Tomato separation conveyor based on color and weight using microcontroller

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ABSTRACT

Indonesia, as an agricultural country, has great potential in the agricultural sector, including horticultural commodities such as tomatoes. Post-harvest tomato processing, such as sorting by color and weight, is often done manually, leading to inefficiency and the potential for human error. This research aims to design and build a microcontroller-based tomato sorting conveyor to improve efficiency and product quality. This system utilizes a color sensor to identify the ripeness of tomatoes and a weight sensor to measure their weight. The microcontroller acts as the main controller, processing data from the sensors, making decisions, and regulating the conveyor mechanism to separate the tomatoes into the appropriate lanes. This research is expected to overcome the inefficiency problem in the manual tomato sorting process. With automatic separation by color and weight, the time and labor required are reduced, thereby reducing operational costs. Furthermore, the use of a microcontroller to process data precisely can help ensure that sorted tomatoes meet the desired quality standards. The results of this research are expected to contribute to the development of microcontroller-based technology in agriculture and serve as a reference for further research..

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1. INTRODUCTION

Post-harvest processing processes, such as sorting tomatoes by color and weight, are often performed manually. This leads to inefficiencies, increased production time, and a significant potential for human error [1]-[3]. Manual sorting requires a significant amount of human labor, which not only prolongs production time but also increases overall operational costs. This process also tends to be more time-consuming, hampering the smooth production and distribution of crops to the market. Furthermore, manual sorting relies heavily on individual visual observation, which is prone to errors due to fatigue, differences in perception, or a lack of consistent standards. These factors lead to variations in the quality of the final product, which can harm the product's image and reduce its selling value [4]-[6]. This inefficiency is a major obstacle, especially for producers who want to meet large-volume market demand in a short time. Therefore, this traditional approach not only limits the industry's growth potential but also poses challenges in meeting the quality and quantity standards expected by consumers and distributors. Along with technological developments, the use of microcontroller-based automated devices is increasing in various sectors, including agriculture. Microcontrollers provide the ability to process data in real-time, perform automated decision-making, and reduce dependence on human labor [7]-[10].

One application of this automated technology can be realized in the form of a microcontroller-based tomato separating conveyor capable of sorting tomatoes based on specific parameters, such as color and weight. In this project, sensor technology is used to detect the color and weight of the tomatoes. A color sensor is used to identify ripeness levels based on the color spectrum, while a distance or dimension sensor is used to measure the tomatoes' physical weight. The microcontroller acts as the main controller, processing data from the sensors, making decisions, and regulating the conveyor mechanism to separate the tomatoes into the appropriate lanes [11]-[13].

This project aims to design and build an effective and efficient microcontroller-based tomato separating conveyor. This is expected to increase productivity and quality in post-harvest processing and serve as the first step in implementing automated technology in agriculture in Indonesia. With broader implementation, this system can support farmers and the agricultural industry in competing in the global market [14]. Based on the above, a Tomato Separator Conveyor Based on Color and Weight Using a Microcontroller-Based DC Motor is proposed.

2. METHOD

This system consists of several main components that function to detect, process data, and control actuators based on information obtained from sensors. The main power source for this system comes from a 12V power supply, which functions as a power provider for all components connected to the Arduino [15]. Figure 1 shows the block diagram of the proposed tomato separating conveyor.

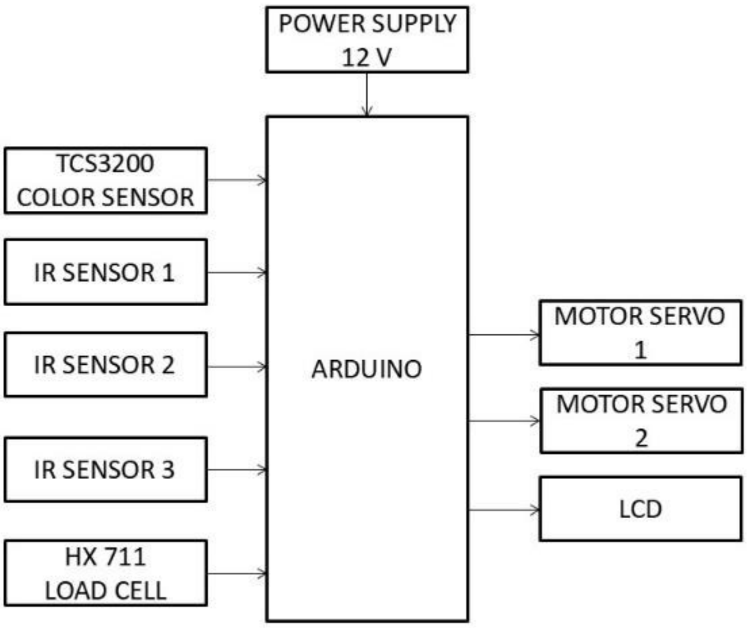

Figure 1. Block diagram of the proposed tomato separating conveyor

In the input section, the system uses several sensors to collect data. The TCS3200 color sensor is used to detect the color of an object by converting color information into frequencies that can be processed by the Arduino. In addition, there are three IR (Infrared Sensors) that function to detect the presence of objects or support the navigation system by detecting infrared signal reflections from surfaces [16]. In the output section, the Arduino controls two servo motors that function as actuators in the system, for example, to move mechanical components according to data obtained from the sensors. Furthermore, there is an LCD (Liquid Crystal Display) used to display information, such as sensor readings or real-time system status [17]. All of these components are controlled by the Arduino, which functions as a data processing and system control center based on pre-programmed algorithms.

Furthermore, the following is a design of the electronic circuit for the process of manufacturing a Tomato Separator Conveyor Based on Color and Weight Based on a Microcontroller. The main components required, such as a microcontroller (Arduino), color sensor (e.g., TCS3200), weight sensor (ultrasonic or infrared sensor), drive motor, and servo actuator, are identified [18]. A system block diagram is created to visualize the tool's workflow. Additionally, software requirements, such as programming logic and data processing, are formulated. Figure 2 shows the electronic component circuit used to control the tomato fruit separating conveyor.

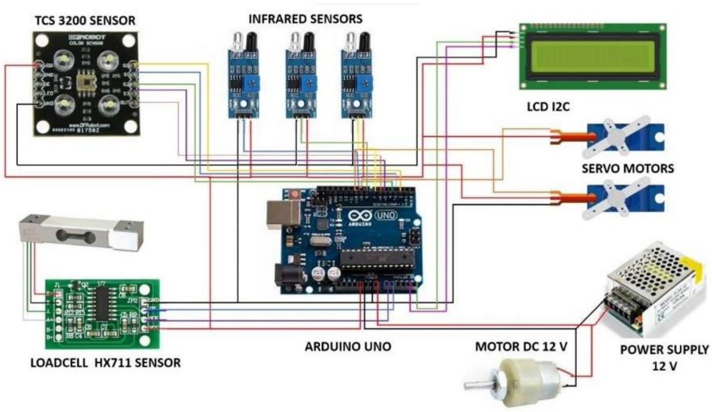

Figure 2. Electronic component circuit for the tomato fruit separating conveyor

Hardware design is crucial before assembling a device, as illustrated in the figure below. This section covers the mechanical and electrical design, as well as the initial design of the device to be built. The mechanical design can be seen in Figure 3 below.

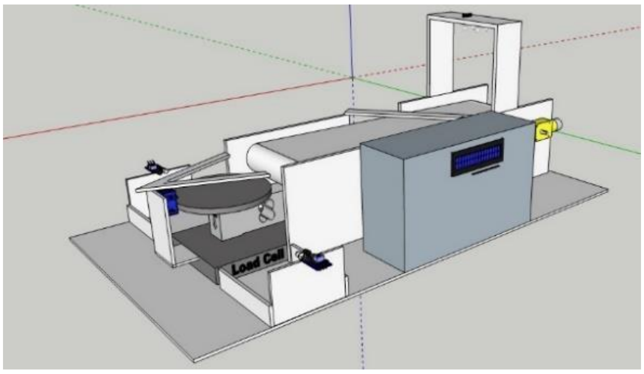

Figure 3. Hardware design

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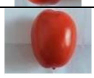
3. RESULTS AND DISCUSSION

This stage presents the color sensor test results. This data includes RGB (Red, Green, Blue) and Hue, Saturation, and Value (HSV) values from six different samples. These samples are labeled 1 through 6. It can be seen that the RGB and HSV values for each sample vary, indicating the color variations detected by the sensor. Table 1 describes the color sensor test results.

Table 1. Color sensor test results

No	Sample	RGB Values			Weight (Gram)	
		R	G	B	Instrument	Sensor
1		359	293	318	76	70.80
2		340	310	407	61	59.51
3		317	340	372	73	71.88
4		280	380	374	58	56.62
5		255	350	333	64	64.03
6		277	313	326	99	97.95

This data was then compared with the actual weight of each sample. The goal was to determine whether there was a correlation between the color detected by the sensor and the weight of the object. Analysis of the data in the table indicates an indication of a relationship between color and weight of the object. For example, sample number 1 has RGB values of 359, 293, 318 and weighs 76 grams, while sample number 4 has RGB values of 280, 380, 374 and weighs 58 grams.

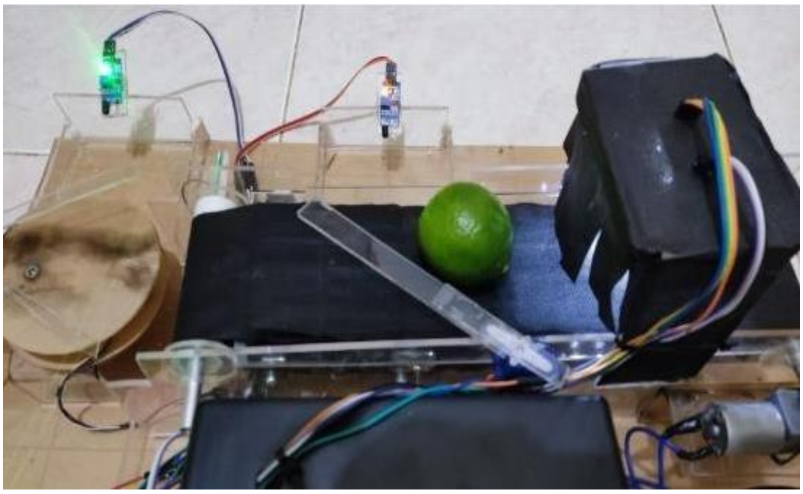


Figure 4. Calibration of the weight sensor

Figure 4 shows the weight sensor calibration process. The purpose of this weight sensor calibration is to ensure the accuracy and precision of the system's mass measurements. The calibration process involves using a series of standard weights with known masses and high precision. The data obtained from this calibration process is then analyzed to determine sensor characteristics, such as scale factor and offset. Next, the infrared sensor testing process is carried out, as shown in Figure 5. This stage shows the results of the infrared sensor test connected to Servo 2 at a distance of 3.3 cm. In this test, the infrared sensor detects the presence of an object (in this case, a tomato) and sends a signal to Servo 2. Servo 2 then responds by moving according to the programmed logic. This movement of Servo 2 shows that the infrared sensor successfully detected the object at the specified distance and provided an appropriate response.

Figure 5. Infrared sensor calibration

Next, the overall device is tested. This stage shows the results of testing the sorting mechanism using a servo. In the left image, the servo is in its initial position, while in the right image, the servo has moved to separate the detected objects. The movement of this servo is controlled by sensors that detect object characteristics, such as weight or color. Data from the sensors is processed by a microcontroller to determine whether the objects need to be separated or not. The microcontroller then commands the servo to move according to the decision. Figure 6 shows the testing process.

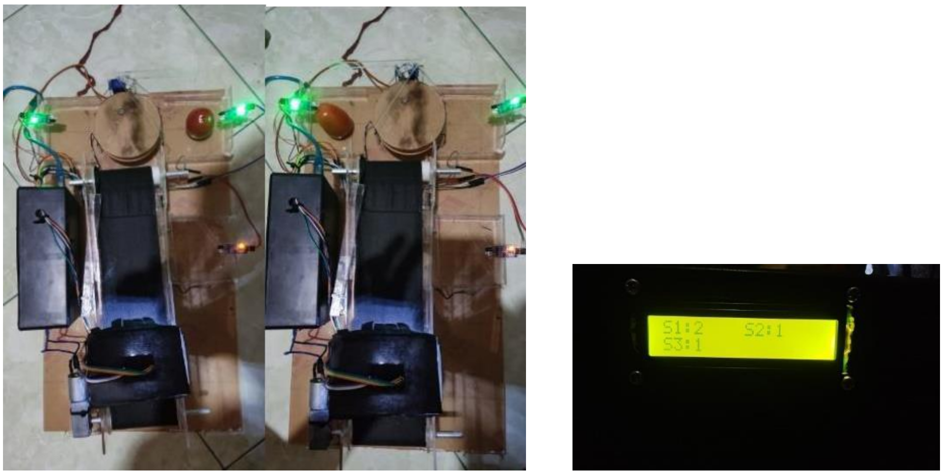


Figure 6. Tomato sorting testing process

4. CONCLUSION

The test results show significant variations in RGB values between samples. For example, sample 1 has RGB values of 359, 293, 318, while sample 4 has RGB values of 280, 380, 374. This difference indicates that the color sensor is able to distinguish tomato colors based on the combination of Red, Green, and Blue values. There is an indication of a correlation between color and tomato weight. Sample 1 with RGB values of 359, 293, 318 weighs 76 grams, while sample 4 with RGB values of 280, 380, 374 weighs 58 grams. This difference in RGB values and weight indicates that color can be an indicator to predict tomato weight. The difference in RGB values between samples is most likely caused by differences in tomato ripeness. Samples with higher RGB values (e.g., sample 1) are likely more ripe than samples with lower RGB values (e.g., sample 4).

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