SORTING MANALAGI APPLE (*Malus sylvetris* Mill) USING IMAGE PROCESSING APPLICATION

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ABSTRACT

Manalagi apple *(Malus sylvestris Mill)* is one type of apple that has been widely known by the public in Indonesia. Fruit sorting in Indonesia, particularly Manalagi apple, is carried out manually so it is still at a disadvantage. This study aimed to arrange image processing applications with criteria for size, width, height, color, and defect area of fruits. The samples of Manalagi apple used in this study were 130 with 50 each in the non reject and reject quality classes and 30 for the validation test. Manalagi apple samples were obtained from one of the collectors located in Batu City. The image of Manalagi apple processed gained several variables, including perimeter, area, height, width, r, g, b, and defect area. Based on statistical analysis, image quality variables that could be used as input for making applications in the form of logical sentences were perimeter, area, and defect area. Based on the application, the validation test obtained an accuracy of 86.65%.

Keywords: Manalagi apple, sorting, image processing

INTRODUCTION

Apple *(Malus sylvestris Mill)* is one of the leading agricultural products from Indonesia. This plant originates from subtropical regions. Apples were planted in 1934 and could grow well in Indonesia. Malang and Pasuruan regency are centers of apple production in Indonesia. Apple plants in this area began to be developed in 1950. In addition to these areas, apple plants are also widely developed in the Situbondo, Banyuwangi, and East Nusa Tenggara regions (Soelarso, 1996).

Apple production in the three apple production centers, namely Malang Regency, Batu City, and Pasuruan Regency, is quite large. The number of apple production in Malang Regency, which was centered in Poncokusumo District, reaches 150,545 tons/year (Agriculture Service of Malang Regency in Rahaju, 2013). Apple production in Batu City reaches 833,915 tons/year (Theresia Maria & Makmur, 2015). Apple production in Pasuruan Regency reaches 140,284 tons/year (Gutomo, 2015).

Manalagi apple is one type of apple that is widely known by the public. In increasing the selling price, apples need to be sorted to separate between good and bad apples. Sorting is a step for apple products to be accepted on the market. Apple sorting in Indonesia is conducted by human manually. Therefore, it has many disadvantages, including the results of sorting are less in similarity, require more time, and there is a difference in perception of the sorting result due to subjectivity.

Image processing can be used as an alternative way of sorting Manalagi apple. Image processing is the process of processing and analyzing images that involve a lot of visual perception (Ahmad, 2005: 4). Image processing can determine variables from fruit quality such as fruit weight, fruit width, and defect area. Some research on image processing for sorting and qualifying fruit has been carried out, and the results were quite satisfying. Yultrisna and Syofian (2016) conducted a study on the sorting of tomatoes using image processing applications.

Application designed to sort tomatoes based on color differences. The research showed that the result of sorting accuracy reached 100%. Other studies conducted (Saintika, Wijayanto, & Wiguna, 2018) on the classification of carrots based on image processing also showed satisfactory results. The designed image processing application was able to predict fruit quality manual parameters such as weight, volume, length, and diameter. The result showed that the classification accuracy reached 98.88%.

Research on the classification of Manalagi apple also been conducted by Anugrahandy *et al* (2013) and Nugraha (2017). Research carried out was the classification of Manalagi apple with various quality classes. Based on the results of the study obtained an accuracy that was quite satisfying, with accuracy reaching 90%. Both of these studies have similarities in the classification of Manalagi apple quality with criteria for size, width, height, and color. Further research needs to be conducted with the sorting criteria, namely the defect area. The criterion of the defect area was the condition of the apple, which has a defect due to animal attack, genetic conditions, and damage during transportation.

Research classification about fruit defect was conducted by (Riquelme *et al,* 2008). This research was classification olive according to external damage. Seven commercial categories of olives, established by product experts, were used: undamaged olives, mussel-scale or 'serpeta', hail-damaged or 'granizo', mill or 'rehu´s', wrinkled olive or 'agostado', purple olive and undefined-damage or 'molestado'. The accuracy of this research reached 75%. The other research about fruit defect area was conducted by (Arjenaki, Moghaddam, & Motlagh, 2013). This research was sorting tomatoes according to surface defects. The accuracy of this research reached 85%.

Therefore, this research aimed to arrange image processing applications with criteria for size, width, height, color, and defect area. The expected result is an application that is accurate enough to sort the Manalagi apple.

MATERIALS AND METHODS
Tools and Materials
The tools used in this study included:

1. CCD camera (Charge Couple Device) as an image capture tool. CCD camera was a special camera for sorting. image capture results had a high pixel value so the results were quite detailed.
2. TL lamp with a power of 5 Watt (220 Volt) as a lighting aid. The white TL lamp was chosen because it had a complete color value content. Thus it would clarify the results of the image that had been obtained.
3. White cloth as the base layer. White cloth was chosen as the background because it had a color that contrasts with the apple object. Thus the resulting image could clearly distinguish between objects and backgrounds. Laptop device with a core i5 processor as image processing hardware

The materials used in this study were two qualified Manalagi apples, no reject and reject, 50 pieces for each, and 15 pieces for the validation process so that the samples of Manalagi apples were 130 pieces. This apple was obtained from one of the collectors located in Batu City.

Methods
This research used a CCD camera to capture images from Manalagi apple. Figure 1 was the stage of research that was being carried out.

a. Determination of image quality variables
Quality variables of Image processing for the classification of Manalagi apple in this study were:
1. non-reject fruit (normal): Large to medium fruit size, standard fruit shape, no or little defect area.
2. reject fruit: Very small fruit size, abnormal shape, there is a large defect area.

Based on the above criteria, the image quality variables used for Manalagi apple include shape, size, color, and damage. The estimation of the variable of image quality can be seen in Table 1.

b. Image Acquisition
Image Acquisition was a process of getting the best images of Manalagi apple. This process was carried out by adjusting the distance of the camera and the irradiation position to resemble a natural image, a slight shadow arises, and no excess light affects the

color of the object. The best camera distance and exposure position are shown in Figure 2.
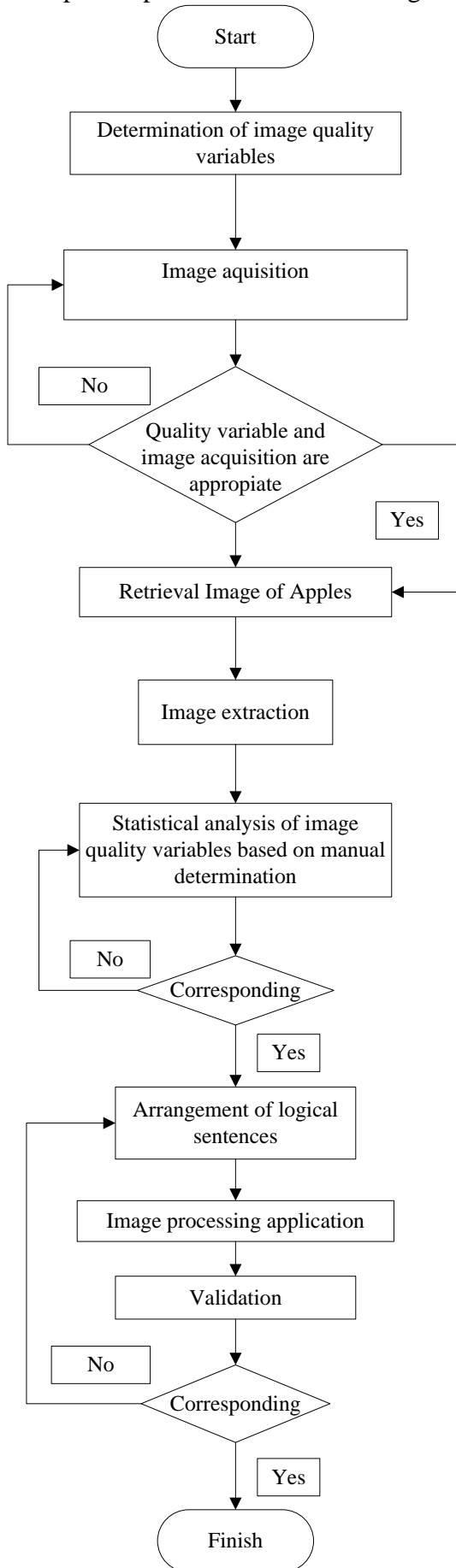

Figure 1. Research procedure

Table 1. Variable quality of Manalagi apple and image processing variable

No	Variable Quality of Manalagi apple	Variable of Image Processing	Description
1	Shape	Perimeter (P)	The image quality variable that can represent the shape characteristics of apples is the perimeter. Perimeters are expressed in units of pixels.
2	Size	Area (A), width (L), and height (H)	Size properties correlate with the variable image quality of the area, width, and height. The area, width, and height of Manalagi apple have pixel dimensions.
3.	Colour	r, g, and b	Quality variables of image processing that can represent the skin color of Manalagi apple are a red color index (r), green color index (G), and blue color index (B).
4	Defect	Defect area (C)	Quality variables representing damage are defective areas. The defect area is obtained based on the threshold function that can separate the area of Manalagi apple fruit from the area of damage. The area of defects of the fruit has pixel dimensions.

c. Image capturing

The apple image was captured by using a CCD camera. The image was taken according to the image acquisition process. The steps are below:

1. place the Manalagi apple on a white cloth as a background and under the CCD camera with the height and angle obtained from the image acquisition procedure.
2. recording images in RGB format.
3. save the file in the BMP format.

d. Image extraction

The data source of Image extraction was a converted image with a resolution of 1024 x 768 pixels. Image extraction was a process to measure the perimeter of the object, area, width, height, area of defect, and a color index of RGB (red, green, blue). Image extraction was conducted with a computer program made in advance using the Sharp Develop 3.2 programming language.

The procedure in image extraction are:

1. creating an Image Processing program in Sharp Develop 3.2, which could calculate object areas, and the RGB color index (red, green, blue).

2. calculating the perimeter of the Manalagi apple

3. calculating the area of Manalagi apple by counting the number of pixels constructing the apple area.

4. calculating the width of the Manalagi apple

5. calculating the color index of R (red), G (green), and B (blue) of the apple

6. calculating the defect area of the binarization process with the threshold function

analyzing collected data with statistics.
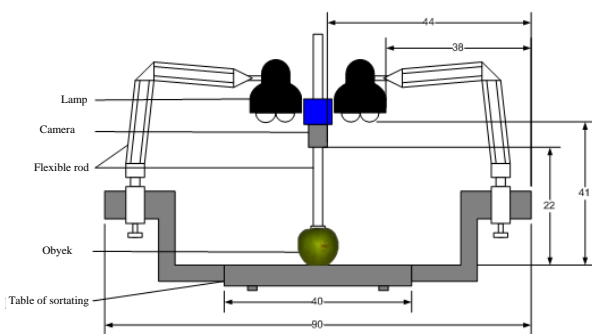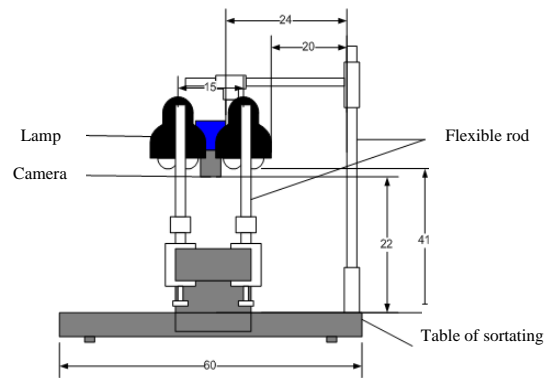
(a)   (b)

Figure 2. Image acquisition from the capturing table (a) the table looks from the front, (b) the table looks from the side

e. Evaluation of the correlation between image quality variables and manual sorting

The results of the data processing of the Manalagi apple image were carried out with a statistical analysis model. The statistical variables used were the average, standard deviation, Q1 (first quartile), median, Q3 (third quartile), minimum value, and maximum value. Furthermore, the values of quality variables that have been tabulated were illustrated in the boxplot graph.

f. Data processing

Procedures in data processing were:

1. collecting data on the quality variable of the apple image obtained from image extraction.

2. tabulating the value of the perimeter image quality variable with the sample number as the independent variable and the perimeter as the independent variable classified by each quality class.

3. calculating the average value, standard deviation, maximum value, and minimum value of the object area for each quality class. These values provided limits to the amount of the object area for each quality class.

4. plotting perimeter variables in the Box graph and whisker plot.

5. determining the boundary values that can be used to separate each sample based on their grade quality.

6. compiling logical statements based on the value limits derived from the statistical analysis.

7. repeating procedures 1-6 for other image quality variables, namely: Area and diameter, index r, g, and b, and area of defect.

8. merging the combination of logical statements with trial and error until the best level of conformity is obtained between the image quality parameters and quality class with the formula

(compatibility level = the number of correct predictions/number of samples x 100%).

g. Validation

Validation was an assessment of the performance or accuracy of the prediction of the Manalagi apple image processing application to the examples given during the training process. This process was conducted by providing data samples other than the training process and seeing the ability of the program to present the correct answer. This validation test was carried out by analyzing the confusion matrix analysis.

Confusion matrix analysis was used to obtain results that illustrate the validation of the program. Besides, the confusion matrix was a table that showed the visualization of the performance of an algorithm explicitly, especially at the supervised training stage. Each column in the matrix shows the predicted class, while each row shows the actual class. Outside the realm of artificial intelligence, confusion matrices were known as contingency tables or error matrices (NRCan in Soedibyo, 2012: 57).

Confusion matrix analysis was a step in the completion of the program in the form of a matrix. The results of predicted sorting were compared with the actual results of sorting. Validation values could be made according to the target in the program that had been made. If the validation value results in a large enough accuracy then there was no need to make improvements to the program and vice versa if the verification value was low then an improvement in the program was needed.

RESULTS AND DISCUSSION
Sorting Application of Manalagi Apple

Chemical analysis results are shown in Table The sorting application of Manalagi apple in this study was created using the SharpDevelop 4.2 program. This program was built to gain the quality variable of the Manalagi apple. Quality variables employed in the sorting process of the fruit were perimeter, area, height, width, the area of defects, and color indexes consisted R, G, and B. Appearance of the fruit sorting application can be seen in Figure 3.
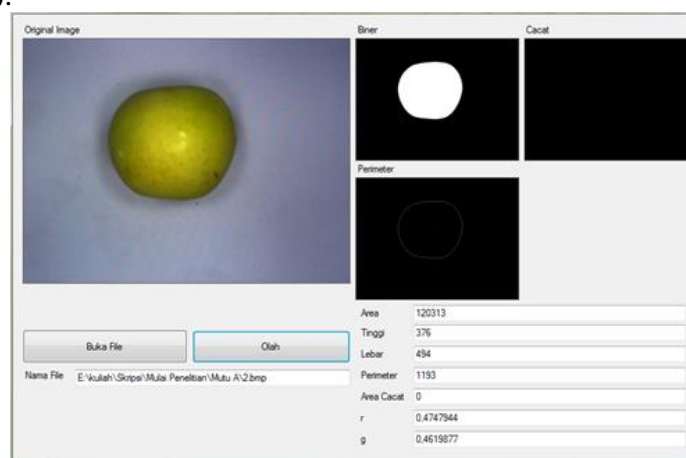

Figure 3. Sorting application of Manalagi Apple

Figure 3. is an appearance of the application used to analyze the image variables of Manalagi apple. In the application, there are two buttons designed to open and process images, four picture boxes arranged to display images, and eight boxes used to display file names and processed images. The procedures performed in the Manalagi apple image processing application are:
1. press the "Open File" button.
2. press the "process" button.

3. repeat procedure 1 and 2 until all the Manalagi apple samples have been processed.

Determination of Segmentation Boundary Value of the Background (Thresholding)

Thresholding is the process of separating a region with a background. The result of image thresholding is called a binary image. Threshold values are obtained from differences in the values of R, G, and B belonging to the object and values of R, G, and B belonging to the background.

Determination of the threshold value was obtained from sampling values of R, G, and B of objects and backgrounds. The sample points used in determining threshold values were ten points. Furthermore, the sample values were analyzed using graphs to determine the differences in the values of R, G, and B objects and background. From these different values, were determined the boundary values of R, G, and B that were able to distinguish between the objects and the background. The graph used to determine the background threshold function can be seen in Figure 4.
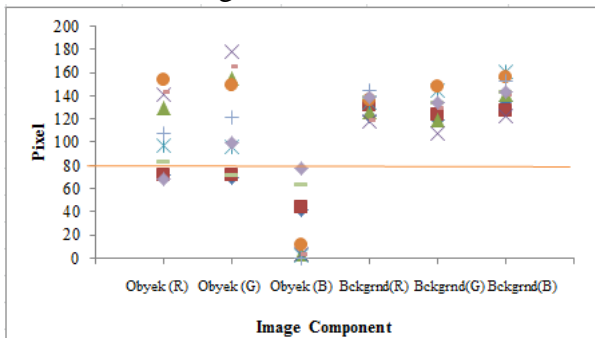
Figure 4. Distribution values of the objects and backgrounds RGB

Figure 4 showed the distribution values of R, G, and B of the ten sample points of Manalagi Apple. Based on Figure 4, in general the distribution values of R, G objects (apples) were almost the same as the values of background (cloth) distributions. The different distribution values were at value B.

The boundary value that distinguished between objects and background was right on B equal to 80. Thus, the background threshold function was when the original image had value B> 80, then the image would be black, otherwise, it would be white. Based on the boundary value, the black image was the background, while the white one was the object.

Determination of the Segmentation Boundary Value (Threshold) of Defect Areas

The threshold of the defect area is used to differentiate fruit defect area pixels from fruit area pixels. The determination of the threshold value was obtained from taking the ten sample points of Manalagi apple. Then, the sample values were analyzed using graphs to determine the differences in the values of R, G, and B in the defects area and fruit areas. The

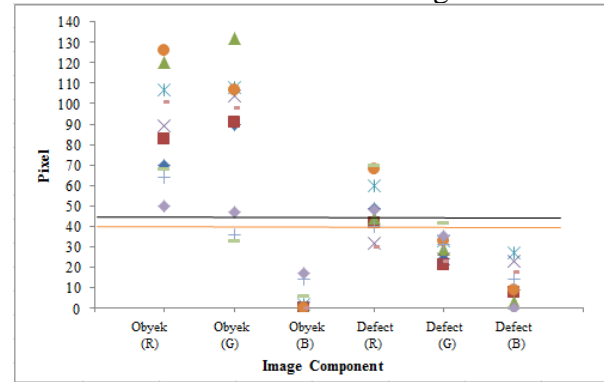graph used to determine the threshold function area for defects can be seen in Figure 5.

Figure 5. Distribution value of RGB of the defect and fruit Area

Figure 4 shows the distribution values of R, G, and B from the ten sample points of the Apple Manalagi defect. Based on Figure 4, the different distribution values are at the values of G and B.

Based on Figure 5, the threshold function of the defect area was when the morphological image was white-colored (R-value = G value = B value = 255) AND (R-value <45) AND (G value <40), so that it displayed the defect area image as white. Otherwise, it displayed the image of the defect area as black.

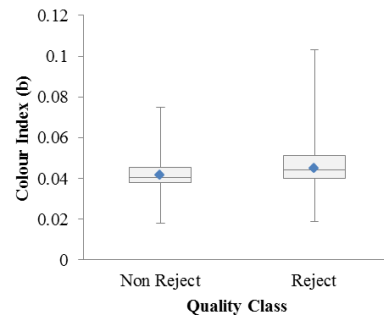**Statistical Analysis of Image Quality Variables**

The process of image extraction is the process of getting the value of the image quality variable through a 100 Manalagi apple sample base on the criteria of non-reject and reject. Statistical analysis of image quality variables was accordingly the result of the image extraction process on the quality variables perimeter, area, width, height, area of defects, and color index (r, g, and b). The results can be seen in the following figures.
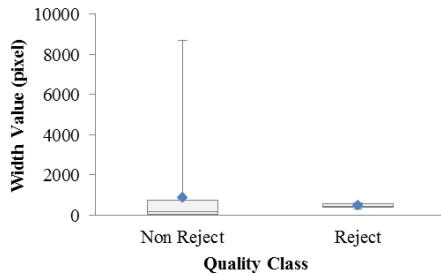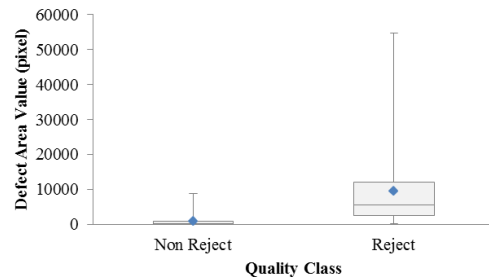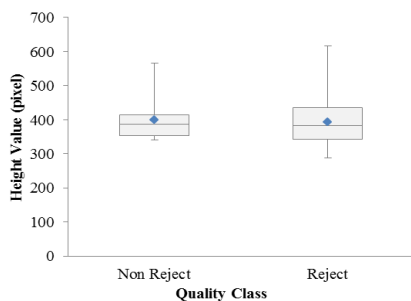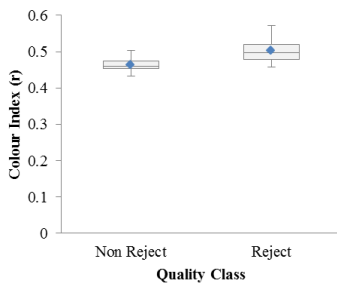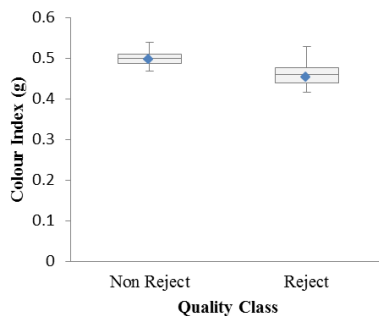

(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)
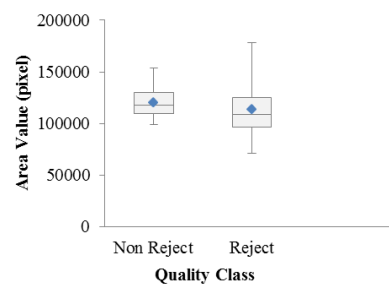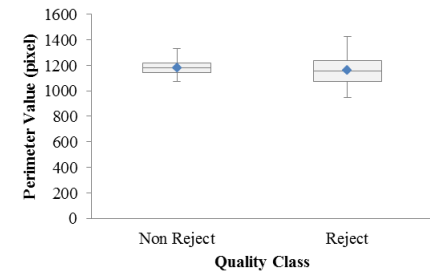
Figure 6. Statistical analysis of image quality variables (a) area, (b) perimeter, (c) height, (d) width, (e) red, (f) green, (g) blue, (h) defect area.

Based on figure 6 graphic, the image quality variables used in compiling the Apple apple sorting application were the area, perimeter, and defect area. These three variables have consistency that can classify apples by non reject and reject apple categories.

Determination of Logical Sentences

The first process in determining a logical sentence was figuring out the boundary value of the image variable used as a qualification reference. Then, statistical analysis was applied to analyze the image quality variables of the apples. Image quality variables that were employed as input in determining the boundary value were perimeter, area, and defect area. The value limits used for the sorting of apples can be seen in Table 2.

Table 2. Variable quality of Manalagi apple and image processing variable

Quality Variables	Quality class	
	Non Reject	*Reject*
Perimeter (P)	$1400 \geq P > 1070$;	$P > 1400$ Or $P < 1070$;
Area (A)	$154000 \geq A > 99000$;	$A > 154000$ Or $A < 99000$;
Defect Area (C)	$800 \geq C > 0$;	$C > 800$ Or $C < 1500$;

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The combination of logical sentences based on the boundary values was used as input for building the application were as follows:

1. And if perimeter≤1400, perimeter> 1070, area≤155000, area> 99000, defect Area> 0, defect area≤350, then sorting decision = "Non Reject"

2. Or if the perimeter> 1400, perimeter <1070, area> 155000, area <99000, defect area> 350, defect area≤1500, then sorting decision = "Reject"

The combinations of quality variables above were the best combinations by trial and error based on the results of the boundary value on each quality variable. Furthermore, the combination was inputted into the program making the Apple Sorting application again. The Apple Sort application has a sorting analysis result box named "Sort Results." The appearance of the Apple Sorting application can be seen in Figure 7.
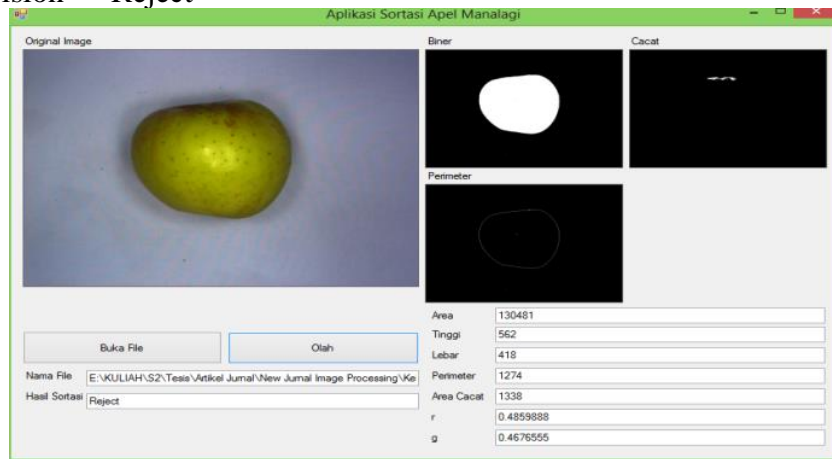

Figure 6. Application of Manalagi apple sorting

Application Validation of Manalagi apple Sorting

The assessment of the accuracy of the Manalagi apple sorting application was carried out on 30 samples of quality Manalagi apple.

The quality sample includes non-reject and reject apples. Testing the accuracy of this program is accomplished by the validation process using the confusion matrix. The results of the validation can be seen in table 3.

Table 3. Validation of the image processing application of Manalagi apple

Quality Class		Prediction		Total row	Prediction accuracy	*Error*
		Non Reject	*Reject*			
Actual	*Non-Reject*	11	4	15	73,33%	26,67 %
	Reject	0	15	15	100%	0%
Accuracy Total				86,65%		

Based on table 3, the total accuracy value was 86.65%. This value was obtained from the average prediction accuracy between non reject and reject. It can be concluded that the sorting application of the Manalagi apple could be applied with high accuracy.

CONCLUSION

Image quality variables used in the sorting of Manalagi apple were perimeter, area, width, height, index (r, g, and, b), and defect area. Furthermore, based on these variables, the variables used as input in the

sorting application are the perimeter, area, and defect area. The three variables were then combined in the form of logical sentences, which were then inputted in the Manalagi apple sorting application. Based on the validation test, obtained a total accuracy value of 86.65%. Thus, it can be concluded that the application sorting of Manalagi apple can execute the sorting with quite high accuracy.

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