Design of orange grading system based on real time image processing

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Abstract. Orange is one of preference agricultural products by consumers, because it has several benefits suchas vitamin C and antioxidants. The fruit is often used for gift when someone visits the relatives, thus the quality of orange is mostly detected by visual suchas size and skin color of the fruit. Determination of the quality is done manually because it takes faster. The manual grading has the weakness and less effisien, resulting several quality gradings and needs man power more. Using the man power tend to be subjective judgement. One of the ways to increase the productivity to determine the orange quality is that using grading methode using technology real time digital analysis mechanically. The aims of the resarch is to design of grading machine and grading program based on diameter and skin color of the orange that analysed by real time image processing. Based on the research result, this system can be applied on orange grading. The capacity of the manual grading is 1,276 fruit/hour,meanwhile capacity of the grading system is 712.87 fruit/hour. From the speed of the process and grading capacity, the manual methode is better instead of grading system using image processing. Meanwhile for the quality of the grading, Using the grading system based on the image processing can be said that it is suitable toward the standard. If using manual grading, it use the principle of habit, without really measure specifically and detail.

1. Introduction

Necessity of fruits, like orange fruit is going to increase in accordance with increament of the population, community income and awareness of the community related to the nutritions. Need on to the fruit also tend to increase due to the advance of technology and knowledge related to the fruit processing enables the food processing method will vary [4]. West Sumatera province has the superior commodity, then Gunung Omeh Siam Orange is one of the superior commodity. The characteristic of the orange is the sweet taste without bitter at all. The size of the orange is bigger than other Siam Orange, i.e Honey Siam Orange. The weight of one orange is around 300-400 g per fruit. The shelf life is also longer than others, i.e 18-22 days, and other 10-15 days.

The main important of the orange marketing is the quality of orange itself. The orange that will be sold and consumed have to fulfill the standard. Grading is the main activity in categorization of agricultural product based on specified criteria, i.e size, weight, and color. They must be in accordance with applying standard and consumer standard.

Orange grading mechanically is limited at this moment. Usually, the orange grading is done manually. Manual method was chosen due to this method is faster. However this method is bot efficient due to need number of workers. Using man power to grade the orange is subjective, because it

just based on human reception. Classification result tend to be inconsistence and experience the incorrect grading due to fatigue on human eyes.

An alternative in improvement of work productivity for orange grading is mechanical grading. Then the image processing can be used. Image processing analysis shows the artificial visual system using CCD (Charge Couple Device) camera as an optic sensor. Detect the fruit based on the color, size, and form visually in computer screen. Several research have been done in application of image processing for fresh fruit grade, i. E. Real time of the determination of mango quality by [2]. Orange grading system based on real time image processing analysis is expected to grade the orange fruit faster, high accuracy, and can be used in real time condition. This research aimed to design of orange grading machine based on real time image processing

2. Materials and Methods

2.1. Materials and tools

Orange fruit that has been used in this research is Siam Gunung Orange. Samples have been taken based on the day after the flower was blossom. The maturity levels that has been used are fruit that have been taken after flower blossom 180, 210 and 240 days.

Tools that have been used on this research are, bolt, nut, bearing, belt conveyor, conveyor ass, elbow plat, wood, lamp. Belt and pulley, cloth. This research also used electricity motor, speed reducer, computer, webcam for image capturer, screw driver, wrench, tachometer, sound level meter, vibration meter, grindstone, saw, scissor,ruler, vernier caliper, stopwatch and others workshop tools. Matlab 1010a as a software was used in this research.

2.2. Design of grading machine system

The research of orange grading consist of several functional pasrts as follow:

- *The frame of the grading machine wa made from iron and image box was made from wood*
- *Image box is mounted in the upper central part of iron frame and using lamp insideby range 27 cm from the object*
- *Webcam was mounted in theupper side of image box function as a tool to capture the objectwhenthe fruit come into the box*
- *Belt conveyor as a tool to transport the orange come into the image box and also as a backround of the picture*
- *Electricity motor and speed reducer are for moving the belt. Power transmission from the speed reducer to conveyor ass use belt and pulley.*
- *Computer is the main tool from grading activities. Ii is run by command from the program. And it will determine the grading based ondiameter and RGB*
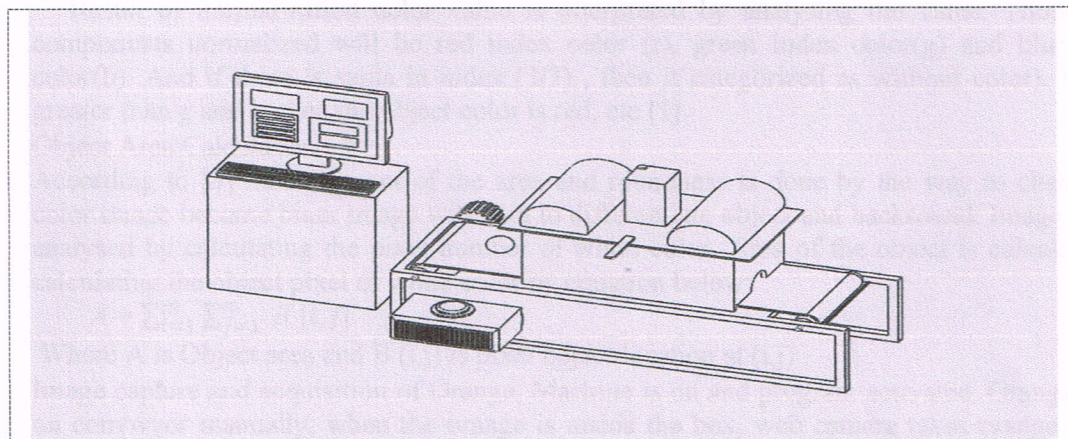
Figure1. Structure of Orange grading system design based on Real Time Image Processing

2.3. Design of Image analysis program for Orange fruit grading.

Design of image analysis program of orange grading uses Matlab 2010a software. Standard for orange quality parameter are based on diameterand RGB index, specially red (R). Steps of design of grading with the image processing as follow:

- Determination of the limitations of diameter and maturity level in accordance with orange class. This step formed the limitations related to orange diameter and maturity level according to SNI (Indonesian National Standard).

<div align="center">

Table 1. Orange Grading Quality Standard

Grade	Diameter (cm)	R-value (red)
A	> 7	> 0.34
B	6.1 – 7	0.33-0.34
C	5 – 6	< 0.33

</div>

- RGB color analysis (Red, Green and Blue).
  According to [1] color analysis using RGB color model is easy and simple,because the color information in the computer has been packed in the same model. The important thing is how we read the value of R,G and B in one pixel, show and interprete the color so that in accordance with what we expected.
  One of the simple ways to analyse and interprete the color into R,G,and B is by `normalization toward those three components.Normalization is important to be done, specially when the number of image is captured by different lighting. The result of each component of main color that normalized will omit ligthing effect, so that for each componentof color can be compared each others, although not so different [1]. Way to do the normalization as follow :

$$r = \frac{R}{R+G+B} \tag{1}$$
$$g = \frac{G}{R+G+B} \tag{2}$$
$$b = \frac{B}{R+G+B} \tag{3}$$

  Where : r = red color index, R = *Red*, g = green color index, G = *Green*, b = Blue color index and B = *Blue*.
  Result of normalization color value is interpreted by analysing the value. Those three components normalized will be red index color (r), green index color(g) and blue index color(b). And if there is same in index (1/3) , then it categorized as without color). If the r greater than g and b, then the object color is red, etc [1].

- Object Area Calculation
  According to [3] measurement of the area and roundness is done by the way to change the color image become biner image with aim to differentiate object and backround. Image area is analysed by calcutating the pixel number of white color. Area of the object is calculated by calculating the object pixel of white color by equation below:

$$A = \sum_{i=1}^{m} \sum_{j=1}^{n} B[i,j] \tag{4}$$

  Where A is Object area and B (i,j) is pixel object location at (i,j)

- Image capture and acquisition of Orange. Machine is on and program activated. Orange is put on convwyor manually, when the orange is inside the box, web camera takes orange image. When the image has been captured then the grading of the orange can be resulted.

- Program performance test.

This part is divided into two steps i.e; first is to do the comparison between manual grading and program grading. Comparison of the grading use sample 60 fruits. The result of comparison will show the error, that can be obtained from the designed program. And seconfd is to calculation of the capacity program in clasifying of orange in unit of time, time to image processing, and time to process all of orange fruit.

- Evaluation

In this step, the evaluation is done for checking back error level that happen when the grading is being done.Error on the program grading is approached by diameter determination equation, because the grading error usually occur due to error in using of such equation. If the equation related to image area toward diameter $R^2 \leq 0.90$, then program will be modificated until get the equation with $R^2 \geq 0.90$ that can be used for determinating of diameter value.

3. Results and Discussion

3.1. Grading machine design result

Process of orange grading machine design generate a tool using electical motor and speed reducer as a mover belt component. Rotation from speed reducer to ass of conveyor is transfered by belt and pulley. At the central part of the steel frame is fitted image box and at the upper part is mounted webcame for object capturing. When the machine is on, then, the conveyor will run , and also orange grading program is activated and grading result will be obtained in accordance with the orange class that determined. The result of machine design can be seen on Figure 2.
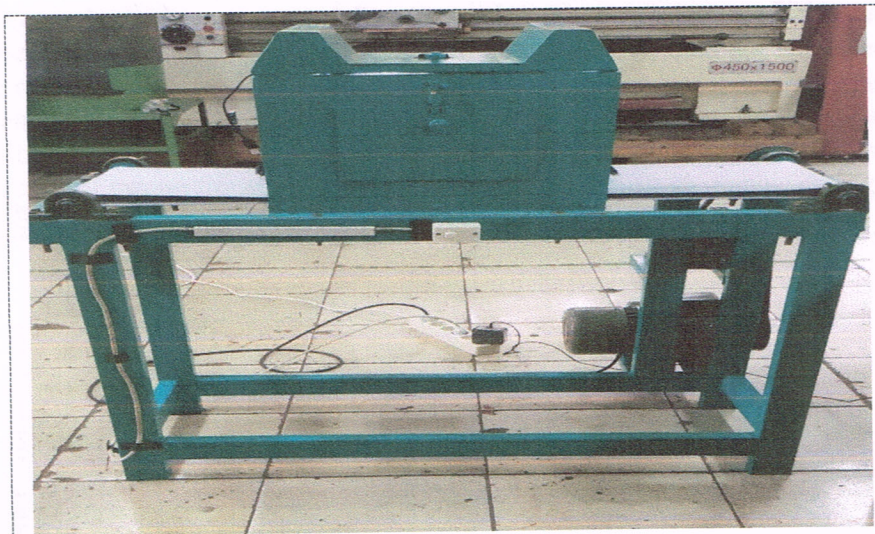

Figure 2. Machine of orange grading system based on real time image processing

3.2. Grading program design result

It has been resulted the program for analysing image for orange grading by using software matlab 2010a. Requirement orange quality used are based on diameter and RGB color, specially R (red). Program is able to do the orange grading in accordance with standard that has been determined.Visual display at the algorithm of image processing can be seen on Figure 3. At the visual display can be seen the diameter button, red value, grade, capture, select camera, reset and exit.
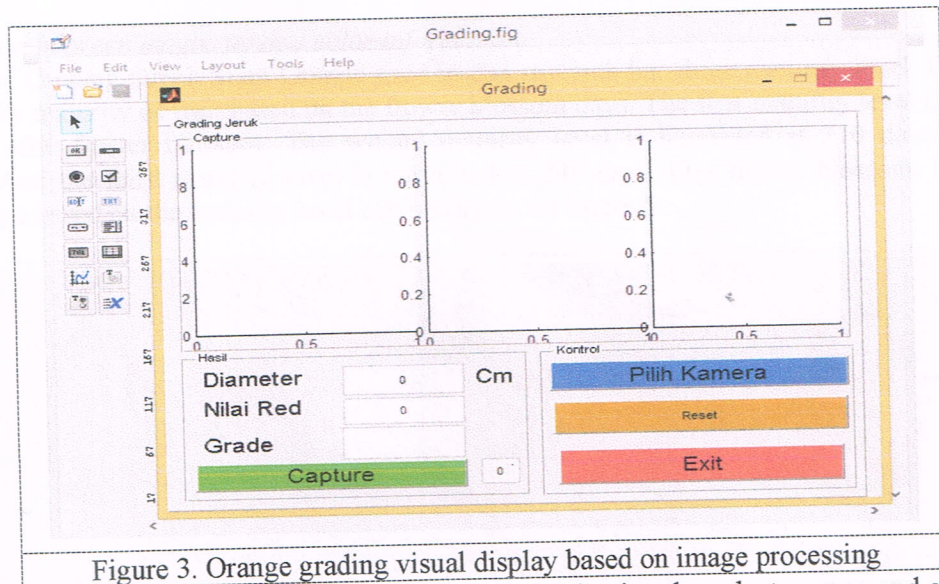
Figure 3. Orange grading visual display based on image processing

The process oh the program is started from program activation then slect camera and capture object and automatically , it will emerge the information of diameter and red value and grade information of orange. Exit button for exit from the program.

3.3. Parameter correlation between actual diameter and image processing result diameter

Diameter of the orange was measured by the digital vernier caliper, then the measurement of image area with the program was done. Measurement of image areaneeded for knowing diameter value from the designed classification program. Diameter value can be known by using equation that obtained from the relation between image area and orange diameter. The data of measurement of diameter manually and result of measurement of image area can be shown through graphic on Figure 4.
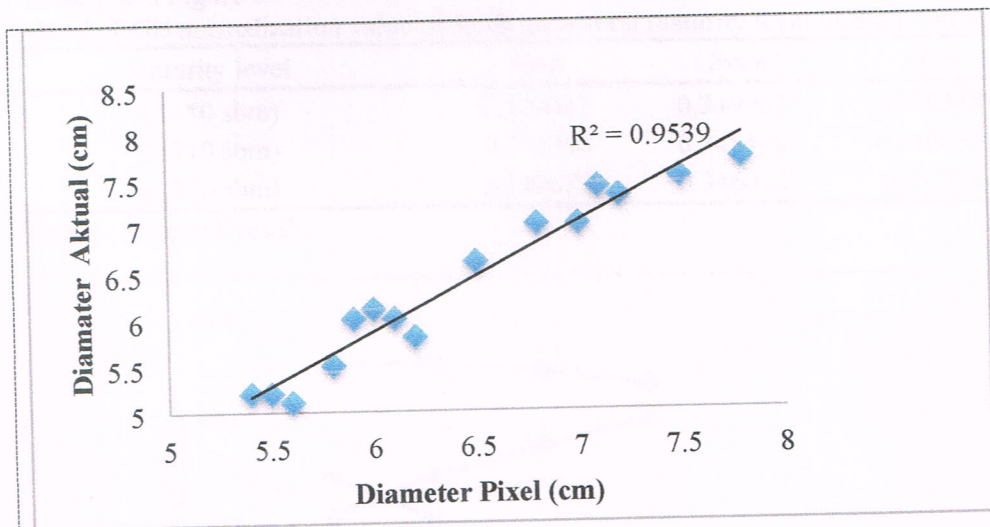

Figure 4. Graphic retalionship between actual diameter and measurement of diameter by image processing.

On the graphic can be seen that linier relationship between orange diameter image processing area nd actual measurement. It can be shown by R^2 (Determination coefficient) 0.9539. Based on the value of the determination coefficient, then, it can be concluded that the model of regression resulted has strong relation, so that the regression model can explain change of y, i.e. the actual orange diameter adequetly.

3.4. Relation between magturity and color information.

The fruit of Gunung Omeh Siam Orange used in this research has three maturity level. Distinghusing indicator for maturity of fruit based on the flower blossom days. The first maturity level is harvested at 180 days after flower blossom. The second maturity level is harvested at 210 days after flower blossom. And the third maturity level is harvested at 240 days after flower blossom. Figure of the Siam orange based on the maturity level can be shown on figure 5.

180 sbm   210 sbm   240 sbm
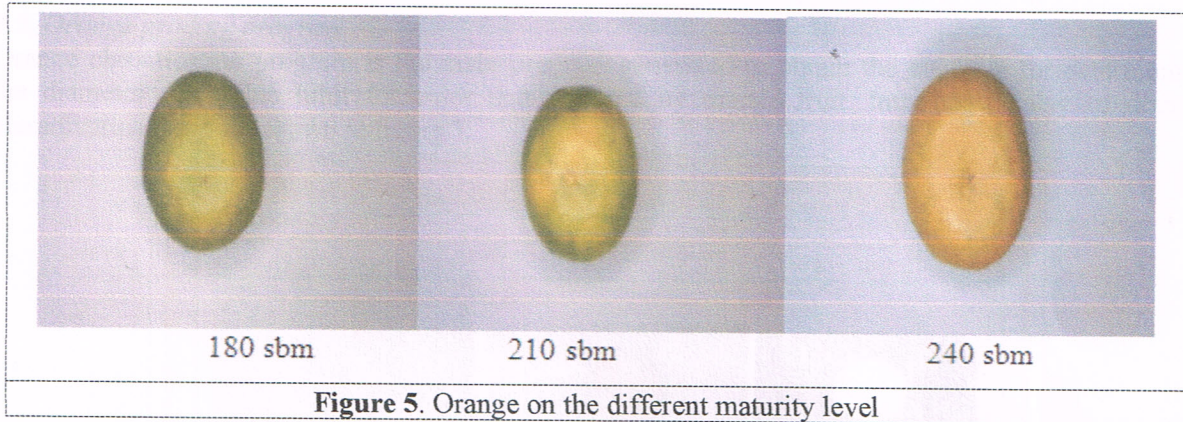
**Figure 5**. Orange on the different maturity level

Maturity level by using program of image processing can be measured by RGB index that can inform the color of orange skin. Index of RGB color taken from 90 orange samples that consist of couple colors based on maturity and quality classification. Determination of the maturity of the Siam Gunung Omeh Orange using matlab 2010a. The digital program produce the index level of color of red (R),green colorindex (G), and Blue color index (B).

The value of the RGB normalization connected by maturity level of Siam Orange fruit can be shown on Table 2 and Figure 6.

Table 2. RGB normalization value of RGB on several maturity level of Siam Orange.

| Maturity level	Red	Green	Blue
1 (180 sbm)	0,329087	0,349963	0,320348
2 (210 sbm)	0,334386	0,348538	0,316655
3 (240 sbm)	0,340679	0,346012	0,31366

Source : Research result
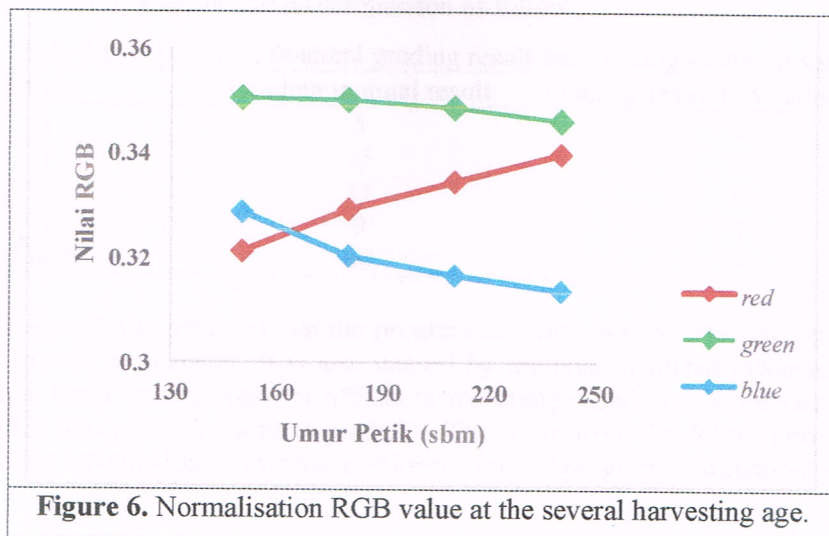
Figure 6. Normalisation RGB value at the several harvesting age.

Based on figure 6, it can be seen that the value of RGB normalization is able to classify Siam Orange fruit in accordance with the harvesting age. The value of RGB normalization shown distinguish of color from harvesting age 150 after flower blossom till 240 after flower blossom, so that it can be a refference to identify Siam orange fruit based on the maturity level. The three values of normalization taht will be used is value of R, which is able to classify of orange fruit in accordance with color appearance.

3.5. Orange grading program

Orange classification program is the main program generated to obtain the equation for determining the diameter and value limit for color that featured by orange fruit. Interface display of orange classification program shown at figure 7.
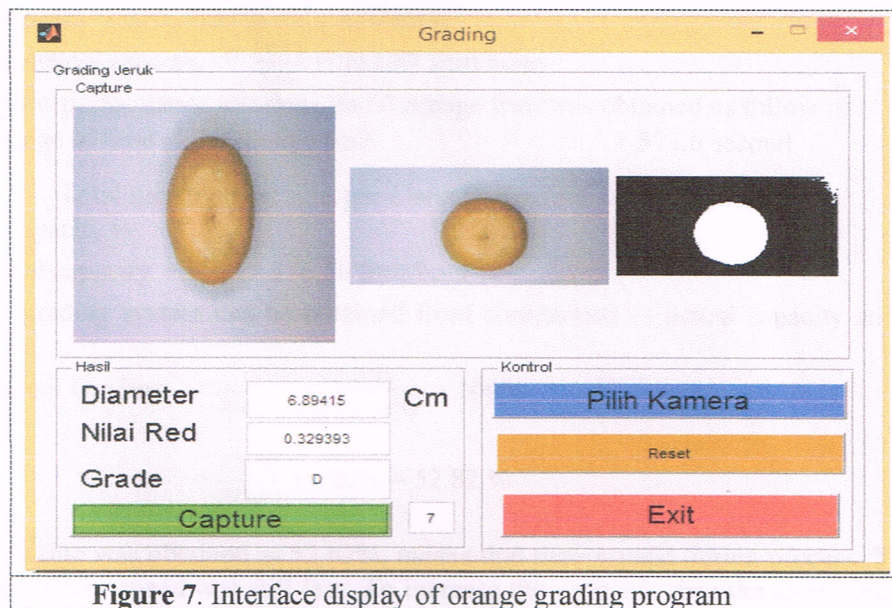
Figure 7. Interface display of orange grading program

Grading information from program will appear when the capture is clicked and result will come by real time. This step is orange grading program performance test by using relation between area of image and diameter of orange fruit and value limit determined before. Program test performance is done for knowing the weakness of the program and comparing the manual grading result . The samples used were 60 orange fruits.

Test performance result of grading and its comparison as follow :

Table 3.Comparison ofmanual grading result and grading system result

Grade	Grading manual result	Grading result of Grading system
A	5	4
B	35	40
C	11	9
D	9	7
Total	60	60

From the test done,it was obtained that the program accuracy was 87.5%, and error is 12.5%. The error occur due to eror in diameter. It is also caused by the area of image inconsistence toward the orange fruit shape. Error on the diameter affects to the orange grading, for instance, an orange that should be classified into grade A, came to grade D. The result from the color information is accurate enough. Because the information from manual information and program information is match.

3.6. Grading System Capacity

Orange grading system capacity can be known by calculating the time consuming when the grading process. The time used for testing the grading process manually and by system is shown at Table 4.

Table 4. time average of grading process for 1 orange fruit

Time for manual grading result (second)	Time for grading by grading system(second)
2.82	5.05

Theoretical capacity was used in grading system is:

$$\text{Theoretical capacity} = \frac{3600}{5.05} = 712.87 \text{ fruit/hour}$$

Time process for performance test done on 60 orange fruit was obtained as follow :

Average of time on 60 orange fruit = 573.6 second

Total time average per 1 orange fruit = 9.56 second

Then, actual capacity is

$$\text{Actual capacity} = \frac{3600}{9.56} = 376.56 \text{ fruit/hour}$$

Efficiency of grading system can be obtained from comparison of actual capacity and theoretical capacity

$$\text{Efficiency Sistem Grading} = \frac{\text{actual capacity}}{\text{theoretical capacity}} \times 100\%$$

$$= \frac{376.56}{712.87} \times 100\% = 52.82 \%$$

Efficiency value was obtained as 52.82%, means that time wasted during process. This thing occur because the conveyor speed was still less. To increase the capacity, then the speed should be turn up. Compared by manual method, grading pricess for 60 orange fruit done by 1 operator needs 12.94 minutes. Then the capacity of manual grading is $\frac{3600}{2.82} = 1,276$ fruits/hour.

Research result done can be known that ability of grading system is half of manual grading. Seen from process speed and capacity of grading, manual method is faster than program system and machine grading. Meanwhile, for the grading result, Using the grading system can be said that the result is approaching the quality standard compared than manual methode, which still usinghabitula principle without measusing the fruit specifically and detail.

CONCLUSION
Conclusion of this research can be withdrown as follow :
- Orange grading system has acuracy of 87%, with error level 12.5%
- Actual grading capacity from the grading system was 376.56 fruits/hour
- Eficiency og orange grading system was obtained 52.82 %.

References

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