Jurnal E-Komtek
Vol. 8 No. 1 (2024) pp. 114-124
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Design and Build a Chili Sorting Tool Using Color Sensor Based on Arduino Uno

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https://doi.org/10.37339/e-komtek.v8i1.1779

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
27-05-2024
Revised:
06-06-2024
Accepted:
07-06-2024
Online first :
26-06-2024

Abstract

Farmers often struggle with selecting the quality of chili peppers due to manpower and time constraints, leading to inaccuracies and subpar quality of marketed chilies. The colour of chili peppers is a key quality indicator. Other important factors include the ripeness level of the chili, potential adverse effects on consumers, and decreased revenue for farmers or traders. To address this issue, researchers designed a chilli ripeness sorting tool using a color sensor. This research follows a Research & Development model with stages including potential and problem identification, information gathering, design planning, product development, testing, and revision. The tool uses Arduino Uno and a TCS 3200 color sensor to capture chili colour data, with a servo motor acting as an actuator. Product testing showed a 93.33% success rate in colour reading. This tool is expected to assist farmers in sorting and determining the quality of chilies to be sold.

Keywords: *Chili Peppers; TCS 3200 Color Sensor; Arduino Uno*

Abstrak

Petani sering kesulitan dalam pemilihan kualitas cabai rawit karena keterbatasan tenaga dan waktu, menyebabkan ketidakakuratan dan kualitas cabai yang dipasarkan kurang baik. Warna cabai adalah salah satu indikator kualitas yang dapat diamati. Faktor penting lainnya adalah tingkat kematangan cabai, dampak buruk bagi konsumen, dan penurunan omset petani atau pedagang. Untuk mengatasi masalah ini, peneliti merancang alat sortir kematangan cabai rawit berbasis sensor warna. Penelitian ini menggunakan model Research & Development dengan tahapan: identifikasi potensi dan masalah, pengumpulan informasi, perancangan desain, pengembangan produk, pengujian, dan revisi produk. Alat ini menggunakan Arduino Uno dan sensor warna TCS 3200 untuk menangkap data warna cabai serta motor servo sebagai aktuator. Uji produk menunjukkan tingkat keberhasilan pembacaan warna sebesar 93,33%. Alat ini diharapkan dapat membantu petani dalam memilah dan menentukan kualitas cabai yang akan dijual.

Kata-kata kunci: *Cabai Rawit; Sensor Warna TCS 3200; Arduino Uno*

1. Introduction

Indonesia is one of the tropical countries that only has two seasons: the rainy season and the dry season [1]. Indeed, this greatly supports Indonesia's reputation as an agrarian country. Indonesia is the largest agrarian country due to its extensive land area compared to other nations [2]. This results in the Indonesian economy being supported by the agricultural sector. Chili peppers are one of the favourite foods among the Indonesian population. This aligns with research conducted by Dudi Septiadi et al [3] which states that almost all residents of Indonesia like chili peppers. Therefore, almost every restaurant always provides sambal (chili paste) as a condiment for meals.

The chili production process consists of planting, plant care, harvesting, and distribution. Each stage in the chili production process has difficulties or factors that need to be given more attention. One of the aspects to consider in the chili planting stage is to avoid excessive water, as it can lead to plant death instead [4]. The maintenance process of chili plants that must be considered includes regular and proportionate irrigation as well as proper fertilization. The difficulty in the harvesting process lies in selecting the green, yellow, and red colors. Challenges in the distribution process include fluctuating chili prices, which can affect profitability [5].

The utilization of technology is needed to assist chili farmers in working more efficiently. This aligns with the findings of research conducted by Romi Mesra [6], which states that labor is scarce because many young people nowadays are reluctant to engage in manual labour. One way to expedite the production process by minimizing human labour is by developing technology capable of assisting humans in addressing these issues [7].

Based on the problems, the author has developed the "Design and Construction of a Chili Ripeness Sorting Tool Using Arduino Uno-based Color Sensor." Automatic sorting aims to separate or classify the quality of bird's eye chilli peppers into good and bad categories. This project is expected to assist farmers in determining the ripeness level of chili peppers, thereby facilitating the sorting process of chili harvests before they are distributed to distributors or consumers.

2. Method

The research method applied is Research and Development (R&D). This research method is used to produce a specific product and test its effectiveness [8]. The stages of Research & Development used in this study are Figure 1.

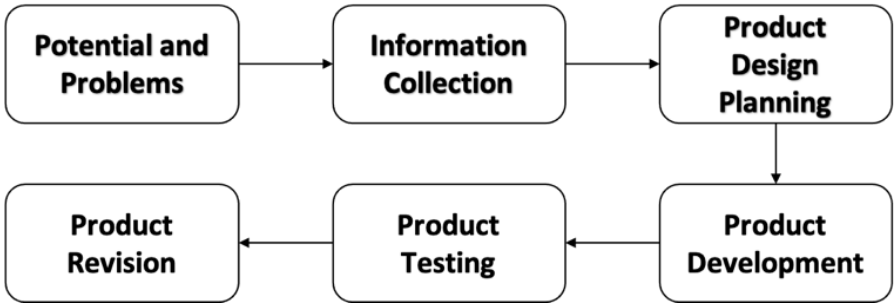

Figure 1. R&D (Research and Development) Method

Potential problems were identified through brainstorming sessions with five chili farmers to uncover various issues. After gathering the necessary data, the design was created with consideration for ease of use and the production costs of the tool to be developed. Product development and testing were conducted in collaboration with experts and farmers as users. Tool improvements will be made if any errors or component failures occur in the future.

2.1 Design Overview

In designing the Arduino Uno-based chili ripeness sorting tool, the working model of the tool follows an input, process, and output structure. The working model of the developed product is Figure 2.

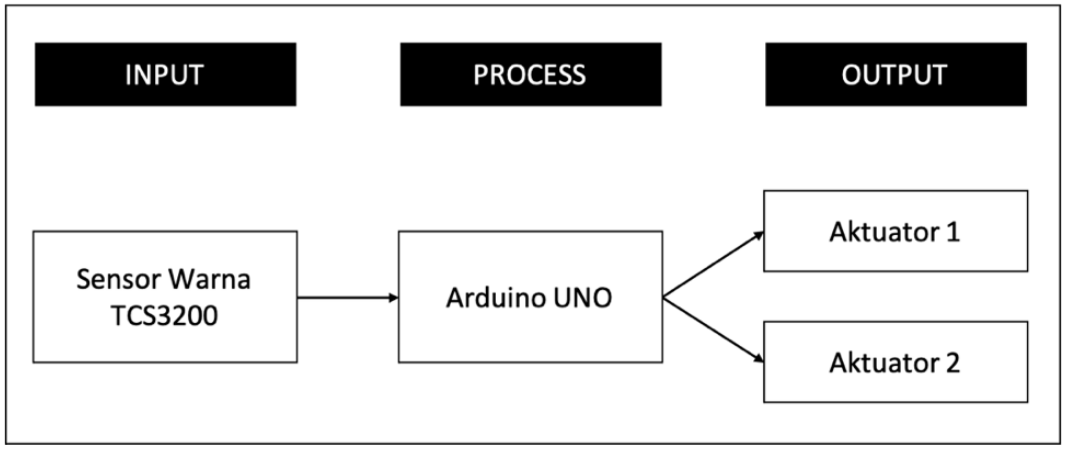

Figure 2. Input, Process, Output (IPO) Model

Input, Process, Output (IPO) is used as the basic model in information systems and data processing, illustrating how data is processed to generate information [9]. This model is applied to the following materials to create a complete tool to address the identified problems.

2.2 Flowchart

The flowchart begins with the color reading of the chili peppers obtained from the TCS3200 sensor. The process is carried out on the Arduino Uno to classify the obtained data into specific colors. A red color reading triggers servo 1 to actuate and close the path. An orange color reading triggers servo 1 to open and servo 2 to close. If neither of these conditions is met, both servos remain open. The flowchart design can be seen in **Figure 3.**

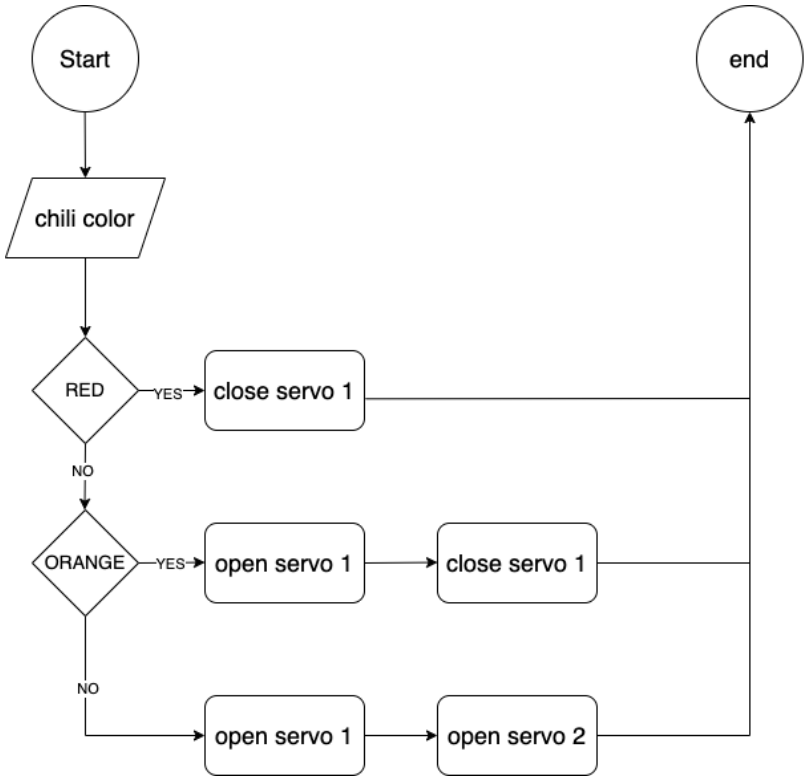

Figure 3. Flowchart

3. Results and Discussion

After determining the appropriate method and flowchart, the selection of materials was carried out as the next step in designing the Arduino Uno-based chili ripeness sorting tool. The following are the results and discussions of the tool development:

3.1 Circuit schematic

a. Arduino

Arduino is an electronic prototyping platform based on easy-to-use hardware and software. In this study, Arduino functions as the main controller, receiving input from the color sensor and controlling the servo motors based on the classification of the chili pepper colors. Arduino has several advantages that make it suitable for this research. First, Arduino is very user-friendly, with a large community that provides many tutorials and case studies, making it easier for both beginners and experts to develop their applications. Second, Arduino is highly flexible and can be used for various applications, as well as connected to a wide range of sensors and actuators, allowing users to develop different types of electronic projects. Lastly, Arduino is known for its affordability, making it a popular choice for DIY (*Do It Yourself*) projects [10]. With these advantages, Arduino is an ideal component for use in automation systems such as chili color classification, where accurate and reliable control is needed.

b. TCS3200 Color Sensor

The TCS3200 color sensor is an advanced sensor capable of detecting color by measuring the intensity of light reflected by an object. This sensor is equipped with an array of color filters (red, green, blue, and clear) and photodiodes that convert light intensity into digital signals. The operation of the TCS3200 starts with illuminating the object using the sensor's built-in LEDs. The light reflected from the object, in this case, chili peppers, then passes through the color filters. The photodiodes inside the sensor capture the light intensity that has passed through the filters and convert it into frequency signals. These frequency signals are then processed by the Arduino to determine the color of the detected object. The TCS3200 has several advantages that make it highly effective in various applications. This sensor offers high precision, capable of detecting a wide range of colors with excellent accuracy, making it ideal for tasks requiring precise color detection. Additionally, the sensor is compact and easy to use, with a small size that facilitates integration into Arduino projects, making it a popular choice for developers and electronics hobbyists.

c. Servo Motor

A servo motor is an actuator capable of moving an object to a specific position with high precision. In this project, two servo motors are used to move the chili peppers to the appropriate location based on the color classification results. The operation of a servo motor involves several key components: a DC motor, a gearbox, and a potentiometer for position feedback. The servo motor is controlled using PWM (Pulse Width Modulation) signals generated by the Arduino, allowing precise control of the rotation angle. With the received PWM signals, the servo motor can be accurately positioned as needed. The advantages of servo motors include high precision, enabling very accurate position control, which is crucial in applications requiring meticulous accuracy. Additionally, servo motors are easy to control with simple PWM signals that can be generated by the Arduino, making them easy to integrate into various projects. Servo motors are also strong, and capable of moving relatively heavy loads, making them ideal for a range of applications that require reliable and precise actuation. All these components are assembled according to the requirements for developing the chili ripeness sorting tool. **Figure 4** is the schematic diagram of the constructed tool.

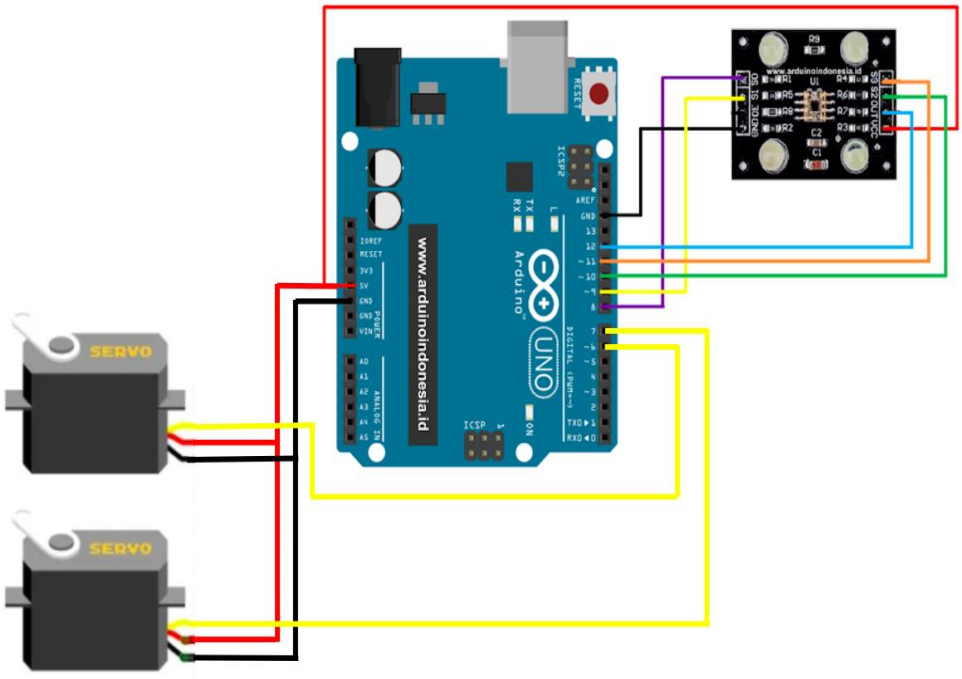

Figure 4. Schematic Diagram of the Arduino Uno-based Chili Ripeness Sorting Tool

To facilitate the assembly of the chili ripeness sorting tool, it is necessary to create a connection table to link each pin of the components is presented in **Table 1**.

Table 1. Pins for Each Component

Sensor TCS3200			**Actuator 1**			**Aktuator 2**		
VCC	→	VCC Arduino	VCC	→	VCC Arduino	VCC	→	VCC Arduino
GND	→	GND Arduini	GND	→	GND Arduino	GND	→	GND Arduino
Pin S0	→	Pin 8 Arduino	Pin Data	→	Pin 6 Arduino	Pin Data	→	Pin 7 Arduino
Pin S1	→	Pin 9 Arduino						
Pin S2	→	Pin 10 Arduino						
Pin S3	→	Pin 11 Arduino						
Pin Output	→	Pin 12 Arduino						

3.2 Outer design

The colour measurement of chilli peppers begins by placing a chilli pepper in front of the TCS3200 colour sensor, which functions to detect color by measuring the intensity of light reflected from the surface of the chili. The TCS3200 sensor then sends the detected color data to the Arduino for further processing. In the data processing stage, the Arduino receives frequency signals generated by the TCS3200 sensor. The Arduino then converts these frequency signals into RGB (Red, Green, Blue) values, which are numerical representations of the color detected by the sensor. Based on the generated RGB values, the Arduino classifies the color of the chili pepper. This classification process allows the Arduino to determine whether the chili pepper is red, orange, or green. **Figure 5** is the output of the Arduino-based chili ripeness sorting tool.

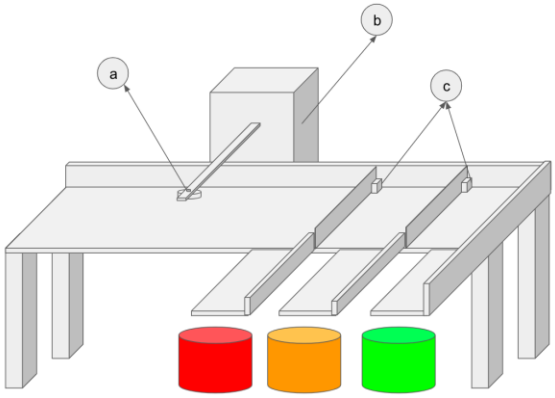

Figure 5. The output of the Arduino Uno-based Chili Ripeness Sorting Tool

After the color classification is done, the next step is actuation. Based on the classified color results, Arduino sends PWM (Pulse Width Modulation) signals to the servo motor. This PWM signal is used to precisely control the position of the servo motor. The servo motor then moves the chili to the appropriate container based on the color classified by Arduino. For example, if the chili is classified as red, the servo motor will move to direct the chili to the container designated for red chilies. The same process applies to orange and green chilies.

The use of the TCS3200 color sensor and Arduino in this system enables automatic and accurate detection and classification of chili colors. The combination of the color sensor, data processing by Arduino, and actuation control by the servo motor creates an efficient system for separating chilies based on their colors. With proper implementation, this system not only enhances efficiency in chili processing but also ensures consistency and accuracy in color classification. This is highly beneficial in agricultural and food processing industries, where chili separation based on color can be a crucial factor in the production process and the quality of the final products.

3.3 Test results

The device underwent testing to assess its quality and accuracy. The chili color classifier tool has been tested through a series of 30 experiments, yielding significant success with 28 trials correctly classified. This success rate of 93.33% indicates that the system built using the TCS3200 color sensor, Arduino, and servo motor functions effectively in accurately classifying chili colours and moving them to the appropriate containers. The primary advantage of this tool lies in its high precision in colour detection and the precise positional control capability of the servo motor, enabling efficient chili separation based on colour. Additionally, the use of Arduino as the main controller adds flexibility and ease of further development. Test results of the cayenne pepper ripeness sorting tool is presented in Table 2.

Table 2. Test Results of the Cayenne Pepper Ripeness Sorting Tool

Red	Orange	Green	Color	Result
310	397	405	Green	v
432	426	434	Green	v
379	321	398	Green	v
355	367	435	Green	v
445	429	448	Red	x
349	440	360	Orange	v
397	400	417	Green	v
399	402	317	Orange	v
317	407	357	Orange	v
343	397	353	Orange	v
362	428	378	Orange	v
402	404	386	Red	x
419	361	440	Green	v
406	382	448	Green	v
403	390	340	Red	v
327	304	309	Red	v
341	421	347	Orange	v
314	404	422	Green	v
440	403	366	Red	v
425	333	408	Red	v
353	316	372	Green	v
361	352	349	Red	v
311	402	358	Orange	v
389	331	418	Green	v
450	371	376	Red	v
415	414	364	Red	v
303	317	398	Green	v
413	446	388	Orange	v
328	330	323	Orange	v
330	427	344	Orange	v

The potential for development of this tool is indeed vast. One area for improvement lies in optimizing the color classification algorithm to further enhance accuracy, nearing 100% success. Additionally, integration with Internet of Things (IoT) technology could enable remote monitoring and control, adding value on a larger production scale. This tool could also be expanded to recognize and classify more colors or even other quality parameters, such as ripeness levels or surface conditions of the chilies. With this potential and its inherent advantages, the chili color classifier tool not only enhances the efficiency of sorting processes but also provides an innovative solution for the agricultural and food processing industries.

4. Conclusion

This research has resulted in the development of a chili ripeness sorting tool based on Arduino Uno with a test success rate of 93.33%. The tool has proven its capability in accurately detecting and classifying chili colors as well as moving them to the appropriate containers. Its main advantages include high precision, ease of control, and flexibility for further development. With the potential for accuracy improvement and integration with IoT technology, this tool offers an effective and innovative solution for applications in the agricultural and food processing industries, enhancing the efficiency and quality of chili sorting processes.

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