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by Rina Mardiati

The Prototype of Arm Robot for Object Mover Using Arduino Mega 2560

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***Abstract* — Robot arm is designed to facilitate human work in industrial fields such as moving and grouping objects to a predetermined place. In this study, a prototype robotic arm for moving goods was designed using an Arduino Mega 2560 and a Pixy2 CMUCam5. The robot arm will detect the object and move the colored object to a predetermined place. The development of this robotic arm prototype uses Arduino Mega 2560, Pixy2 CMUCam5, Servo MG90S, servo SG90, jumper cable, and laptop. While the software used is Arduino IDE and PixyMon. The object used in this study is a beam that has a length and width of 5x4cm and is green and blue. The recognition of this object uses a visual sensor, namely the Pixy2 CMUCam5 camera. The Pixy camera is used to detect colors in objects, which are then processed by the Arduino Mega 2560 using the programming algorithm found in the Arduino IDE software. From the program, it will produce output in the form of movement of the 4 servos contained in each joint of the robot arm. The results obtained on this arm robot are that when the Pixy camera detects a green object, the arm robot will pick up the object and servo 4 will rotate to move the green object to the left at an angle of 180°. Meanwhile, if the Pixy camera detects a blue object, the robotic arm will pick up the object and servo 4 will rotate to move the blue object to the right at an angle of 10°.**

Keywords— arm robot, pixy cam, vision sensor

I. INTRODUCTION

Along with the development of technology in various sector, including the sector of robotics, it has helped in facilitating various human activities. Human activities that were previously carried out manually can now be done automatically with the help of robots. A Robot is a tool that has many advantages that humans do not have such as, being fast, efficient, not tired, and having a high level of accuracy [1].

One example of a robot that petrifies human work is an industrial robot. In industrial working especially in the sector of carried out distribution grouping and moving of goods is to a predetermined place. This job requires a lot of energy and time. To optimize time and reduce manpower, use robot power, such as the use of robotic arms that can do distribution tasks quickly and efficiently. A robot arm or robot manipulator is a combination of several segments and joints which are generally divided into three parts, namely arm, wrist, and gripper [2]. The arm Robot is needed in the distribution process in the industrial sector so that work can be completed quickly and does not require a lot of human labor. The robot is designed to be able to move and group items according to the specified shape and place automatically. Automatic here means the operation of the robot without the need for human intervention. The robot arm also works as a substitute tool in carrying out high-risk work such as moving heavy goods, hazardous chemicals, hot materials, and others. [3].

To design a smart device that can move items according to size and color and can work automatically, a tool or component is needed that can control, remember, and make choices or decisions. This capability is owned by Arduino. Arduino can be programmed as needed to control, remember, and make the choices we need. Visual sensors play an important role in the operation of this robotic arm. The visual sensor used is a pixy camera with Arduino mega 2560 as the microcontroller. The pixy camera functions to detect the color of objects and the Arduino Mega 2560 functions as a microcontroller used in the robotic arm system [1].

In 2020, research was conducted on an automated cargo transporting robot system used in the industrial field based on line sensors and fuzzy logic control so that the robot can run stably and by using the BFD-1000 sensor and barometric sensor as inputs used in the fuzzy logic system by A Mutolib [4]. In 2018 the design of a robotic arm that is controlled wirelessly by using Arduino Uno as a microcontroller to control a robotic arm with an android-based Bluetooth smartphone control has been carried out by Purwono Prasetya and the design of a sorting robot that can detect and be able to sort colored objects using a pixy camera and image processing. In detecting the color of the object by Md Jamilur [5] [6]. The arm robot can also function as a harvesting robot whose research was carried out in 2019 and 2021 where the robot arm was used to assist in harvesting red and green tomatoes using image processing, Arduino mega 2560, raspberry pi, and a camera by Yurni Oktarina and as a separator robot. Pepper plants using a pixy2 camera, TC3400 color sensor, and image processing performed by Mustafa Ahmed [7] [8].

After the conducted several previous studies, it is known that this object-moving arm robot can be designed using 4 Degree of Freedom (DOF). The number of DOF used is intended so that the robotic arm can have a wider range of movement. Each DOF used moves with a servo motor that is connected and controlled by a microcontroller (Arduino Mega 2560) and a vision sensor (Pixy camera). So research was conducted under the title "The Prototype of Arm Robot for Object Mover using Arduino Mega 2560".

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II. MODELING ROBOT

A. Block Diagram System

Block diagram of the arm robot for object mover system using Arduino Mega 2560, it can be explained how the working principle of the robot arm moving goods. The working system of this robotic arm is that when the robot is active, the pixy camera will detect the color of the object in front of the robot. After the color of the object is detected, the robotic arm will move to pick up the object with the robot's clamp at the specified degree point and after that, the arm robot will move the object to a place according to the color of the object. And so on until all objects are moved to their respective places.

Arm robot for object mover can be divided into three system stages: input, process, and output. The system stages of this robotic arm can be seen in Fig. 1.

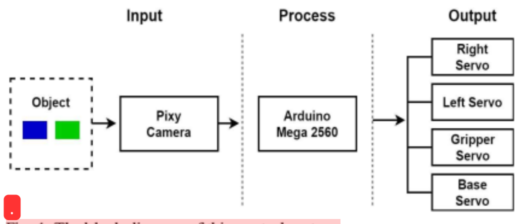

Fig. 1. The block diagram of this control system.

The arm robot for object mover using Arduino Mega 2560, including input, processing and output. In general, all these parts are related to each other, so that a usable robot can be created.

1. The input part is vision sensor. The component used is a pixy camera which functions to detect the color of the object used, namely blue objects and green objects. The object used is a block-shaped object with a size of 5x4 cm which is blue and green.
2. The processing part is the main part of this tool. Because this process functions to process color detection from objects given by the pixy camera. In this section, the Arduino Mega 2560 microcontroller is used to control or process input from the pixy camera to process the movements that will be carried out by the robot arm.
3. The output part is the final result of data processing after the Arduino Mega 2560 receives the input of the pixy camera. The output of the processing by Arduino is the movement carried out by the 4 servos contained in the robot arm. The 4 servos are the right servo, left servo, gripper servo, and base servo.

B. Hardware Design

When designing an arm robot for object mover, some electronic and non-electronic supporting components are used. The names and number of components needed on the prototype Arm robot moving objects using Arduino Mega 2560 can be seen in Table I.

TABLE I. COMPONENT

No	Component	
	Name	*Lots*
1	Arm Robot Kit Parts	1
2	Arduino Mega 2560	1
3	Pixy2 CMUCam5	1
4	Servo MG90S	3
5	Servo SG90	1
6	FC-10P to FC-6P Cable	1
7	Jumper	14

After all the components are prepared, the electronic circuit design used on the robot arm is carried out according to the schematic circuit that can be seen in Fig. 2. The schematic circuit in arm robot requires 4 servos, Arduino Mega 2560, and Pixy2 CMUCam5.

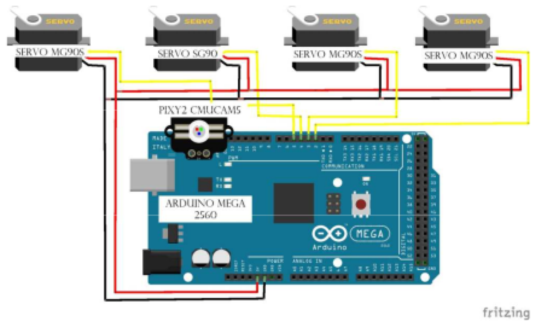

Fig. 2. Schematic of the prototype of arm robot for object mover using arduino mega 2560.

C. Implementation

In this study, 4 DOF arm robot was made using four servo motors located on the base, left arm, right arm, and gripper. The skeleton of the robot arm is made of 3D printing and is about 18.5cm long. The framework of the robot arm that has not been and has been designed can be seen in Fig. 3 and Fig. 4.

Fig. 3. Arm robot kit parts.

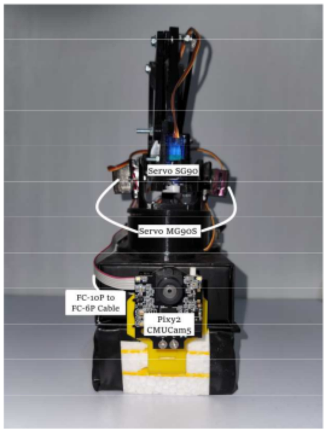

Fig. 4. Prototype arm robot.

Fig. 4 is an image of the assembled robot arm, with the Pixy Camera positioned on the front of the robot and the servo located at each joint of the robot. The pixy camera is placed on the front so that the robot can detect the object used and is located on the front.

D. Design Software

Designing software on the prototype system of arm robot for object mover it explains the working system of the robot arm controller so that it matches the desired color data. After the design of the tool and the work process of the robotic arm control system is complete, then programming is carried out using Arduino IDE software as a programming text editor and PixyMon software as initializing objects based on color. Flowchart design software of arm robot for object mover can be seen in Fig. 5.

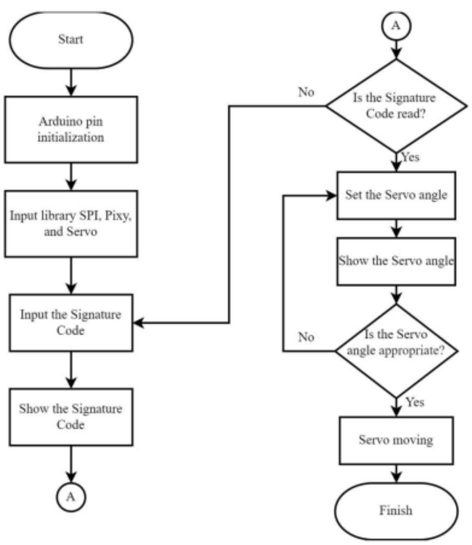

Fig. 5. Flowchart program.

Based on Fig. 5, it can be seen that the first thing to do in designing the arm robot system is to initialize the Arduino Pin. Furthermore, the SPI, Pixy, and servo libraries are entered and continued with the input code signature. If the code signature is unreadable, the code signature will be entered again. If the code signature has been read, then the process will be continued by adjusting the servo angle. If the servo angle does not match, then the servo angle will be reset to the servo angle set section. If the servo angle is appropriate, then the servo will move according to the previous signature input code and finish.

III. Result and Analysis

A. Pixy Camera Test

The pixy camera test is carried out to determine the color of the object (green and blue) and the object color data will be sent to the Arduino Mega 2560. The first test is when there is no object and the second test is when there is an object (green and blue). In this test, an Arduino Mega 2560, Pixy2 CMUCam5, jumper cable, and laptop. When the blue and green colors have been set to signature 1 and signature 2 in the PixyMon software, the object display on PixyMon will look like Fig. 6.

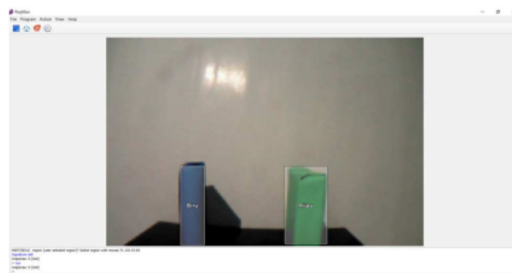

Fig. 6. PixyMon display.

In testing the camera sensor, testing the effect of the distance between the object and the camera is also carried out. This test procedure changes the object-to-camera distance by 5 cm. the results of this test can be seen in Table II.

TABLE II. Visual Sensor Testing Result

No	Visual sensor testing result	
	Range (cm)	***Description***
1	5	Detected
2	10	Detected
3	15	Detected
4	20	Detected

This test is carried out with a maximum distance of 20 cm, this is done because the maximum range of the robot arm is 20 cm.

B. Servo Motor Testing

Servo testing is carried out to determine the accuracy of the angle readings on the servo using a potentiometer and a protractor. The equipment used in this test is a servo, Arduino Mega 2560, potentiometer, protractor, and Arduino IDE software. The test is carried out by connecting 4 servos to pins (2), (3), (4), and (5) Arduino Mega 2560 with the conditions as in Table III.

TABLE III. PIN SERVO ON ARDUINO MEGA 2560

No	Pin Servo on Arduino	
	Servo	*Arduino*
1	Servo 1 (left)	2
2	Servo 2 (right)	3
3	Servo3 (gripper)	4
4	Servo 4 (base)	5

The use of these 4 servos is adjusted to the number of joints in the robot, servo 1 is used on the left joint of the robot, servo 2 is on the right joint of the robot, servo 3 is used as a gripper on the front arm of the robot, and servo 4 is for the base that regulates the position of the robot.

When the servo and potentiometer have been connected to the Arduino, the first test is carried out, namely measuring the servo using a potentiometer. This test is carried out by measuring the accuracy of the servo angle from 0 until 180 degrees. From the test results obtained data on the value of the degree reading on the servo using a potentiometer shown in Table IV.

TABLE IV. SERVO TEST DATA ON POTENSIOMETER

Testing Angle	Servo Testing Data on Potentiometer			
	Servo 1	*Servo 2*	*Servo 3*	*Servo 4*
0°	0°	0°	1°	1°
10°	10°	11°	11°	11°
20°	20°	21°	21	21°
30°	30°	30°	30°	30°
40°	40°	40°	40°	41°
50°	50°	50°	50°	51°
60°	60°	60°	60°	60°
70°	70°	70°	70°	70°
80°	80°	80°	81°	81°
90°	90°	90°	90°	91°
100°	101°	100°	101°	100°
110°	110°	110°	110°	110°
120°	120°	120°	120°	121°
130°	130°	130°	130°	131°
140°	140°	140°	140°	139°
150°	150°	150°	150°	150°
160°	161°	161°	161°	160°
170°	170°	170°	171°	170°
180°	180°	179°	177°	177°

Based on the data obtained in the Table IV, it can be seen in chart form for the results of the servo motor testing using a potentiometer at Fig. 6.

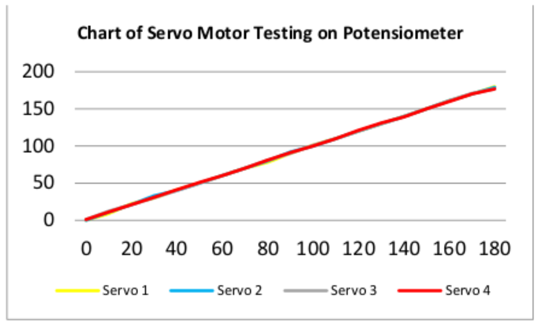

Fig. 6. Chart of servo motor testing.

The results of the servo testing that has been carried out in Table IV and chart in Fig. 6, it was found that the result of the difference in degrees on the servo with the rotation of the potentiometer displayed by the serial monitor is not more than 5°. And it is known that if the servo is in the minimum and maximum positions of 0° and 180°, the servo will vibrate slightly, so steps are taken by changing the minimum and maximum degrees of the servo to be 10° and 170°.

Furthermore, the second servo test is carried out, namely by using a protractor. This test is carried out to determine the average error difference owned by the servo. The results of this test can be seen in Table V.

TABLE V. SERVO TEST RESULT WITH PROTRACTOR

No	Servo test results with a protractor			
	Protractor angle	*Serial monitor*	*Error Difference*	*error (%)*
1	0°	0°	0	0
2	10°	12°	2	0.2
3	20°	22°	2	0.1
4	30°	33°	3	0.1
5	40°	40°	0	0
6	50°	49°	1	0.02
7	60°	58°	2	0.03
8	70°	71°	1	0.01
9	80°	80°	0	0
10	90°	90°	0	0
11	100°	100°	0	0
12	110°	110°	0	0

No	Servo test results with a protractor			
	Protractor angle	*Serial monitor*	*Error Difference*	*error (%)*
13	120°	120°	0	0.000
14	130°	130°	0	0.000
15	140°	139°	1	0.007
16	150°	150°	0	0.000
17	160°	161°	1	0.006
18	170°	171°	1	0.005
19	180°	180°	0	0.000
average difference error			0.7368	0.025

C. Overall Test

This overall test is carried out to know the ability of the robot arm in moving and detecting the color of the object from the point of collection to the place of placement that has been determined according to the color of the detected object.

The prototype of the arm robot in this study is deployed to move the blue and green objects. The first step of this robot is to detect the color of the object with the pixy camera. Table VI shows the servo motor degree output data while the robot moves objects. This data shows how the robotic arm moves based on the color of the object captured by the camera. The left and right movements of the robot are driven by the MG90S servo motor mounted on the base arm robot. The up and down movement of the robot is driven by the MG90S servo which is located on the left and right of the robot. And in the object retrieval process, the SG90 servo motor is used to move the robot gripper. The data from four servo degrees of the robotic arm can be seen in Table VI.

TABLE VI. DEGREE OF SERVO MOTOR

Motion Robot	Degree of Servo Motor (°)			
	Left Servo	Right Servo	Servo Gripper	Base Servo
Standby	15°	90°	170°	95°
Going down	50°	165°	170°	95°
Going Up	15°	90°	20°	95°
Right	15°	90°	20°	10°
Standby right	15°	90°	170°	10°
Left	15°	90°	20°	180°
Standby Left	15°	90°	170°	180°

From the Table VI, it can be seen that the standby position of the robot from the servo base is 95°, which means the robot arm is in the middle, so the robot can move left and right.

In this research, two colored objects are taken and transferred namely, green and blue objects that can be detected by the pixy camera. If the pixy camera detects a green object, the robot will move to take the object from the standby position to the going down position. Then the gripper will clamp the object and the robot will switch to the going up position and then the base servo will rotate 180° (left). Then the robot lowers the object to a predetermined place. After that the robot will continue to the standby left position and then the base servo will rotate again to the initial position, which is 95°. Data on the degree of taking and moving green objects can be seen in Table VII.

TABLE VII. DEGREE OF SERVO MOTOR TO MOVER GREEN OBJECT

Motion Robot	Degree of Servo Motor (°)			
	Left Servo	Right Servo	Servo Gripper	Base Servo
Standby	15°	90°	170°	95°
Going down	50°	165°	170°	95°
Take object	50°	165°	20°	95°
Going up	15°	90°	20°	95°
Turn left	15°	90°	20°	180°
Going down	50°	165°	20°	180°
Take off object	50°	165°	170°	180°
Standby left	15°	90°	170°	180°
Standby	15°	90°	170°	95°

Furthermore, if the camera detects a blue object, the robot will rotate to a position of 10° to move the object to the right. The robot arm that was initially in the initial position or standby will go down to the going down position, and then the gripper will clamp the blue object. After that the robot will switch to the going up position, after that the base servo will rotate to the right as far as 85 ° from the initial 95° position, which means the base servo is in the 10° position. After the base servo is on the right, the robot will lower the object to the specified place, then the robot will be in the standby right position, then the base servo will rotate back to its initial position, which is 95°. Data on the degree of taking and moving objects in blue can be seen in Table VIII.

TABLE VIII. DEGREE OF SERVO MOTOR TO MOVER GREEN OBJECT

Motion Robot	Degree of Servo Motor (°)			
	Left Servo	Right Servo	Servo Gripper	Base Servo
Standby	15°	90°	170°	95°
Going down	50°	165°	170°	95°
Take object	50°	165°	20°	95°
Going up	15°	90°	20°	95°
Turn right	15°	90°	20°	10°
Going down	50°	165°	20°	10°
Take off object	50°	165°	170°	10°
Going up	15°	90°	170°	10°
Standby	15°	90°	170°	95°

IV. CONCLUSION

In this study, the robot arm is controlled by a pixy camera with an Arduino Mega 2560 as the microcontroller, and a servo motor as the driving force for the robot arm to pick up and move objects. When designing the system, the PixyMon application is used to design the rules to be set on the robot arm. In-camera testing, it can be concluded that the color reading on the camera can be more than one color. In this test, the camera is instructed to detect green and blue colors. PixyMon sets a blue object as signature 1 and a green object as signature 2. In the servo motor test, the difference between the protractor and the servo is 0.7368° and with an average error of 0.025%. From the error difference obtained, it is known that the success of this robotic arm is 99.975%, so the system created can work well. There are 4 servos used in this robot, and each servo is set at an angle. The servo angle in the standby position is 15° for the right servo, 90° for the left servo, 170° for the gripper servo, and 95° for the base servo. When the pixy camera captures a green object, the robot will be ordered to take the object and the base servo will rotate to 170° to move the green object to the green object container located on the left side. If the object detected by the camera is blue, the robot will be ordered to pick up the object and the base servo will rotate to the right or at a position of 10° to move the blue object to the blue object container. From the results of the data obtained, it is known that the robot can move and can detect colored objects well.

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