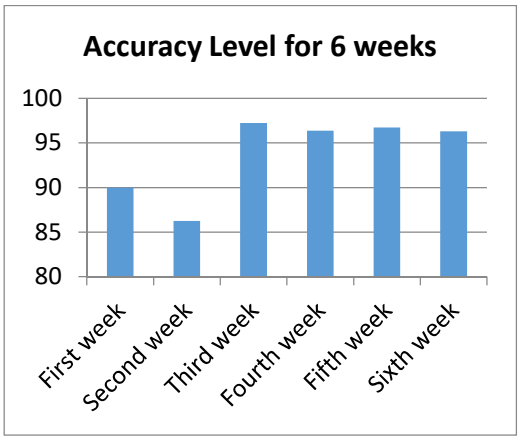

Fig. 13. Accuracy Level for 6 weeks

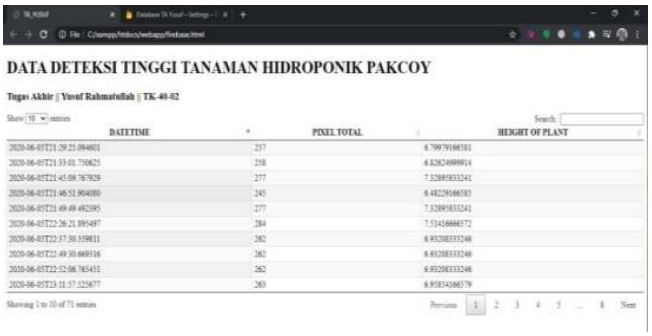

Fig. 14. Web Display of Detection Result

V. CONCLUSION

From the research carried out, the system created to detect Pak Choy hydroponic plant height using the Morphological Image Processing method can work well at an accuracy of 93.81% with a light intensity of 15.7 lux. During the 6 weeks of testing, the best accuracy was on the 3rd week with 97.24% with an average light intensity of 13.65 lux, and the worst accuracy was found in the 2nd week with an accuracy of 86.25% at 15 lux light intensity.

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