DECISION-MAKING IN GRIPPER CONTROL SYSTEMS USING FUZZY LOGIC METHOD AND TELEGRAM APPLICATION

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ABSTRACT

The application of the gripper in the industrial world has facilitated human work in the sorting process but has the disadvantage of not being able to sort objects based on the object's color. Conditions like these can affect the production quality factor when sorting objects. This research resulted in a gripper end effector system using the fuzzy method and the telegram application as a control, which has a function to distinguish the color of objects gripped by the gripper, thereby minimizing errors in sorting objects based on color. Telegram is used because the application is relatively light and can be accessed anywhere as long as it is connected to an internet connection. This study uses the fuzzy logic method as a decision-making process. The fuzzy method is used because it is very flexible and has a tolerance value in the existing data. The telegram function in this study is the main control to give orders to the gripper. The TCS3200 color sensor, in this study, is used to detect object color. The TCS3200 sensor converts the light intensity value to 8 bits so that the microcontroller can read it for each color in the test. The colors red, green, and blue were chosen as a reference because they are the primary or basic colors of all colors. From the results of testing the entire system in this study, 90% success was obtained in moving objects precisely based on the object's color. This result is enough to prove that the system can work properly.

Keywords: *Fuzzy logic, Gripper, Color sensor, Telegram*

1. INTRODUCTION

The development of modern industry cannot be separated from the role of robots as a substitute for human labor in the production process. Apart from picking up objects that are difficult to reach or dangerous for humans, robot technology is also used to maintain stability and improve product quality [1]. Another advantage of using a robot is that it doesn't get tired easily can be reprogrammed and can be used for several different tasks. Arm robots are the most frequently used robots in the industrial world [2]. The robot arm has several important components that are used to carry out its function properly, one of the important components is the end effector. An end effector is a component located at the end of a robot, which is used to interact directly with objects [3]. Robots usually interact with a hand system, and in industrial activities, the hand is usually referred to as a gripper [4].

The design of the long-range gripper car robot that has been developed has a weakness, namely that it still uses a Bluetooth connection to control the robot, so it must be within Bluetooth range to be able to run the robot [5]. Recent research has developed gripper control systems for controlling patients [6], improving robot functions [7], model-free mechanical systems [7], harvesting small fruit [8], and other jobs that require robot functions [9]. Research on transporter robot gripper control engineering using ESP32 [10], has used a wireless network as control, but no decision-making method is used in this research, so the robot cannot run automatically to carry out commands. The design of the gripper for handling plastic machines has been developed [11]. The application of the gripper in the industrial world only functions the same as a human finger, it cannot know the color of the object being held by the gripper, so there is no grouping of objects.

The gripper end effector decision-making system uses fuzzy logic and the telegram application produced in this research. Apart from holding objects, the gripper also aims to differentiate the color of objects. The system can also be used to help the waste processing industry so that it can sort waste based on color type. Apart from that, control the movement of this gripper via smartphone using the Telegram application so it is easier to operate. The Telegram application was chosen because it is quite light and easy to use and can be accessed from anywhere as long as it is connected to an internet connection. The fuzzy method is used as a decision-making method because it is very flexible and has more tolerance for existing data than other traditional algorithms. The ESP32 works as a microcontroller in this research, because it already has WiFi integrated on the ESP board, so there is no need for additional devices. The only sensor used in this research is the TCS3200 Color Sensor.

2. RESEARCH METHODOLOGY

2.1 Hardware Design

In Hardware Design, Technically Consists Of A Servo Gripper, Tcs3200 Color Sensor, Lcd, And Servo Motor To Be Combined With An Esp32 Microcontroller As A Control And Data Processing Center. There Are 3 Processes, The First Is Input From The Tcs3200 Color Sensor. In The Process, There Is A Microcontroller To Receive Sensor Data As Well As For Output Controller. Meanwhile, At The Output, There Is A Servo Motor And Gripper To Grip And Direct The Object To The Programmed Location. To display output data using a 16x2 LCD. The hardware block diagram is as shown in Figure 1.

The 2D hardware mechanical design will be the main reference in hardware design. Mechanical design also includes hardware dimensions along with an explanation of each component. The mechanical hardware design of this study is shown in Figure 2.

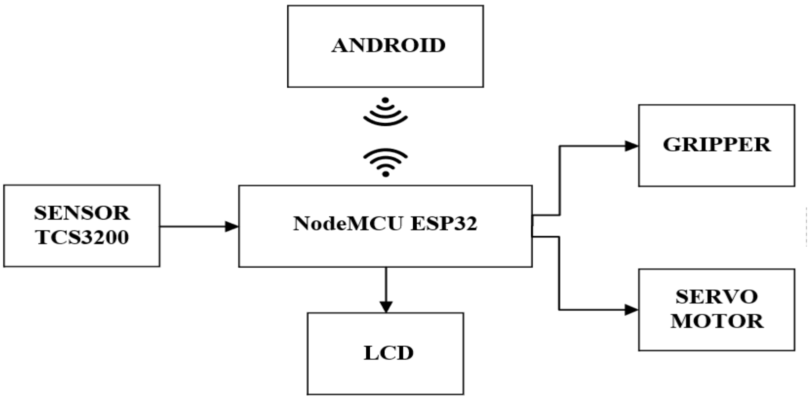


Figure 1. Block Diagram System.

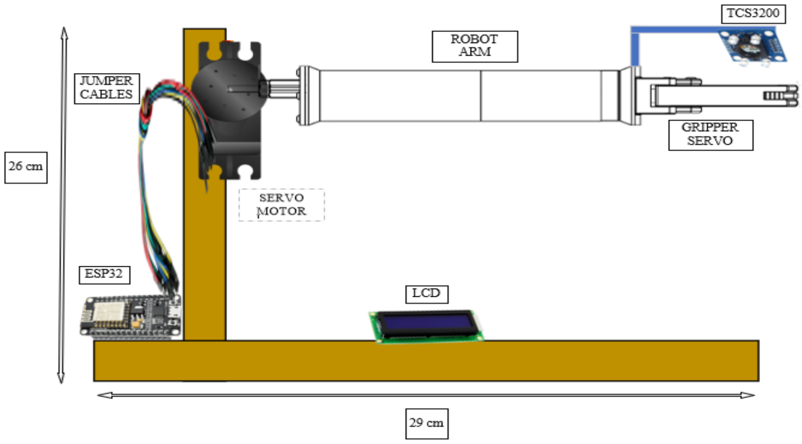


Figure 2. Mechanical Hardware Design.

2.2 Software Design

In software design, the flowchart of the main program of this research is shown in Figure 3 and the fuzzy logic process sub-program for decision-making in gripper control is shown in Figure 4. The working system of the system can be controlled via smartphone using the ESP32 microcontroller module as a data sender. Also, the system can run automatically according to the values from the TCS3200 sensor.

2.2.1 Decision-Making in Gripper Control Using Fuzzy Logic Method

The basis of fuzzy logic is fuzzy set theory. The role of the degree of membership or membership function is very influential in determining the existence of elements in a set [12]. The membership value or degree of membership or fuzzy variable is the main characteristic of fuzzy logic reasoning. Decision-Making in Gripper Control using The Sugeno Fuzzy Logic method with 1 input from the color sensor and 1 output. Where the 3 stages of fuzzy logic design are as follows:

1. The Fuzzification:

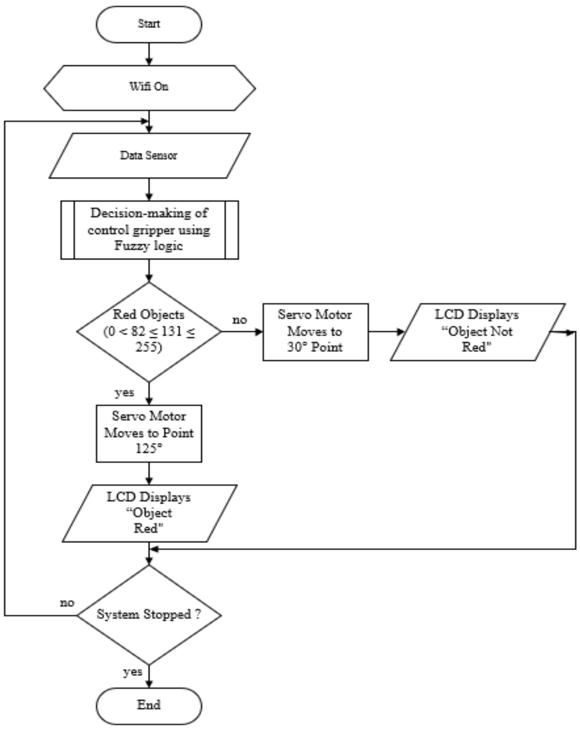


Figure 3. Flowchart of Main Program.

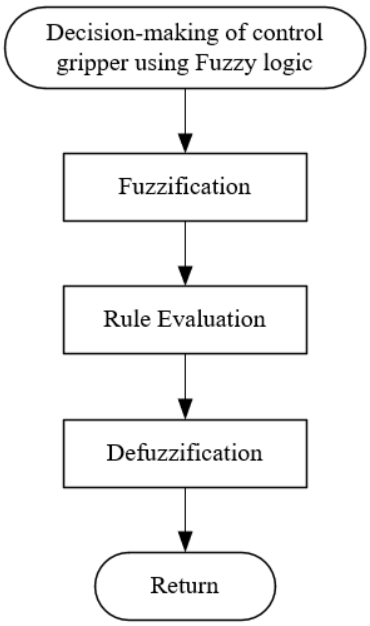
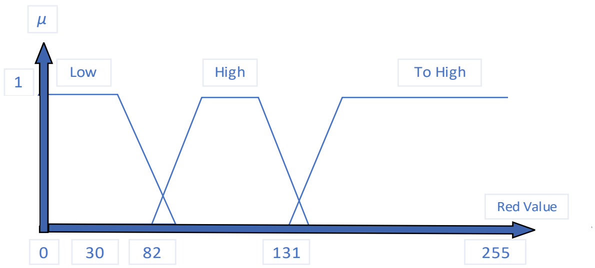
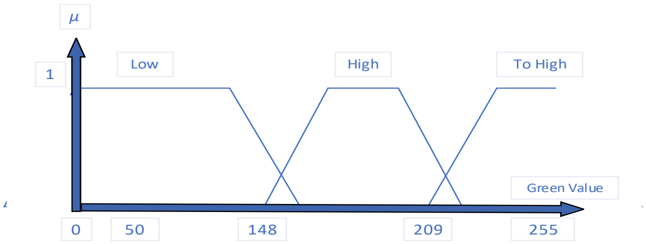


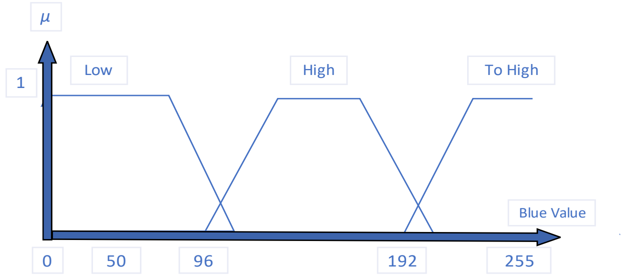
Figure 4. Flowchart of Sub Program for decision-making gripper control using fuzzy logic.



(a)



(b)



(c)

Figure 5. Input Membership Function for Color Sensor: (a) Red value; (b) Green value; (c) Blue value.

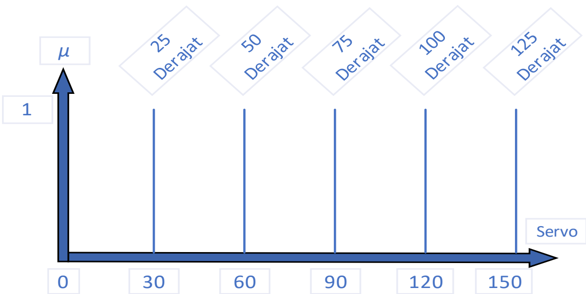


Figure 6. Output Membership function for output fuzzy.

Table 1. Rule Base

Red	**Green**	**Blue**	**Respon**
High	Low	Low	125°
Low	High	Low	60°
Low	Low	High	60°

2. The Rule Base:

The rule base functions to determine decisions, so that the system can run with the planned plant. Table 2 is a rule base for fuzzy logic. The rule base functions to determine decisions, so that the system can run with the planned plant. Table 1 is a rule base for fuzzy logic.

3. The Defuzzification:

The next step in fuzzy logic is the defuzzification process, which is carried out by determining the degree of movement of the gripper which is represented by the Z value. This defuzzification is used to determine the crisp size of the fuzzy set. The method used for defuzzification uses the Weighted Average method so that Z is obtained using the formula [9]:

$$Z = \sum \frac{\mu i.Zi}{\mu i} \quad (1)$$

Where μi is the membership degree value and Zi is the degree value that has been determined in the fuzzy membership function output.

3. RESULTS AND DISCUSSIONS

3.1 Sensor Testing

To determine the performance capabilities of the sensor, the characteristics of the color sensor used were tested by providing an object that has RGB colors (Red, Green, Blue). This color was chosen because it is the basis of all colors. The following are the results of sensor testing based on RGB colors, as presented in Table 2, Table 3, and Table 4.

3.2 Gripper Testing Using Telegram

The Telegram application as a gripper control is tested by giving commands from the Telegram application so that the gripper can run optimally. Figure 7 is the initial display of the program. The "/start" command is used to start the system. When the system starts, an output command will appear that can be used. Namely of the servo on condition to activate the gripper servo. The servo-off condition is to turn off the servo gripper or give the servo gripper an order to be in the 0° position.

The "/servo on" command is used to activate the servo gripper to close or hold an object. When the servo on command is sent from the telegram, the servo gripper will move from 0° to 45° to grip the object. The response from the microcontroller is the notification "Servo set to ON" which means the gripper servo is in active condition. Figure 8 is the display when the servo gripper is in the on condition.

Table 2. Test results for red objects

Data	distance 1cm		
	R	G	B
1	**82**	184	129
2	**82**	178	123
3	**76**	185	129
4	**82**	184	129
5	**82**	185	123

Table 3. Test results for green objects

Data	distance 1cm		
	R	G	B
1	177	**104**	90
2	176	**104**	90
3	177	**98**	85
4	171	**104**	90
5	177	**104**	84

Table 4. Test results for blue objects

Data	Distance 1cm		
	R	G	B
1	189	96	**40**
2	184	98	**46**
3	190	99	**46**
4	189	92	**46**
5	190	98	**46**

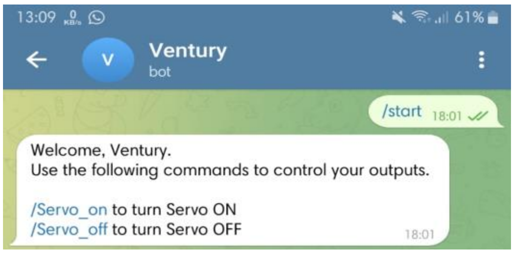


Figure 7. Initial Telegram Control Display.

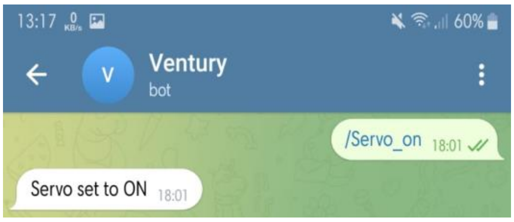


Figure 8. Servo On Condition.

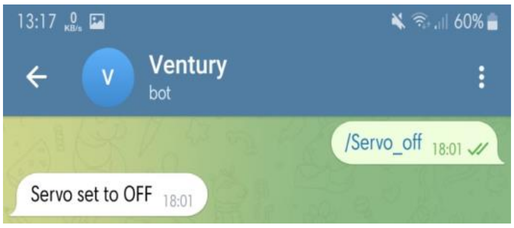


Figure 9. Servo Off Condition.

The command "/servo off" is used to return the servo gripper to open or release the object. When the servo-off command is sent from the telegram, the servo gripper will move from the 45° position to 0° to release the object. The response from the microcontroller is the notification "Servo set to OFF" which means the servo is in an inactive condition. Figure 9 is the display when the servo gripper is in the off condition.

3.3 System Testing

System testing is carried out using artificial spatial objects colored red, green, and blue to prove whether the system is working well or not. The working principle of the system is, that if an object that has a red color is moved or brought closer to the TCS3200 sensor using a servo gripper as an object clamp, the TCS3200 sensor detects the colored object. If the object is successfully detected, the data from the sensor is then processed via the microcontroller. ESP32 is the brain or data controller which has been programmed in advance to connect other components. When the object has been successfully detected and the data is processed on the microcontroller, then the object is moved using a servo motor to be grouped according to color. Table 5 is the result of the overall system testing.

From the test results in Table 5, the output results are obtained with a system accuracy of 90%. This figure was obtained from a calculation of 20 attempts that resulted in 2 failures, so the number of successful attempts was 18 times. There were 2 failures in testing the system with red objects, namely, in the 6th and 17th trials, where the servo should have been in High condition but in testing the servo was in low condition. The red color is divided into 3 membership functions of fuzzy logic, namely low, high, and high, the high value of the sensor conversion is used and can be converted perfectly. From testing the red object, it can be said that the system as a whole has good performance.

Table 6 is the results of testing the entire system using green objects. From the test results in Table 6, output results are obtained with system accuracy with a value of 90%. This figure was obtained from the calculation of 10 trials carried out, resulting in 1 failure. So the number of successful tests was 9 times. There was 1 failed attempt, namely on the 3rd attempt, the servo should have been in high condition, but there was no response from the servo. The green color is divided into 3 membership functions fuzzy logic, namely low, high, and high, the high value of the sensor conversion is used and can be converted perfectly. From the results of testing the green object, it can be said that the system can work well. The system cannot respond to anything other than green objects.

Table 5. System test results of the red object

No	Sensor Value			Servo	Status
1	R:85	G:247	B:51	High	succeed
2	R:92	G:247	B:51	High	succeed
3	R:82	G:248	B:52	High	succeed
4	R:86	G:246	B:51	High	succeed
5	R:90	G:179	B:126	High	succeed
6	R:131	G:241	B:51	High	failed
7	R:91	G:247	B:52	High	succeed
8	R:90	G:247	B:51	High	succeed
9	R:91	G:178	B:124	High	succeed
10	R:91	G:247	B:52	High	succeed
11	R:90	G:173	B:126	High	succeed
12	R:85	G:247	B:51	High	succeed
13	R:91	G:179	B:126	High	succeed

14	R:92	G:247	B:51	High	succeed
15	R:90	G:247	B:51	High	succeed
16	R:90	G:247	B:51	High	succeed
17	R:208	G:494	B:116	High	failed
18	R:91	G:179	B:126	High	succeed
19	R:86	G:173	B:126	High	succeed
20	R:82	G:248	B:52	High	succeed

Table 6. System test results for green object

No	Sensor Value			Servo	Status
1	R:245	G:153	B:60	Low	succeed
2	R:251	G:148	B:60	Low	succeed
3	R:251	G:153	B:59	Low	failed
4	R:251	G:153	B:60	Low	succeed
5	R:255	G:209	B:59	Low	succeed
6	R:215	G:138	B:78	Low	succeed
7	R:212	G:138	B:74	Low	succeed
8	R:215	G:139	B:78	Low	succeed
9	R:210	G:139	B:84	Low	succeed
10	R:215	G:139	B:85	Low	succeed

Table 7. System test results for the blue object.

No.	Sensor Value			Servo	Status
1	R:217	G:126	B:54	Low	succeed
2	R:211	G:126	B:61	Low	succeed
3	R:217	G:126	B:62	Low	succeed
4	R:217	G:119	B:55	Low	succeed
5	R:218	G:126	B:62	Low	succeed
6	R:211	G:126	B:62	Low	succeed
7	R:217	G:126	B:61	Low	succeed
8	R:217	G:126	B:63	Low	succeed
9	R:218	G:126	B:62	Low	succeed
10	R:217	G:126	B:62	Low	succeed

Table 7 is the results of testing the entire system using blue objects. From the test results in Table 7, the output results are obtained with system accuracy with a value of 100%. This figure was obtained from the calculation of 10 trials carried out, all of which were successful and there were no failures. From several tests of the entire system, it can be said that the system can work well as desired to select objects based on the red color.

3.4 Control System Testing using Telegram

At this stage, testing was carried out on the control of the smartphone via the Telegram application for control of servo 1 which functions as a gripper. Telegram was chosen because it has a good application response and is of course quite light. The results of testing the entire system can be seen in Figure 11–14.

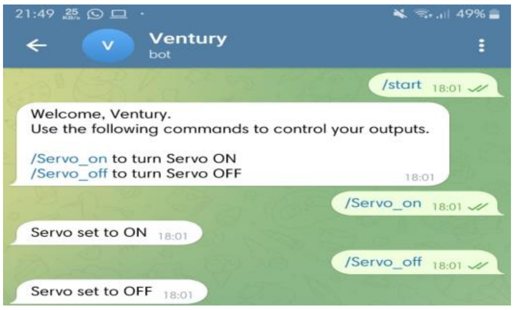


Figure 10. Gripper Servo control using the Telegram application.


Figure 11. Response results for red objects.


Figure 12. Response results for green objects.


Figure 13. Response results for blue objects.

There are 3 commands to control, namely, start, servo on, and servo off. The start is used to start the program and displays what commands the system can respond to. The servo on to control the servo to move closed to grip the object. Servo off is for control so that the servo opens to release the object. The telegram control results can be seen in Figure 10.

Figure 11 –13 is the result of the color response read by the TCS3200 color sensor. Data from the color sensor is sent to the ESP32 microcontroller for further processing and processing using fuzzy logic. To be grouped according to color type. If the color is red then servo 2 will rotate towards 125° from the initial system point, namely 60° and the LCD will display if the object is red. If the color sensor detects a color other than red, the servo will rotate 30° and the LCD will display objects that are not red.

4. CONCLUSION

Based on the results of designing and testing the decision-making system of the control gripper using the fuzzy logic method and the telegram application that has been carried out, several conclusions can be drawn that the system that has been created has quite good performance for separating and grouping objects based on color using the fuzzy logic method. The color of the objects to be grouped must be bright and clear because it affects the accuracy of the sensor reading so that the sensor performance becomes better. The level of accuracy in grouping color types is influenced by the fuzzy method which requires light intensity values from the sensor as fuzzy logic input. From several tests carried out using objects that have RGB colors, a successful presentation of 90% was obtained, these results prove that the system works well according to the expected results.

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