

Application of Computer Vision for Real-Time Detection of Fruit Color and Size in Fruit Sorter

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Abstract—Computer vision aims to build a computer that can see like humans. Humans can immediately recognize and define an object after seeing and recording an object. This is different from computer visual systems, where camera recordings cannot be directly translated, defined, and recognized by computers, therefore digital image processing is needed first. In this study, computer vision technology was used to detect fruit based on color, size, and shape in real time. The fruit is placed on a conveyor belt, then the fruit object is captured by a webcam using object tracking. Computer vision algorithms and programs can detect fruit objects and recognize ripe and unripe fruits by converting RGB (Red, Green, Blue) colors into HSV (Hue, Saturation, Value) for the color segmentation process. After the detection process, a selector is placed at the end of the conveyor which is used to sort the fruit into 2 categories, namely ripe and unripe. In addition, this study also determines the size and shape of the fruit. From design, realization, and testing, it was found that the success rate of detecting ripe fruit was 97.33% and unripe fruit was 93.33%. To get maximum results, it needs to be supported by room lighting settings that are kept constant.

Keywords: Computer vision, Digital image processing, Segmentation, HSV, Sorting.

I. INTRODUCTION

ADVANCES in information technology have provided many conveniences in human life, one of which is in the field of computer technology. Webcam (web camera) is the most widely used and developed computer device. A webcam is an electronic device made specifically for capturing images and recording video in real-time, then directly storing it on a computer's hard drive. To find out the information and characteristics of a video and digital image, digital image processing techniques are needed. Digital image processing is a method of performing multiple operations on an image using a computer to obtain an enhanced image and to extract the necessary information inside the image as needed [1].

Digital image processing is closely related to computer vision. In principle, computer vision mimics the workings of the human visual system, making computers able to see and recognize objects like humans [2]. Humans can immediately recognize and define an object and its background as soon as

the eye captures and records an object, even the human eye can know the movement of objects when there is an object moving [3]. While on computers, the results of capture and webcam recordings cannot be directly translated, defined, and recognized by computers. Therefore, digital image processing techniques are needed in computer vision systems.

The application of computer vision can be found in various fields including agriculture, namely, to automate and obtain information about agriculture such as the management of agricultural products [4], quality cultivation of agricultural and plantation products [5]–[7], fruit sorting machine manufacture [8]–[11]. In the field of health and medicine, namely for the identification of the diagnosis of a disease [12]–[15], and detection of mask users indoors [16]. On computer device controls, such as cursor controls, mouse, keyboards, and monitors [17], [18]. In the field of robotics [19]–[21] and so on.

In this study, computer vision was implemented to create a tool that can be used to detect fruit based on color and determine its size and shape by using a webcam as a video object capture. AC electric motor for conveyor drive as fruit line, servo motor for fruit sorter drive and Arduino uno microcontroller as drive driver of servo motor.

In its development, this research can help provide simple solutions related to the classification of fruits harvested on a large scale as one component of improving the quality of fruit sales and fruit processing production for farmers, so that it can help ease work and save time with fruit sorting tools that can be used in everyday life.

II. METHOD

A. System Design

In this study, the system design consists of hardware design and software design as shown in Figure 1. On the hardware part, a webcam is used to capture and record the object to be detected. The object used is tamarillo fruits (*solanum betaceum*) placed on a conveyor belt. A webcam is a digital camera that plugs into a computer via a USB port or COM port and can capture images and videos, then directly store them on the computer's hard drive. A conveyor belt as a path for moving fruit to the sorting box driven by an AC electric motor with a power of 220V and a motor speed of 2800 rpm, this induction

motor is operated on a 1-phase power system and is widely used mainly for household appliances because it has low output power. Then the arduino uno microcontroller receives object color detection information by a computer vision program in the form of characters to be instructed on the servo motor to move as a fruit sorting actuator. This character will be processed into data on the angle of movement of the servo motor. This data is sent via a USB port and then processed by the arduino uno microcontroller to emit square waves (pulse) to the servo motor by the direction and movement of the object.

In the process, if the object is detected as ripe fruit (red color), then automatically the servo motor will be instructed to move at an angle of 56° (char 'r') to the right. As for objects detected as unripe fruit (green color), the servo motor will automatically move at an angle of 120° (char 'l') to the left. The ripe fruit will go into box 1 and the unripe fruit will go into box 2 which has been provided at the end of the conveyor belt. While in the software section, the video captured by the webcam is processed with digital image processing techniques and computer vision using Microsoft Visual C++ and OpenCV programming. This programming consists of three main program algorithms, namely segmentation algorithm, morphological operation algorithm, and object tracking algorithm.

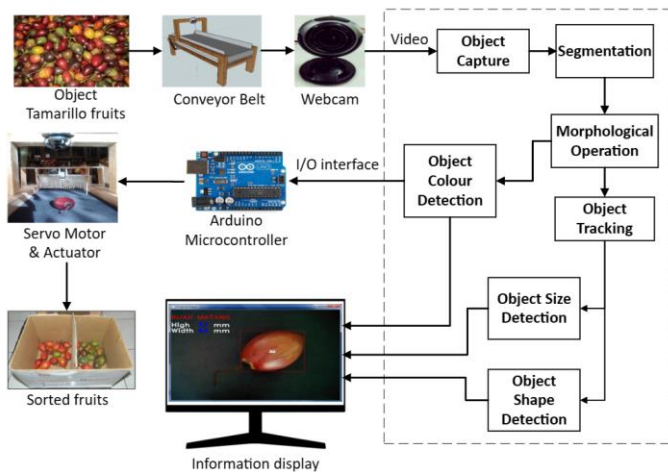


Fig. 1. Block system diagram

B. Video Processing

A video is a series of still images (frames) that are displayed sequentially at specific time intervals at a certain speed [22]. The video consists of pixels arranged on a three-dimensional array, where two dimensions represent spatial images vertically and horizontally, and one dimension represents the time or number of images. To analyze a video, it is necessary to divide the video into smaller units and have several semantic relationships, namely shots, keyframes, and scenes [23].

This research begins with the process of capturing video in the form of video frames. The process that occurs is when the camera is aimed at the object to be taken, the object will reflect light to the camera as much as the intensity of light received by the object multiplied by the light reflected by the object against the camera. The object captured by the camera is then processed through a program on the computer. The computer will recognize that a pixel is an RGB component that has been

transformed into digital form, and a frame is a collection of pixels. This frame will be moved at a certain speed so that the movement of the image will be visible.

C. Video Segmentation

Segmentation is the process of separating certain areas or parts of an image, where these parts have homogeneity, including texture, color, and intensity. Segmentation aims to separate the detected object from its background [24]. In this study, segmentation was carried out on each frame in the video, more precisely on each pixel of each frame consisting of a certain color range. The color range is depicted on the RGB color model. Therefore, the initial process in this method is to convert the RGB (Red, Green, and Blue) color model to the HSV (Hue, Saturation, and Value) color model, namely:

$$H = \begin{cases} 0, \left(60^\circ \times \frac{G - B}{Max - Min} + 360^\circ\right) & \text{if } Max = Min \\ x \bmod 360^\circ, & \text{if } Max = R \\ \left(60^\circ \times \frac{B - R}{Max - Min} + 120^\circ\right), & \text{if } Max = G \\ \left(60^\circ \times \frac{R - G}{Max - Min} + 240^\circ\right), & \text{if } Max = B \end{cases}$$

$$S = \begin{cases} 0, & \text{if } Max = 0 \\ \frac{Max - Min}{Max}, & \text{otherwise} \end{cases}$$

$$V = Max \tag{1}$$

To form segments according to the desired color, a tolerance value is determined in each HSV color dimension, then the tolerance value is used in the calculation of the thresholding process [25]. The thresholding process is to determine the colors that fall into a predetermined color range (target color) and block all colors that fall outside that range. Pixels that have the same range of HSV values are considered objects, while the background is pixels that are not in the HSV range of the target color. The segmentation output results in the form of binary videos with black backgrounds and white objects. The HSV to binary thresholding process is:

$$\text{if } \begin{cases} i > H \geq j \\ i > S \geq j \text{ then replace by } 1; \\ i > V \geq j \end{cases} \tag{2}$$

else replace by 0;

D. Morphological Operations

The morphological operations carried out in this study consisted of erosion surgery and dilation surgery. The erosion operation aims to remove the boundary points of the object into part of the background. While dilation operations are the opposite of erosion operations which aim to combine background points into part of the object. Both algorithms are used to clarify the appearance of objects after they are detected. This morphological operation is useful for removing noise in segmentation results and improving the image quality of segmentation results.

E. Object Tracking

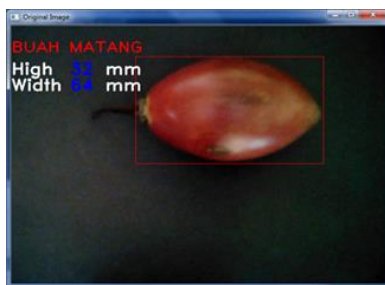
Object tracking is a very important part of computer vision. Object tracking can be defined as estimating the trajectory of an

object in the image plane as it moves around the frame [26]. In this study, object tracking was applied to video recorded in real time, where in the video the object moved and then tracked wherever the object moved. Objects that have been detected from the process of segmentation and morphological operations, are then locked with four corner points from the original image in the form of square lines and always follow the position of the object when the object moves.

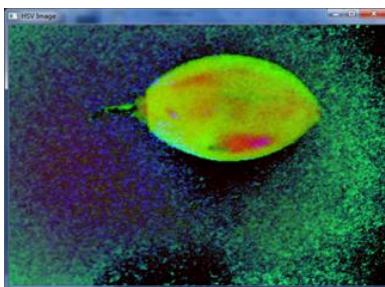
III. RESULTS AND DISCUSSION

The results of this study consist of two outputs. The first output is displayed on the computer monitor screen in the form of information on the results of detecting fruit objects to determine the maturity of the fruit, the size of the fruit, and the shape of the fruit. The second output is in the form of the results of detecting fruit objects based on color which is connected to the Arduino microcontroller for commands to drive the servo motor as a fruit sorter so that the fruit can be sorted into two categories, namely ripe fruit and unripe fruit.

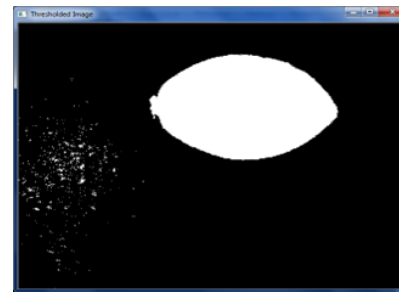
Segmentation is the result of color thresholding in the HSV color space. The result of segmentation in the form of binary frames is shown in Figure 2. Binary frames are frames or images that only have two grayish degree values, namely black and white. The object pixels are 0 and the background pixels are 1. So, in binary frames, the background is black while the object is white. Objects with colors that have HSV range values such as $H_{min} = 0$ and $H_{max} = 256$, $S_{min} = 147$ and $S_{max} = 256$, and $V_{min} = 132$ and $V_{max} = 195$ will be detected and recognized as ripe fruit, while objects with colors that have HSV range values other than those mentioned above, then objects will be recognized as unripe fruit.



(a) Frame video original (RGB)



(b) Frame HSV



(c) Binary frame segmentation results

Fig. 2. Segmentation process

From the results of segmentation, this system can already separate objects from their backgrounds, namely by passing the color of the selected object and blackening the background. But this system is not perfect, where there is still noise because of the color of the background or other objects that have the same color as the target object, or the object is still at the same threshold range.

For the improvement of the segmentation process, a filtering process is needed so that noise can be eliminated, namely by using morphological operations consisting of dilation operations and erosion operations. Dilation operations are the process of adding pixels to the boundary of an object in the input digital image, while erosion operations are the process of removing or reducing pixels at the boundary of an object. The number of pixels added to or removed from the object boundary in the input digital image depends on the size and shape of the structuring element used. Some of the results of this morphological process can be seen in Figure 3.

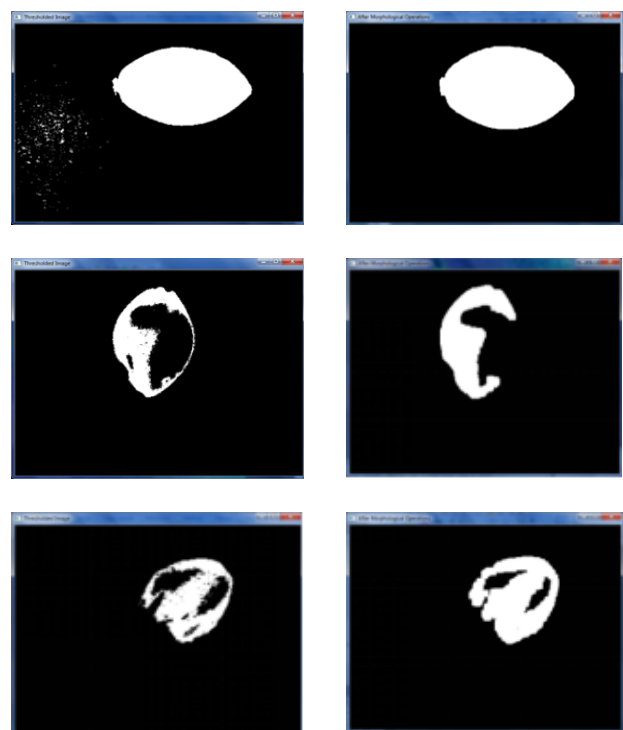
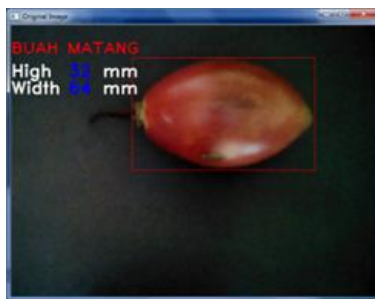


Fig. 3. Results of morphological operations

Next, determine the size of the detected object by counting the successfully tracked objects. The object that is used as a tracking target is all object surfaces detected by the four square-line corner points in the recorded video. In the object tracking algorithm, each point is located on the (x, y) axis forming a rectangle with points P1, P2, P3, and P4. To measure the size of the m width and high n objects, the thing that needs to be done is to determine the distance between points. The width of the object is the distance from point P1 to point P2, while the height of the object is the distance from point P2 to point P3. To determine the distance between two points used the Pythagorean theorem. If each point is likened to (X1, y1) and (X2, y2), then the formula used is:

$$Distance = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \quad (3)$$

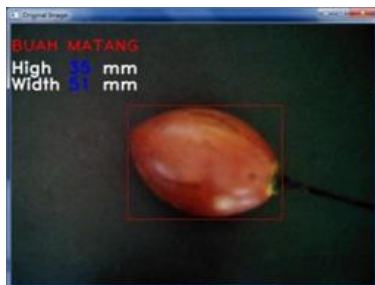
In Figure 4, several objects in the form of fruit were detected as ripe fruit with a size of high n and width m in mm units. Objects are measured based on the size of the red box surrounding the object.



Height = 3,2 cm
Width = 6,4 cm



Height = 6,4 cm
Width = 3,9 cm



Height = 3,5 cm
Width = 5,1 cm

Fig. 4. Display object size

Determining the shape of the object aims to classify the shape of the object into several shapes, namely circles, squares, triangles, and so on. In determining the shape of the object used functions contained in the OpenCV additional library. The shape of the object in principle finds how many angles are formed from the surface of the detected object. To determine

the number of angles using vector summation of the surface of the detected object. If the angles formed from the object are three then the object will be recognized as a triangle shape, if there are four corners formed then the object is square, if five corners are formed then the object is recognized as pentagonal, and so on. For the shape of a circle or circle is a condition where no angle is formed, or angles formed more than six. In this study, the shape of the object recognized is only circular because fruit objects are generally circular or oval. In Figure 5 you can see that the object is detected as a circle shape with the display 'CIR' as the circle code. In future research, this algorithm can be used to detect various shapes of objects.

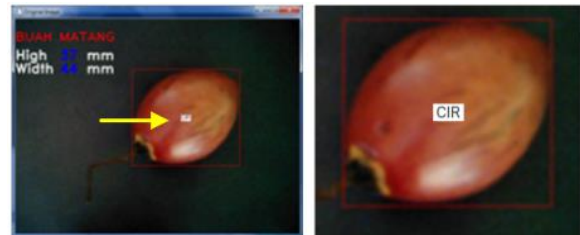


Fig 5. Display object shapes

In the testing phase using 60 samples of tamarillo fruits (*solanum betaceum*), from the 60 samples there were 30 samples of ripe fruit and 30 samples of unripe fruit. The fruit is placed randomly on a conveyor belt, so the webcam can capture objects in real time, and computer vision programs can instantly detect ripe fruit and unripe fruit based on the color of the fruit. The program that has been tested, is then applied to the tool to determine the performance of the tool to sort the fruit as desired. The designed fruit sorter can be seen in Figure 6. The test was carried out five times with 60 samples randomized. The system successfully detects ripe fruit and unripe fruit. In each experiment, different detection and error results were obtained, this was due to the influence of room light, uneven fruit color, or lack of a mechanical system of the tool.



Fig. 6. Fruit sorter

Based on the test results, the percentage of success in each experiment is obtained as shown in Table 1. The average success percentage of detecting ripe fruit in box 1 as many as five experiments was 97.33%, while the percentage of success in detecting unripe fruit in box 2 as many as five experiments was 93.33%, so the total percentage of success of the fruit sorting system in this study was 95.33%. From the percentage

results obtained, in general, the system can recognize and detect objects, and the fruit sorter can work properly.

TABLE I
TEST SUCCESS PERCENTAGE

Test	Ripe Fruit (%)	Unripe Fruit (%)	Test Average
I	100	93,33	96,67
II	93,33	93,33	93,33
III	100	93,33	96,67
IV	100	100	100
V	93,33	86,67	90
Success Percentage	97,33	93,33	95,33

IV. CONCLUSION

From the results obtained, it can be concluded that the application of computer vision in the process of detecting and recognizing objects has been successfully carried out. The system designed is already capable of detecting and recognizing ripe fruit objects and unripe fruit based on color, size, and shape. In testing, the percentage of success rate was 95.33%. This test has less than 100% success, this is due to the influence of outside light which can cause a lot of noise, and still not optimal system mechanics. Suggestions for the development of computer vision systems in this fruit sorter are the need to add categories to detect underripe and rotten fruit, sorting fruits based on fruit size to obtain quality fruit sorting results and maximizing the performance of the mechanical system of the tool.

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