Design of Mobile Line Follower Robot as a Helper in Carrying Goods at Poltekbang Surabaya

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Abstract
A line follower robot is a robot that is able to walk automatically following the line that has been made as the path it will follow. The advancement of robot technology is very rapid, starting from airplane autopilots using robots, cars using robots, to household appliances using robot systems, therefore this robot technology if applied to carry parts in the AMTO hangar of the Surabaya Aviation Polytechnic will make it easier to carry something by saving time and energy to be efficient in doing work. The research method used is a qualitative method using observation which consists of several stages including problem identification, data collection, tool design, tool design and tool testing. The results of this study are that the robot can walk along the line when the robot is out of line or has arrived at the robot stop, it will give a signal in the form of a sound through a buzzer. When the ultrasonic sensor of the robot detects an object blocking in front of it, the robot will stop moving, the buzzer will make a sound as a signal that the robot is blocked until the blocking object is gone then the robot moves again. The robot is able to carry loads up to 10 Kg with the time taken getting longer when the load carried is heavier and able to carry a load of 20 Kg when the robot runs on a straight path. it can be concluded that the mobile line follower robot tool made works according to what was planned.

Keywords: Robot, mobile line follower, line

INTRODUCTION

Along with the passage of time technology began to develop rapidly, all objects that use technology are increasingly sophisticated and modern making everything able to save time, making it easier to carry out activities quickly, precisely and efficiently. At this time electronic facilities are widely used in all fields of life. The rapid development of electronic technology makes things that are much in demand and sought after by the community.

Therefore, technology that uses robots is developed so that humans can be helped in doing work by minimizing errors because the robot will work according to what is ordered or the program made for the robot. Many countries are competing to create a sophisticated robot in the industrial field, aviation technology, vehicle technology, everything is created with a robot system, one of which is a line follower robot.

A line follower robot is a robot that runs automatically following the line that has been made as the path it will follow. The line that is made is a black line on a white surface or a track with a line color that contrasts with the surface

METHODS

This research method was carried out at the Surabaya aviation polytechnic. The research time is approximately 5 months, starting in November 2022 to March 2023. With the research carried out including hardware design, software design and tool testing.

2.1 Hardware Design

In making a tool, you must have a tool design that will be used as a reference in the manufacturing process. In Figure 1. Is a mobile line follower

robot scheme, starting from the power supply sending electric current then the infrared sensor and ultrasonic sensor will send an ADC value which then the data will be processed by Arduino and the data will be sent to the motor driver to move the left motor and right motor. This robot uses 5 infrared sensors mounted on the front and 1 ultrasonic sensor. When the robot stops, the Arduino will send digital data to the buzzer so that the buzzer works.

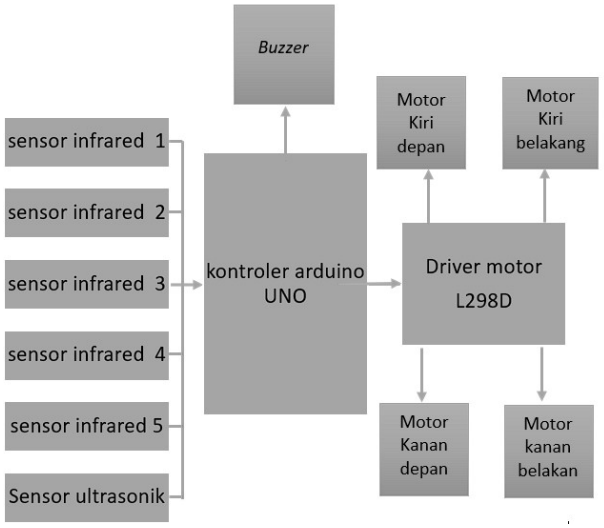

Figure 1. Hardware Design Schematic

Infrared sensors are electronic components that can measure or detect the surrounding area in this tool used as a line reader sensor. The nature of how the photo diode works is that if the more light is received, the smaller the resistance value obtained by the diode, so that if the sensor is in a white field, a lot of infrared light is reflected and received by the photo diode and then the obstacle LED will light up (ON) indicating that there is a reflection of infrared light received making the output voltage of this sensor will be close to 0V (LOW). And if the sensor is in a black or dark field indicating that the infrared light received by the photo diode is little, making the obstacle LED not lit (OFF), so that the output voltage of the infrared sensor will be 5V (HIGH). This robot uses 5 infrared sensors with a distance between the sensor and the surface of 2 cm and the distance between the sensors is 1.5 cm. with ADC values on white 0 - 511 and 512 - 1023 on black.

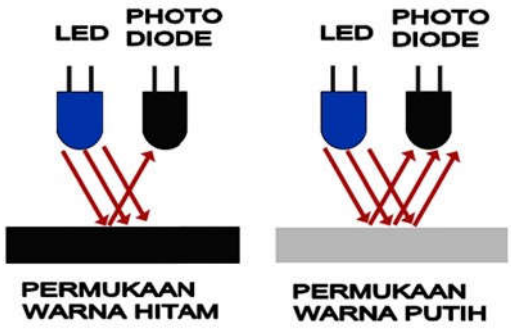

Figure 2. infrared sensor works

The L298D motor driver is an electronic component that functions to regulate the speed and direction of rotation on a DC motor. This type of driver is used because it has the ability to supply currents up to 4A at a voltage of 6V to 46V. L298D motor drivers are able to control the speed of DC motors with a value level of 0 to 255.

Buzzer or sound module When the five infrared sensors read the line or the five sensors do not read the line, the data from the sensor will be forwarded to the Arduino and forwarded to the motor driver, the motor will stop rotating and the buzzer will sound. At the stop line or when the robot is blocked by an object in front of it.

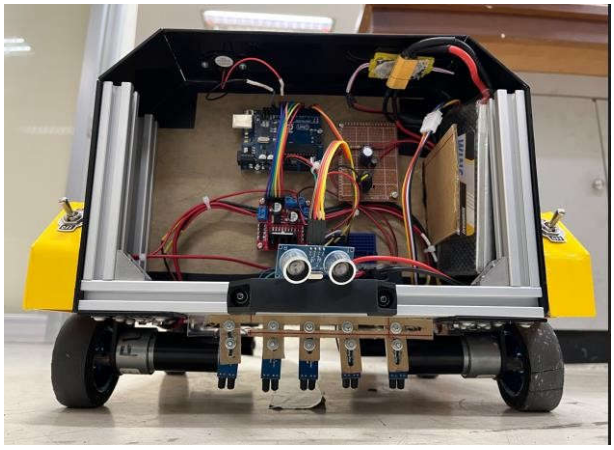

Figure 3. Hardware

Software Design

The programming language used on Arduino is C / C ++ programming language which is one of the programming languages used in various applications and has been recognized by programmers. This programming language used on Arduino is made as simple as possible so that beginners who want to learn can easily program it.

Tool Testing

1. Infrared sensor testing in the form of testing the line on the robot where this test is done taking data by knowing how much light is emitted by the LED and how much light is received by the photodiode, later a lot of light that can be received will be the difference in resistance as an output on the infrared sensor. The field that will be tested is the color difference of the path field that will be used by the robot.

Next, data collection when the robot is straight following the line and when the robot is on the turn line so that the robot does not get out of line and still follows the line, then at the stop the sensor will read the line so that the robot must stop.

Furthermore, testing the distance between the reflection field and the line sensor to find out how far the distance can be received by the photodiode when the LED emits infrared light. From these results, the ADC value will be known to be processed by the
Microcontroller.

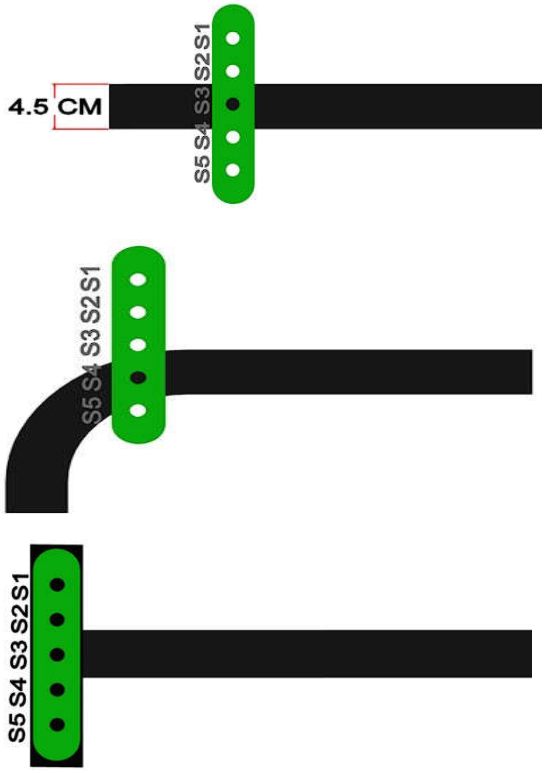

Figure 4. Line Testing

2. Testing the utrasonic distance sensor in the form of testing taking data processed by the sensor by comparing the distance that can be received back when TRIG sends a signal and is received by ECHO. And how many milliseconds the signal can be received back by the sensor to determine that the signal has been reflected back because there is an object in front of it. Testing the proximity sensor by providing an obstacle object that is right in front of the sensor to make sure the sensor can read the object.

3. Testing this system is in the form of overall testing from the installed hardware to the software that has been applied to the microcontroller by testing the robot. This test will take data on how much success when the robot walks along the line to provide objects to simulate if there are objects or people in front of the robot. If all systems have run well, the test is complete and if there is a mistake from the system, the programming or installation of the robot hardware will be carried out again until the robot runs according to what is programmed in it.

4. Weight testing on this mobile line follower robot in the form of data collection by giving a load on the place to put the object to be carried, the place to put the object is shown in Figure 3.3, the load that will be given to do this weight test starts from giving 1 kg to 10 kg on the turning path and 1 kg to 20 kg on the straight path. The load will be given in the form of tools and engine components. This test is carried out to find out how strong the robot is in carrying goods to the destination.

RESULTS

Hardware Design Results

The hardware that has been designed in this research is a mobile line follower robot with the ability to carry goods automatically at the Surabaya Aviation Polytechnic. The hardware in this design consists of a T-Slot type aluminum profile frame with size 2020 as the chassis of the robot, acrylic with a thickness of 0.2 and 0.3, rubber wheels, Arduino UNO, motor drive, ultrasonic sensor, infrared sensor, motor DC, buzzer, strobe light circuit, switch, terminal block, mini breadboard and 11.1 Volt battery. With a

length of 49 cm, a width of 30 cm can be seen In Figure 5.

Figure 5. Design Results

Software Design Results

After the mechanical design of the hardware (hardware) is complete, the next process is to make software (software). The software design used is a program written in C++ in the Arduino application, namely IDE. The programs created include the line follower program, ultrasonic distance program, buzzer program.

Furthermore, filling the program into the microcontroller using a connecting cable, namely a USB cable. In the IDE display, the menu display at the top, to transfer the program first click the verification icon first to find out whether the program still has an error or not. If there is no error, then transfer the data by clicking the tools menu first to determine the port that will be used in the data transferring process. Then upload to transfer the code data to the microcontroller.

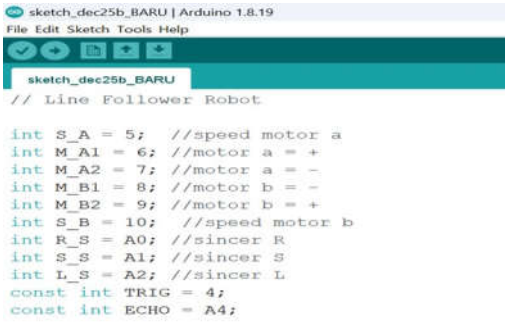

Figure 6. Arduino IDE application 1.8.19

Tool Testing Results

1. Line sensor testing is done by measuring the distance used on the robot and displaying the ADC value that comes out of each infrared sensor, namely sensor 1 to sensor 5. The output value of the sensor will be displayed in the IDE software application. By creating a program to check the output value of the sensor. Line sensor testing is carried out in 2 fields, namely the field with black color as the path of the robot and the white color of the robot's line foundation. The results of this test obtained the following data:

Table 1. Line Sensor Testing Results

No	Lebar *Line*	Jarak Antara Sensor Dan permukaan	Jarak Antara Sensor	Keterangan
1.	4.5 cm	1 cm	1.5 cm	Tidak berfungsi
2.		2 cm	1.5 cm	Berfungsi
3.		3 cm	1.5 cm	Berfungsi

Table 2. Results of Testing a Black Colored Field

Sensor Garis	Nilai ADC (hitam)	Hasil Nilai ADC (analog)
Sensor 1	512-1023	982
Sensor 2	512-1023	981
Sensor 3	512-1023	982
Sensor 4	512-1023	985
Sensor 5	512-1023	985

Table 3. White Field Testing Results

Sensor Garis	Nilai ADC (putih)	Hasil Nilai ADC (analog)
Sensor 1	0-511	75
Sensor 2	0-511	81
Sensor 3	0-511	85
Sensor 4	0-511	72
Sensor 5	0-511	84

Based on the data obtained from the table above, it can be concluded that when testing with a distance of 1 cm between the sensor and the surface, the results are too close to the sensor so that the analog value obtained changes due to poor lighting. Therefore, the sensor installation used on the robot is 2 cm from the surface and the distance between sensors is 1.5 cm and must use a black line with a width of 4.5 cm. The results of testing the ADC value that comes out of the sensor when detecting a black ground is> 981 and the ADC value that detects white is <511. Lighting is very influential on determining the color value of each line sensor that can be displayed on the Arduino software. The difference from this value will affect the input from the motor drive to rotate the motor.

2. After testing the line obtained, then testing the distance by providing a barrier object to find out the response to the mobile line follower robot when given obstacles in the form of objects and cadets who are in front of it. The results of the jark test obtained the following data:

Table 4. Sensor Distance Testing Results

No	Jarak Sensor Terhadap Objek	Pembacaan Sensor Terhadap Objek		Kondisi robot
		Terdeteksi	Tidak terdeteksi	
1.	5 cm	Ya	-	Berhenti
2.	10 cm	Ya	-	Berhenti
3.	15 cm	Ya	-	Berhenti
4.	20 cm	Ya	-	Berhenti
5	25 cm	Ya	-	Berhenti

Figure 7. Person as a barrier object

From the test data, it shows that the results of distance testing on objects 5, 10, 15, 20, 25 were successfully carried out by the robot. Testing using a stationary object, a cadet object as a barrier and testing suddenly placing objects directly in front of the robot. The robot managed to stop temporarily for 50 seconds according to the software created.

3. System testing by checking the entire system installed on the robot. In the system testing stage, 2 testing processes are carried out, namely hardware and software. The first test, namely hardware testing, is done by checking each connection of each component by following the wiring diagram and program that has been made. And testing the software in the form of an Arduino program code that has been transferred to the microcontroller and applied to the path that has been made.

4. Testing the hardware system by checking the interconnected components in accordance with the wiring diagram then given a voltage sourced from a 11.1 volt DC battery. The results of this test are as follows:

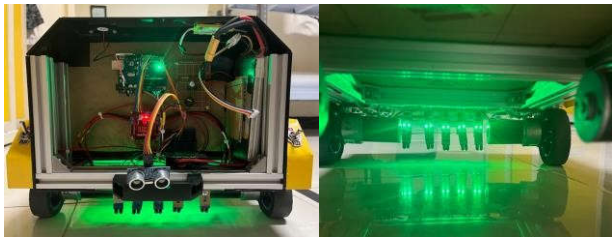

Figure 8. Components Function Well.

The picture above shows the results of hardware testing, namely the relationship between the installed robot components working properly marked indicator lights on each compone lit. The strobe lights are able to blink and are adjusted using a potentio meter.

15. Furthermore, software testing is carried out in the form of testing by comparing the software and the movements made by the robot.

Table 5. Line Software Testing Results

Sensor Garis					Pergerakan Robot	*buzzer*
S1	S2	S3	S4	S5		
0	0	1	0	0	*Forword*	*Off*
0	1	1	0	0	*Turnright*	*Off*
1	1	0	0	0	*Turnright*	*Off*
0	1	0	0	0	*Turnright*	*Off*
1	0	0	0	0	*Turnright*	*Off*
0	0	1	1	0	*Turnleft*	*Off*
0	0	0	1	1	*Turnleft*	*Off*
0	0	0	1	0	*Turnleft*	*Off*
0	0	0	0	1	*Turnleft*	*Off*
1	1	1	1	1	*Stop*	*On*
0	0	0	0	0	*Stop*	*On*

Table 6: Distance Software Testing Results

Sensor Jarak	*Buzzer*
5 cm	*On*
10 cm	*On*
15 cm	*On*
20 cm	*On*
25 cm	*On*

The results of the data above state that the system on the robot runs according to the software. 0 on the sensor states that the sensor does not read the line and 1 states that the sensor reads the line. The system on the robot both in the form of hardware and software is successful. Execution of the system is evidenced by the robot walking forward according to the software that has been made.

5. This test is carried out by giving a load to the robot in the form of aircraft components and tools carried out at the engine shop Poltekbang Surabaya. Weight testing is carried out to determine the maximum weight of goods that can be carried by the robot with this test knowing the results that can be transported by the robot as follows:

Table 7. Test Results of Load Weight on the Turn Lane

No	Berat Muatan (Kg)	Waktu (detik) yang ditempuh dalam 4 meter	Kondisi
1.	1	13.37	Robot dapat berjalan maju
2.	2	13.88	Robot dapat berjalan maju
3.	3	14.97	Robot dapat berjalan maju
4.	4	14.97	Robot dapat berjalan maju
5.	5	15.43	Robot dapat berjalan maju
6.	6	16.01	Robot dapat berjalan maju
7.	7	16.64	Robot dapat berjalan maju
8.	8	17.70	Robot dapat berjalan maju
9.	9	18.20	Robot dapat berjalan maju
10.	10	19.09	Robot dapat berjalan maju
11.	11	-	Robot berhenti

From the above data, weight testing is carried out, the results of weight testing are obtained in the form of giving a load of aircraft components and tools when turning, the robot can carry loads up to 10 kg in 13.37 - 19.09 seconds in the distance traveled, namely 4 meters, the time taken the heavier the load, the longer the time it takes, and when given an additional load of up to 11 kg the robot stops walking forward. When turning the motor that rotates only 2 left side motors front and back when turning right. And vice versa when turning left. When turning using 2 motors so that the power generated from the robot is less than maximum.

Table 8. Results of Weight Testing on Straight Paths

No	Berat Muatan (Kg)	Waktu yang ditempuh dalam 4 meter	Kondisi
1.	1	11.06	Robot dapat berjalan maju
2.	2	11.27	Robot dapat berjalan maju
3.	3	11.58	Robot dapat berjalan maju
4.	4	11.89	Robot dapat berjalan maju
5.	5	12.01	Robot dapat berjalan maju
6.	6	12.24	Robot dapat berjalan maju
7.	7	12.50	Robot dapat berjalan maju
8.	8	12.67	Robot dapat berjalan maju
9.	9	12.71	Robot dapat berjalan maju
10.	10	12.84	Robot dapat berjalan maju
11.	11	12.92	Robot dapat berjalan maju
12.	12	13.00	Robot dapat berjalan maju
13.	13	13.12	Robot dapat berjalan maju
14.	14	13.49	Robot dapat berjalan maju
15.	15	13.88	Robot dapat berjalan maju
16.	16	13.89	Robot dapat berjalan maju
17.	17	13.99	Robot dapat berjalan maju
8.	18	14.10	Robot dapat berjalan maju
19.	19	14.17	Robot dapat berjalan maju
20.	20	14.21	Robot dapat berjalan maju
21.	21	-	Robot berhenti

In table 8. obtained the results of testing the weight of the load on a straight line when given a load weight of 1 to 20 Kg the robot can walk according to the line made with a time ranging from 11 - 14.21 seconds in the distance traveled, namely 4 meters the comparison of the time taken from 1-20 kg is not too long and when the robot is given 21 Kg of load, the robot stops moving.

The results of testing mobile line follower robots can carry a maximum of 10 kg of goods from the initial place of delivery to the destination. With a longer time than the speed when this robot runs on a straight path because when turning requires slow acceleration of movement. And the time traveled when the load is added is getting longer.

CONCLUSION

Based on research and testing on the design of the mobile line follower robot, it can be concluded that:

1. The realization of this research with the results obtained in the form of a mobile line follower robot which is not too large and is able to carry a maximum load of 10 kg when the road turns with a slower time than when the robot runs straight because when turning requires acceleration to turn with slow movement, the time taken is getting longer when the load carried is getting heavier and able to carry a load of 20 kg when the robot runs on a straight path. 2.

2. The robot is able to follow the line that has been made starting from the starting place to a place with a line width of 4.5 cm.

3. Based on the research results that the robot will move if the infrared sensor with the surface is 2 cm away with a line width of 4.5 cm, and the ADC (analog) value between the black line> 981 and the white line < 511.

4. When the robot is blocked by an object within a distance of 5 to 25 cm the robot will stop moving and not hit the object in front of it. And will move forward again when the obstacle in front of him is gone.

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