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# The Use of Image Processing and Sensor in Tomato Sorting Machine by Color, Size, and Weight

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***Abstract*— Tomatoes are a popular vegetable in Indonesia, where production increases every year according to market demand. The large production requires proper post-harvest handling both in quality and time. It has been well-known that sorting and grading are the first and foremost processes in the post-harvest process of tomatoes. Sorting tomatoes can be conducted by color and adjusted to the target market. The automation process in the post-sorting and grading process can save time and resources. This research proposes a sorting system that sorts tomatoes based on color, size, and weight. Tomatoes are sorted by red, yellow, and green colors. The detection of color and size was carried out by image processing with the OpenCV library. The color detection was carried out by HSV's red, yellow, and green values. In comparison, the dimensional measurement was carried out by determining the outermost point of the detected object both vertically and horizontally. At the same time, tomatoes' weight was measured by a weight sensor. This system was implemented into a prototype sorting system with a webcam, Arduino, a conveyor, and motors. The final part was a storage box used to accommodate tomatoes based on grading. The implementation has the maximum results for detecting color with 100% accuracy and measuring weight with 95% accuracy. However, it still needs development for dimensional measurements. In this research, it has only 5% accuracy. This proposed system can be used both in software and hardware design as an inline tomato sorting tool.**

***Keywords*— Tomatoes sorting; color detection; size measuring; load cell; image processing**

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## I. Introduction

Tomato is a horticultural vegetable plant that is quite popular. The tomatoes are also commonly used in various dishes. Tomato production, according to data from the Central Statistics Agency (BPS), in Indonesia for all provinces in 2020, reached more than 1 million tons [1], [2]. Their usage and marketing also determine the process of harvesting tomatoes. Tomatoes must be harvested fresh, i.e., ripe and red on the tree. However, if they are distributed far, they are harvested in a green state, which will ripen in about 3-7 days. For medium distance marketing, they can be harvested in a yellow state. An improper harvest sorting process causes a 40-50% reduction in fresh produce. It is due to the physiological nature of fresh horticultural products, which are easily damaged [3], [4].

The sorting process of tomatoes according to color and quality is the first step in the post-harvest process. This process is crucial to maintain freshness during the harvesting process and distribution to marketing places. The sorting of large quantities of production will be quite time-consuming. Therefore, the automatic selection process is expected to reduce the post-harvest processing time to speed up the marketing process and reduce less-fresh produce.

Several studies are focusing on sorting tomatoes by color. In research [5]–[7], tomato color detection implemented a color sensor, and tomato color was detected to determine the level of ripeness of tomatoes. While in research [8]–[16] for the detection and classification of tomato color using image processing, computer vision, and artificial intelligence. This study implemented image processing as a color classification of tomatoes based on the value of HSV (Hue, Saturation, and Value).

In addition to color, this study also grouped the tomatoes based on size and weight. The quality of tomatoes can also be grouped according to size, determining to what grade the tomatoes belong. There are several levels of grade or size, namely the first class (grade A), the second class (grade B), and the third class (grade C). Each tomato is collected or included based on its grades in a different box or container. Classification will determine the price of tomatoes.[3].

Previous research that measured tomatoes' dimensions [17], [18]. Dimensional measurement is based on the number of pixels detected as a white area (a tomato object) and compared with the entire image frame. Research by Behera et al. [19] measures dimensions based on the total pixels in the captured image to classify the type of tomatoes. Meanwhile, a study [20] built algorithms to estimate of size and shape of tomatoes using artificial vision techniques. The study by de Luna et al. [21] estimated tomato size using Thresholding, Machine Learning, and Deep Learning Techniques. Thus, the recent study by Yang et al. [22] used spectroscopic analysis to estimate tomato size. In this research, the dimension measurement was carried out by providing a reference point and converting the number of pixels from the two measured points into distance units (cm).

Another determinant of quality is the weight that determines the storage capacity. Previous research by Nyalala et al. [23] made predictions of weight and volume based on image processing. Meanwhile, research [24] used artificial intelligence to estimate the weight based on the volume of tomatoes. In this study, the weight of tomatoes was measured using a load cell.

This study examines the effect of object distance to the camera, light intensity, and processing time in color detection. Overall, the study sorted the tomatoes based on color and size using image processing and weight measurement using separate hardware. The final result showed that the sorting device was in the form of a conveyor and grouped tomatoes according to grading based on color, size, and weight.

## II. Material and Methods

This section describes the design and implementation of a tomato sorting system based on color, size, and weight.

### *A. The Design of Tomato Sorting System*

In the sorting process, the tomato grouping was divided into three groups/grades, with each grade having the criteria according to Table 1 below.

TABLE I
GRADING CRITERIA

| Grade | Color | Size HxW(mm) | Weight (gr) |
|---|---|---|---|
| A | Red | 47x46 | 58-60 |
| B | Yellow | 47x43 | 43-45 |
| C | Green | 38x40 | 33-35 |

Based on the grouping in Table 1, the main criteria are based on color, then weight, and size. Each grade will be put into different final placement boxes. The sorting by color and size implemented image processing with input taken via webcam. Meanwhile, to measure the weight of tomatoes, it used a load cell sensor.

The color detection was carried out by looking for the red, yellow, and green HSV values. The value search started from low value to high value, as shown in Table 1. The examples of colors with low and high values are in Figure 1.

(a) (b)

Fig. 1 Red color (a) Low color (b) high color

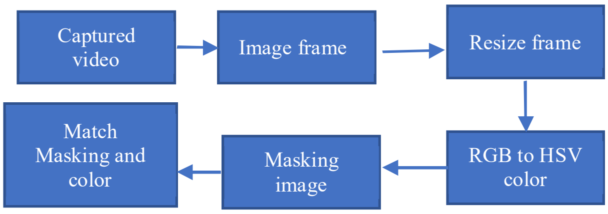



Fig. 2 Flow Diagram of Color Detection

The input from color detection is from the image frame resulting from the captured video. The frame image size remains by the camera resolution to lighten the process; the frame size is reduced by 50%. The next process is the conversion of color formats from RGB to HSV format. The frame image will be masked, and the masking results having the largest dimensions will be categorized into colors that match their masks.

The dimensional measurement was carried out by determining the outermost point of the detected object vertically and horizontally. In Figure 2, a red dot is the outermost point of the tomato detection results, and then it was calculated between points vertically and horizontally.

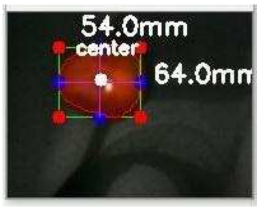



Fig. 3 Dimension Measurement

The following components are required for the sorting system development:

*1) Conveyor:* The conveyor serves to carry and move tomatoes to the storage box. The conveyor requires a power voltage of 12 Volt and has a dimension of 20x30 cm. It also has a roller, belt, and DC motor to move the conveyor. Figure 4 shows implemented conveyor.

Fig. 4 Conveyor

*2) Two motor servos, type of MG955 and MG90s:* Servo motors with models MG995(shown in Figure 5) and MG90S (shown in Figure 6), which each consist of 3 jumper cables (VCC, GND, Data). The servo motors act as a switcher, which is a tool that classifies tomatoes based on the specified data. In addition, the servo motors also function as a driving force for tomatoes to fall onto the conveyor.

Fig. 5 Motor Servo MG995R

Fig. 6 Motor Servo MG90S

*3) Load Cell connected to HX711model:* A load cell is used to measure tomatoes' weight. As shown in figure X, the load cell is connected to get accurate data from the load cell.

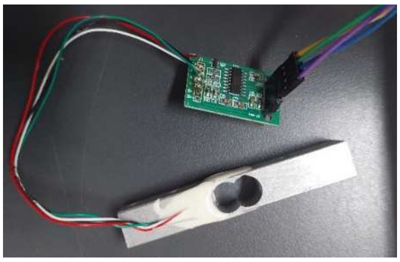


Fig. 6 Load cell and HX711

*4) Arduino Uno:* Arduino Uno (shown in Figure 7) gets data that consists of the color and size of tomatoes from the laptop. Arduino also receives data from the load cell. In addition, Arduino controls the motor according to the input.

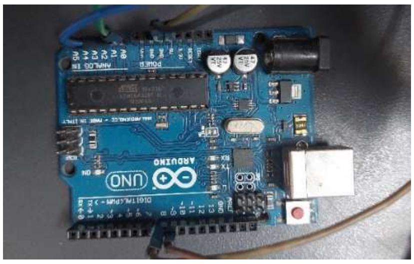


Fig. 7 Arduino Uno

*5) Webcam with 720p resolution directly connected to the laptop:* The webcam (shown in Figure 8) is used to capture images to detect tomatoes' color and size dimensions. Operation using the OpenCV program with the Python programming language so that the webcam can detect red, yellow, and green colors.

Fig. 8 Webcam

The connection of each component can be seen in Figure 9.

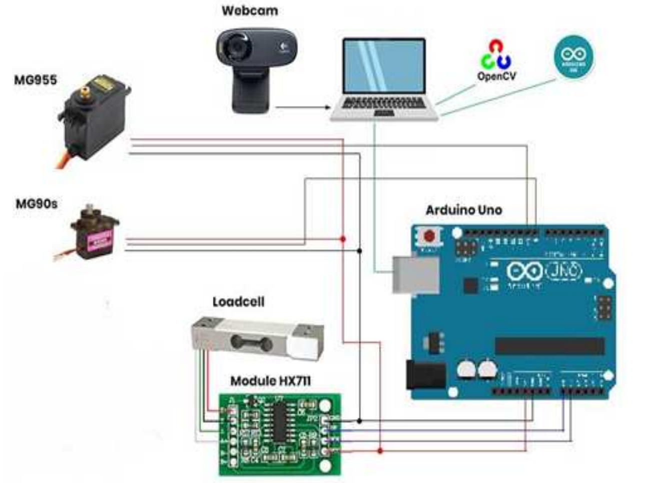



Fig. 9 The Connection Setup of Tomato Sorting System

The computer carried out the color and dimension detection, and the input was obtained from the capture camera. OpenCV processed captured image to run color detection and dimension measurement programs. In contrast, a load cell combined with the HX711 module and processed by Arduino carried out the weight measurement. Arduino also carried out control on servo motors and DC motors, which was to control the motor at the end when grouping tomatoes according to class after receiving color data sent from the computer to Arduino.

Overall, the workflow of the system is shown in Figure 10.

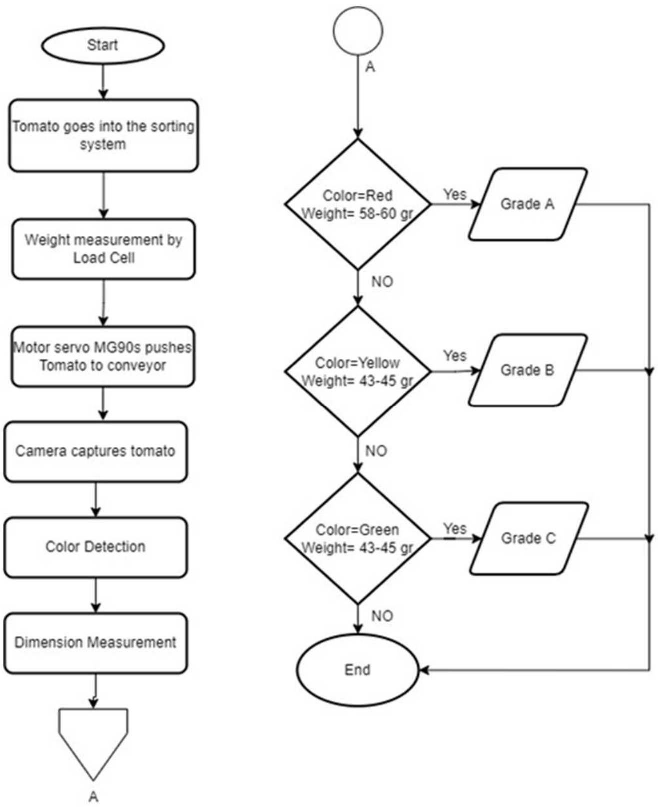



Fig. 10 Flow Diagram for Color Detection and Dimension Measurement

### B. System Implementation

The system was implemented as a conveyor with the latest process was the storage box based on their specified grades. Figure 11 shows the prototype of the tomato sorter.

The orders of the system are as follows:

- The tomatoes roll and fall onto the weight sensor and are held by the servo motor,
- The weight sensor takes the result of tomatoes' weight,
- Servo motor pushes the tomatoes to the conveyor,
- At the same time, the conveyor brings the tomatoes to the webcam process to carry out the color detection process and take the results of the tomatoes' dimensions,
- The conveyor then carries the tomatoes to the grade sorting servo motor,
- The servo motor then sorts the tomatoes by their class.

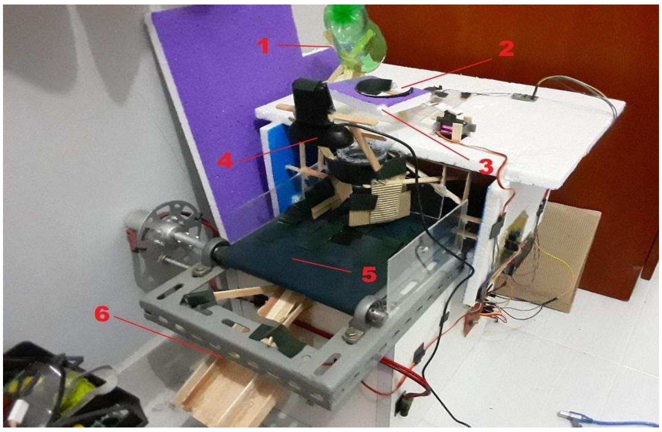



Fig. 11 Prototype of Tomato sorting system

## III. Result and Discussion

### A. Color Detection

The color testing was carried out by taking input via a webcam with a 720p resolution. Color detection was performed on the HSV color format. The initial testing was conducted by carrying out some experiments to determine the range of HSV values for red, yellow, and green colors based on the actual color of tomatoes. The test results are shown in Table 2.

TABLE II
THE TESTING OF HSV VALUE OF COLORS

| Color | Low Color | High Color |
|---|---|---|
| Red | 0,135,40 | 12,255,255 |
| Yellow | 14, 220, 35 | 45.255.255 |
| Green | 24, 110, 19 | 87, 255, 245 |

Table 1 shows that the detected HSV value with the maximum value of Hue was [87], Saturation was [255], and value was [255]. The colormap from HSV value for each color shows in Figure 12.

For tomatoes detection, it was directly affected by the distance between the camera and the object and the intensity of the light. The glossy surface of the tomato causes the detectable parts to separate from the tomato parts. The test results in Table 3 are the results of tomato detection tests to distance and light intensity.

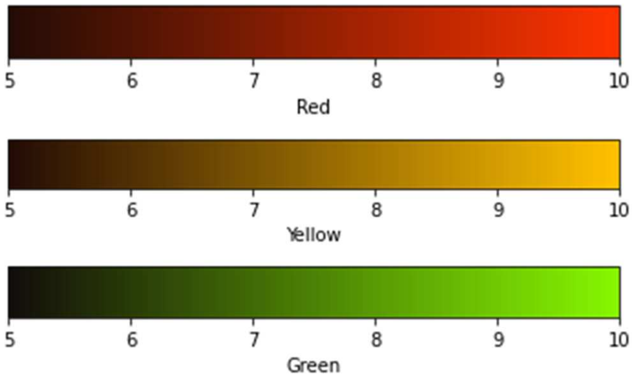



Fig. 12 HSV Colormap for Detection Color

TABLE III
THE TESTING OF LIGHT INTENSITY ON IMAGE CAPTURE RESULTS

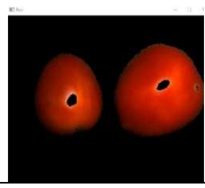
| Captured Image | Preprocessing Image | Light Intensity | Notes |
|---|---|---|---|
|  |  | 3% | Not visible at all and blur |
|  |  | 15% | Slightly visible but blur |
|  |  | 35% | Visible but too bright, which makes it blur |
|  |  | 55% | Very Visible and not blur |

Table 3 shows the results of the tomato images clearly visible at the light intensity of 55%, and the light was not too bright on the tomatoes. Thus, the next test was carried out under conditions with a light intensity of 55%. The object distance to the camera was tested at the next distance, namely the effect of 0-200 cm distance. The best capture results were when the distance between the camera and the object was 30-50 cm. The color detection tests were carried out at 55% light intensity and a camera-object distance of 30 cm based on the distance and light intensity measurements. The results of the color detection test are shown in Table 4.

TABLE IV
THE TESTING OF COLORS DETECTION

| Color | Required Time | Accuracy Level |
|---|---|---|
| Red | 6.747s | 100% |
| Yellow | 5.818s | 100% |
| Green | 6.878s | 100% |

In this test, the accuracy of color detection was 100%, and the time required to detect tomato color in the image processing process was 5 to 6 seconds. It occurred because the conveyor moved slowly and affected the time required to detect the color.

### B. Dimension Testing

This test recorded the results of the webcam test to obtain dimensional measurement data, where the data proceeding aimed to test the level of accuracy of dimensional measurements and the time required to detect the dimension size using the webcam. The accuracy was compared with the results of manual measurements using a ruler. The examples of manual measurements and the results of dimension measurements using image processing are shown in Figure 13. In contrast, the test results are shown in Table 5.


(a) (b)

Fig. 13 Dimension Measurement (a) manual measurement of the width and height of tomatoes (b) measurement results with image processing

TABLE V
THE TESTING OF WEBCAM ACCURACY LEVEL IN DIMENSIONS MEASUREMENT

| Testing to | Initial Measurement of Width | Initial Measurement of Lenght | Measurement Result with Webcam | Final Explanation | Accuracy Level |
|---|---|---|---|---|---|
| First | 40mm | 43mm | 78mmx64 mm | Final Result of Length and Width | 5% |
| Second | 33mm | 39mm | 64mmx54 mm | Final Result of Length and Width | 5% |

This test found that proceeding with dimensional measurement data using the webcam was not accurate. The accuracy level of dimensional measurements using a Webcam was only 5% if the tomatoes were moved; the dimension size values changed drastically. The dimensional size values were relatively inconsistent.

### C. Weight Testing

This test shows the results of the weight sensor test were recorded to get the weight value of tomatoes, where the value is captured and aims to determine the accuracy level of weight measurement using the weight sensor. The accuracy was compared with the results of manual measurements using the weighing device. Examples of manual measurements and measurement results with load cells are shown in Figure 14. Test results are shown in Table 6.


(a) (b)

Fig. 14 Measurement with Scales and Load Cell

TABLE VI
WEIGHT SENSOR ACCURACY TESTING

| Tomato | Initial Weighing | Score result with Weight Sensor | Accuracy Level |
|---|---|---|---|
| First | 34 grams | 34.15 grams | 95% |
| Second | 47 grams | 47.24 grams | 95% |
| Third | 50 grams | 50.29 grams | 95% |

In this test, it was found the accuracy level of getting the weight value using the weight sensor was 95%. The weight sensor obtained satisfactory results; the measured weight value was similar to the ordinary scale.

## IV. CONCLUSION

The results of the sorting system implementation were in the form of a prototype conveyor with supporting components such as motors, cameras, load cells, and Arduino Uno. The color and weight-based sorting system had high accuracy, 100% for color detection and 95% for weight measurement. The color detection was affected by the distance between the object to the camera and light intensity. Meanwhile, sorting by size depended on the color. It can also be developed to detect tomato types such as grape tomatoes, cherry tomatoes, and many more. The dimensional measurements need further development. Overall, the sorting system was successful. Further work can be studied on color detection with tomatoes that have random color distribution to determine the ripeness of tomatoes.

## REFERENCES


[1] BPS - Statistics Indonesia, “Produksi Tanaman Sayuran 2020.” .

[2] BPS - Statistics Indonesia “Produksi Tomat Menurut Provinsi, 2015-2019.”.

[3] D. Nofriati, *Penanganan Pascapanen Tomat*. Jambi: Balai Pengkajian Teknologi Pertanian Jambi, 2018.

[4] B. Farneti, *Tomato quality : from the field to the consumer Interactions between genotype , cultivation Brian Farneti*. 2014.

[5] F. Putra and T. Rizaldi, "Application of Color Sensor in the Determination of Tomato Fruit Ripeness (Solanum Lycopersicum, L) in Gravitation Type Fruit Sorting Tool (Gravitation Type)," *Indones. J. Agric. Res.*, vol. 2, no. 1, pp. 13–20, 2019, doi: 10.32734/injar.v2i1.862.

[6] Sandra, R. Damayanti, Y. Hendrawan, B. Susilo, and S. Oktavia, "Prediction of tomatoes maturity using TCS3200 color sensor," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 475, no. 1, 2020, doi: 10.1088/1755-1315/475/1/012011.

[7] Y. Kalnar, R. Balakrishnan, S. Mann, T. Bidyalakshmi, S. Dawange, and N. Indore., "Microcontrollers and Sensors in Post-harvest Application of Agricultural Commodity's Sorting/ Grading and Storage," *ICAR Research Data Repository for Knowledge Management*, 2018.

[8] S. Tamakuwala, J. Lavji, and R. Patel, "Quality Identification Of Tomato Using Image Processing technique," *Int. J. Electr. Electron. Data Commun.*, vol. 6, no. 5, pp. 67–70, 2018.

[9] A. A. Adamu and A. Shehu, "Development of an Automatic Tomato Sorting Machine Based on Color Sensor," *Int. J. Recent Eng. Res. Dev.*, vol. 03, no. 11, pp. 1–7, 2018.

[10] L. Liu, Z. Li, Y. Lan, Y. Shi, and Y. C. Id, "Design of a tomato classifier based on machine vision," *PLoS One*, vol. 14, no. 7, pp. 1–16, 2019, doi: 10.6084/m9.figshare.8227853.

[11] L. Zu, Y. Zhao, J. Liu, F. Su, Y. Zhang, and P. Liu, "Detection and Segmentation of Mature Green Tomatoes Based on Mask R-CNN with Automatic Image Acquisition Approach," *Sensors*, vol. 21, no. 23, 2021, doi: 10.3390/s21237842.

[12] N. Astrianda and F. S. Mohamad, "Ripeness Identification of Tomato Using Different Color Models Based on Neural Networklevenberg-Marquardt," *World Appl. Sci. J.*, vol. 35, no. Lm, pp. 57–61, 2017, doi: 10.5829/idosi/wasj.2017.57.61.

[13] P. Avalekar and L. S. Admuthe, "Tomato grading system based on colour models by using neural network," *Int. Res. J. Eng. Technol.*, vol. 5, no. 7, pp. 513–522, 2018.

[14] D. Ireri, E. Belal, C. Okinda, N. Makange, and C. Ji, "A computer vision system for defect discrimination and grading in tomatoes using machine learning and image processing," *Artif. Intell. Agric.*, vol. 2, pp. 28–37, 2019, doi: 10.1016/j.aiia.2019.06.001.

[15] M. Haggag, S. Abdelhay, A. Mecheter, S. Gowid, F. Musharavati, and S. Ghani, "An Intelligent Hybrid Experimental-Based Deep Learning Algorithm for Tomato-Sorting Controllers," *IEEE Access*, vol. 7, pp. 106890–106898, 2019, doi: 10.1109/ACCESS.2019.2932730.

[16] G. Liu, S. Mao, and J. H. Kim, "A mature-tomato detection algorithm using machine learning and color analysis," *Sensors (Switzerland)*, vol. 19, no. 9, pp. 1–19, 2019, doi: 10.3390/s19092023.

[17] O. O. Arjenaki, P. A. Moghaddam, and A. M. Motlagh, "Online tomato sorting based on shape, maturity, size, and surface defects using machine vision," *Turkish J. Agric. For.*, vol. 37, no. 1, pp. 62–68, 2013, doi: 10.3906/tar-1201-10.

[18] S. Jha, S. Agrawal, and C. K. Dewangan, "Grading Of Tomatoes Using Digital Image Processing On The Basis Of Size," *Int. J. Res. Eng. Technol.*, vol. 5, no. 10, pp. 2319–2321, 2016.

[19] S. K. Behera, A. Mahapatra, A. K. Rath, and P. K. Sethy, "Classification & grading of tomatoes using image processing techniques," *Int. J. Innov. Technol. Explor. Eng.*, vol. 8, no. 6, pp. 545–550, 2019.

[20] W. D. P. Niño, F. R. L. Jiménez, and A. F. L. Jiménez, “Algorithms to estimation of size and shape tomato using Artificial Vision Techniques,” *Proc. LACCEI Int. Multi-conference Eng. Educ. Technol.*, vol. 2019-July, no. July, pp. 24–26, 2019, doi: 10.18687/LACCEI2019.1.1.5.

[21] R. G. de Luna, E. P. Dadios, A. A. Bandala, and R. R. P. Vicerra, "Size classification of tomato fruit using thresholding, machine learning and deep learning techniques," *Agrivita*, vol. 41, no. 3, pp. 586–596, 2019, doi: 10.17503/agrivita.v41i3.2435.

[22] H. Yang, B. Kuang, and A. M. Mouazen, "Size estimation of tomato fruits based on spectroscopic analysis," *Adv. Mater. Res.*, vol. 225–226, no. 1, pp. 1254–1257, 2011, doi: 10.4028/www.scientific.net/AMR.225-226.1254.

[23] I. Nyalala *et al.*, "Weight and volume estimation of single and occluded tomatoes using machine vision," *Int. J. Food Prop.*, vol. 24, no. 1, pp. 818–832, 2021, doi: 10.1080/10942912.2021.1933024.

[24] J. Lee, H. Nazki, J. Baek, Y. Hong, and M. Lee, "Artificial intelligence approach for tomato detection and mass estimation in precision agriculture," *Sustain.*, vol. 12, no. 21, pp. 1–15, 2020, doi: 10.3390/su12219138.