ABE

Agricultural and Biological Engineering

https://ph04.tci-thaijo.org/index.php/abe/index

Published by the Faculty of Engineering, Khon Kaen University, Thailand

Research and development of a strawberry color sorting machine using Image Processing techniques

Sanong Amaroek[1]*, Manop Rakyat[1], Pongrawee Namwong[1], Niti Pookjit[1], Sorawit Chanchenchob[1] and Supattanakij Posawang[2]

[1]Chiang Mai Agricultural Engineering Research Center, Agricultural Engineering Institute, Department of Agriculture, Chiang Mai, Thailand

[2]Chiang Mai Agricultural Royal Research Center, Horticulture Research Institute, Department of Agriculture, Chiangmai, Thailand

*Corresponding author.
Email address: osanonga13@gmail.com

Received 24 July 2024
Accepted 21 August 2024

Abstract

The objective of this is to research and develop the strawberry sorter by using image processing technology. The machine size is 1,325 x 3,000 x 1,400 mm, a camera's 752 x 480 pixels resolution is used for color detection and IV-H1 software is used for image analyzing. The sorting system is automatically operated by PLC programmed control. The machine can sort 4 types of strawberry colors white, pink, red, and dark red. The test was done at 0.05, 0.08 and 0.10 m/s of sorting speed, and the result showed a good condition for strawberry grading at 0.05 m/s. The average sorting accuracy was 93.23% and the average working capacity was 3,214 fruits/h, compared with manual grading it is 2.15 times faster. The manual grading capacity was 1,494 fruits/h. The machine price is 150,000 THB, the operation time is 7 years and the break-even point is 4.81 years.

Keywords: Strawberry, Color sorter, Image processing

1. Introduction

Strawberry is a genus of flowering plants in the rose family. The results can be eaten. In the past it was grown as a ground cover for other cultivated trees. This may be where the name comes from. There are more than 20 species and many hybrids. But the strawberries that are most popularly grown today are garden strawberry fruit has a variety of flavors depending on the variety. Tastes range from sweet to sour. Strawberries are an important commercial fruit grown in a wide range of climates around the world.

Growing strawberries in northern Thailand the cost value of production per rai is approximately 25,000-30,000 baht and the income in return per rai is 62,500 baht (calculated from an average of 2,500 kg/rai and 25 baht/kg), while farmers on Doi Inthanon use the cost of production per rai. 30,000 - 35,000 baht and has an income of 72,500 baht/rai because it can be sold as fresh food to tourists and produce longer harvests than on flat land Normally, the produce will be released around November to May. In areas growing at high altitudes and between December and April in areas planted on level ground. The produce that comes out early in November and December will be of good quality. And the large size allows them to be sold at a high price of about 70-80 baht/kg in the general market. After that, the fruit size will be smaller and sold at a price of 20-30 baht/kg from January to mid-March. Currently, there is still market demand both within and abroad for the production of Industrial strawberries are produced in large quantities and are trending towards increasing according to the population Japan is Thailand's largest source of imported strawberries for processing (In the past, about 1,000-3,000 tons/year). In addition, there used to be a small amount of fresh edible fruit transported to sell to Hong Kong, Singapore, and some European countries, by the Royal Project Foundation [1].

Color sorting by the color on the object's surface is a device used to separate materials with different colors. It works by capturing images and analyzing them, comparing the results to a stored database. In the food industry, it is used to sort raw materials, fruits, and seeds in packing facilities [2]. Studied a method for sorting mangoes using a machine vision system. The system sorts mangoes by size, ripeness, and defects. Ripeness sorting is done by determining the ratio of the yellow area on the peel to the total area. This allows the system to identify overripe mangoes unsuitable for export with an accuracy of 93.40%. For mature but unripe mangoes, the accuracy is 68.10%, and for immature mangoes, the accuracy is 42.6% [3]. And studied a fruit sorting system using color image processing for high-speed automatic fruit sorting. Their experiment focused on grading the quality of Crystal Fuji apples. The quality grading was divided into three grades: Grade A, with more than 70% of the surface area being deep red; Grade B, with 40-70% of the surface area being red; and Grade C, with less than 30% of the surface area being red. The system achieved an average sorting accuracy of 90% [4].

Currently, the strawberry production process is in the process of sorting. Farmers have to sort out fruits that are too ripe and unripe fruit. There is still no machinery to help with the work, causing farmers to work late because strawberries bruise easily. Harvesting also takes into account the distance of transportation to the market. If the distance is long, 20-50% of the ripe or red fruits must be picked, which will result in hard fruits that are convenient for transportation. The time to store should be in the morning. When collected, the fruit should not be exposed to sunlight. Farmers collect strawberries by mixing different colors. If the fruit is too old, it will easily rot. Therefore, if there is research and development of machinery to help sort strawberry color, it will result in quality strawberries and can help reduce labor costs.

2. Materials and methods

2.1 Study the practices of farmers who sort strawberry fruit colors

Sorting the color of strawberries for fresh eating by farmers and purchasing plants currently, there are 4 colors: red, pink, dark red (too ripe) and white (not yet ripe). Selection is mainly done by manual labor. Samoeng District Chiang Mai Province in Thailand It is the source of the largest planting area in the northern region, approximately 4,000 rai. The most commonly planted varieties are Royal Variety 80, the colors selected for fresh consumption are pink and red, while the white and dark red ones are processed into other products such as dried strawberries and wine, etc. Therefore, for desired color of strawberry fruit there are 4 colors to sort: white, pink, red, and dark red, as shown in Figure 1.

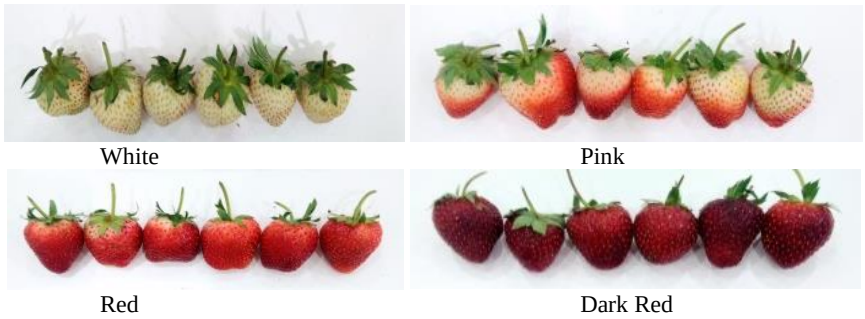

Figure 1 Farmers sorted strawberry fruit and fresh strawberry.

The color image processing program in this research uses the HSB color standard. Hue values in the program represent color values with degrees from 0 to 360 degrees according to the standard color wheel. Saturation values will start at 0 to 300 if specified. Saturation is set to 0. The color will be less bright, but if set to 300, the color will be very bright. The Brightness value will start at 0 to 300. If set to 0, the brightness will be low, which will be black, but if the value is set to 300, the color will be bright [5]. Test the camera uses a camera to detect color images with a resolution of 752 x 480 pixels. The camera is focus adjustment is automatic. The illumination is a white LED. The lighting method uses DC lighting because it provides continuous light. Install the camera at a distance of 150 mm from the object. Then take the colors of strawberries you want to sort: white, pink, red, and dark red. Come do color photography. The process the images using the IV - H1 package to separate the color values of the strawberries that need to be sorted as shown in Table 1.

Table 1 Strawberry color value obtained from image processing

Color of strawberry	**Hue**	**Saturation**	**Brightness**
	(H)	**(S)**	**(B)**
White	30 - 35	77 - 130	144 - 220
Pink	3 - 17	132 - 198	112 - 180
Red	5 - 11	183 - 222	120 - 204
Dark red	357 - 27	81 - 251	24 - 216

2.2 Design and build a prototype of a strawberry sorting machine using Image Processing techniques

Carry out the design and construction of a preliminary prototype. The machine has dimensions of width 1,100 mm, length 2,800 mm, height 1,200 mm. It can sort strawberry colors into 4 main colors: dark red, red, pink, and white. and at the end there is another basket to accommodate colors that have fallen into grades or colors. that cannot be selected and specify that the machine has the ability to work not less than 3,000 fruits per hour, as shown in Figure 2 and Figure 3.

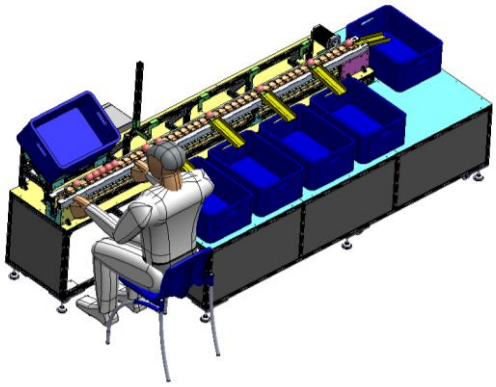

Figure 2 Model of strawberry color sorter using Image Processing technique

Figure 3 Preliminary prototype of strawberry color sorter using Image Processing technique

The working principle of the machine is to feed strawberries onto a conveyor belt. The camera will take a photo and the program will process the strawberry color image when the camera detects a strawberry color according to the value set in the program. The processing program then sends out put to the Programmable Logic Controller (PLC) to operate the pneumatic solenoid valve, sorting strawberries by color into each basket.

In the case where the camera detects a dark red color, the image processing program sends a signal from the amplifier output 1 data collector to the PLC to command the solenoid valve to blow air into basket 1.

When the camera detects red strawberries, the image processing program sends signals from the amplifier output 2 data collector to the PLC to operate the pneumatic solenoid valve to blow into the second basket.

When the camera detects a pink strawberry, the image processing program sends a signal from the amplifier output 3 data collector to the PLC to operate the pneumatic solenoid valve and blow into the third basket.

When the camera detects white the image processing program sends a signal from the fourth amplifier output data collector to the PLC to command the solenoid valve to blow air into the fourth basket. In the case of the strawberry color shade that was set did not match. the machine then released the strawberries into the basket at the end of the conveyor belt.

2.3 Testing a prototype machine compared to manual labor

Once the prototype machine is completed, test the prototype machine against manual labor for sorted strawberries by color. The indicators used are accuracy (%) and work capacity (fruits/h), as shown in equations (1) and (2).

$$\mathrm{ACC} = 100 - \mathrm{Error} \quad (1)$$

Where ACC is the sorting accuracy of the machine and manual labor (%) and error is the percentage error in sorting strawberries by color (%).

$$CAP = \frac{NS}{T} \quad (2)$$

Where CAP is the work capacity of the machine and manual labor (fruits/h), NS is the number of strawberries sorted (fruits), and T is the time for sorting strawberries (h).

3. Results and discussion

Results of preliminary testing of the prototype at a sorting belt speed of 0.05 m/s found that the machine sorted strawberry fruit colors with an average accuracy of 88.33%, with an error of 11.67%. The error occurred due to light from outside interfering with the light. And while sorting, there was a problem with strawberries falling into the space between the sorting belt and the chute, while releasing into the sorting basket.

From the preliminary test results of the machine, the prototype was improved and developed. They designed and built a camera housing room on the sorting conveyor. To solve the problem of light interference from outside and has improved the new belt rail as shown in Figure 4 by designing a new end belt. Install the rail closer to the belt to solve the problem of strawberries falling out into the space between the sorting belt and the rear rail, the improved prototype is shown in Figure 5.

Figure 4 Install the camera cage on the sorting belt before adjustment (Left) after adjustment (right).

Figure 5 Improved and developed prototype.

A test prototype was then conducted to select the sorting belt linear speed. It was tested at the sorting belt linear speed of 0.05, 0.08 and 0.10 m/s, as shown in Figure 6. From the test results, it was found that the machine operating at the sorting belt linear speed of 0.05 m/s gave the best test results. The machine has an average accuracy of 93.23%. The machine's working ability is an average of 3,214 fruits/h.

Figure 6 Test the prototype machine.

As for sorting the color of strawberries using human labor, it was found to have the ability to work an average of 1,494 fruits/h with an average accuracy of 88.38%. The test results are as shown in Table 2 and randomly collected strawberry fruit samples to check the bruises of the selected strawberries, with a prototype machine compared to manual selection Stored for 24 h at room temperature, no damage was found from machine-sorting and manual-sorting.

Table 2 Strawberries color sorter test summary

Linear speed (m/s)	Accuracy (%)	Capacity (fruits/h)
0.05	93.23	3,214
0.08	85.55	3,812
0.10	80.36	4,531
Laborer	88.38	1,494

4. Conclusions

Design and development of a strawberry color sorting machine using image processing techniques. The machine has dimensions of width of 1,325 mm, length of 3,000 mm and height of 1,400 mm. As for the strawberry color image detection camera, this research chose to use a color image detection camera with a resolution of 752 x 480 pixels and used the IV-H1 ready-made program to read. Receive images from the camera and image processing using the machine by feeding strawberries into the machine, the color sorting system will work automatically, controlling the sorting mechanism with a PLC program. The prototype machine can sort strawberry fruit colors into 4 colors: white, pink, red, and dark red, at the end of the belt of the machine, there is another basket to accommodate strawberries that are out of grade or that cannot be selected. Machine test results at sorting belt linear speeds of 0.05, 0.08 and 0.10 m/s. Sorting belt speed of 0.05 m/s, gives the best test results, the machine has an average accuracy of 93.23%, with an average working ability of 3,214 fruits/h. The manual selection has an average working ability of 1,494 fruits/h, with an average accuracy of 88.38%. The sampling checked the bruises of the strawberries, no bruises were found in both manual and machine screening. Comparing the capacity of sorting using the machine is approximately 2.15 times faster than manual selection by farmers using manual labor. The prototype machine costs 150,000 baht, has a useful life of 7 years, and has a break-even point of 4.81 years.

5. Acknowledgements

Thank you to the staff of the Chiang Mai Agricultural Engineering Research Center for build and testing the prototype machine, as well as farmers, farmer groups and packing factory strawberries in Samoeng District Chiang Mai Province that provides a place to test the prototype until the set objectives.

6. References

[1] Phiphattanawong N. Growing strawberries [Internet]. 2001 [cited 2017 Jun 17]. Available from: http://www.ku.ac.th/e-magazine/january44/agri/strawberry.
[2] Pornchalempong P, Rattanapanon N. Color sorter. 2015 [cited 2017 Jun 18]. Available from: http://www.foodnetwork solution.com/wiki/word/2320/color-sorter.
[3] Poonnoi P, Tansakun A. Mango sorting by machine vision system [dissertation]. Bangkok: King Mongkut's University of Technology Thonburi; 2005.
[4] Feng G, Qixin C. Study on color image processing based intelligent fruit sorting system. Proceedings of the 5th World Congress on Intelligent Control and Automation; 2004 June 15-19; Hangzhou, P.R. China: IEEE Robotic and Automation Society; 2004. p. 4802-4805.
[5] Onnuam S. Principles of using color and light in computers [Internet]. 2013 [cited 2017 May 10]. Available from: http:// www.krumoocenter.com.