Wall Follower Based Fire Extinguisher Wheeled Robot Prototype using 5 Channel Fire Sensor

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Abstract: Fires can occur anywhere, be it in schools, offices, and housing or other open spaces. Fire cannot be predicted when it will happen. In the modern era robots are one of the very special technologies, the benefits of these robots can facilitate human work. Robot cars in this era are attracting quite a lot of attention from experts to develop. Therefore, the author designed a "Wall Follower-based Fire Extinguishing Robot using a 5 Channel fire sensor" to reduce the risk of fire. This robot uses the HC-SR04 sensor to detect the barrier wall so that the extinguishing robot reaches the fire point. For the microcontroller tool used in this design system in the form of an Arduino Nano microcontroller which functions as part of the 5 Channel Flame Sensor controller to detect hotspots and a DC water pump to extinguish the fire. In this study using experimental research. This robot has successfully passed the track and put out the fire as the author has designed. The average flame sensor on this robot can read the fire point at a distance of 20 cm with angles of 90°, 60°, 120°, 150°, then the output voltage generated on the DC motor with a PWM value of 191 or 75% duty cycle produces an output of 8.77V measured using a multimeter, and this robot can extinguish the fire on the track with different distances with an average fire extinguishing time of 7.1 seconds.

Keywords: Fire, Robot, Wall Follower, 5 Channel Fire Sensor, Mini Pump Dc, HC-SR04 Sensor

1. Introduction

Fire is a powerful ecological and evolutionary force that regulates organismal traits, population sizes, species interactions, community composition, carbon and nutrient cycling and ecosystem function [1]. Fire is an unpredictable event that can occur at any time [2], fire often occurs in various places [3] one of them is in an area that has a population density so that it can be a problem if a fire occurs [4] which can result in losses such as loss of life, and property [5 - 6].

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Fires can occur due to natural factors, one of which is a lightning strike that hits the house [3], Apart from natural factors, fires can also be caused by human error, for example, improper electrical installations resulting in a short circuit (electrical short circuit), cigarette butts that are discarded carelessly and leaks in gas pipes [2], [5 - 7]. In this modern era, science and technology are developing quickly, one of which is in the field of electronics which helps and is used by humans to fulfil their needs [8 - 9]. One example of the development of electronic technology that is developing at this time is robots. Robotics is one of the fastest growing fields of engineering in the current era. Robots are designed and developed so that they can help humans [10] in doing dangerous / risky work that requires accuracy, and work with high precision [11 - 12].

In the development of robotics, various types of robots have been made by humans. Many robots have been developed to complete a task in a dangerous field [13], such as assisting an activity or work that requires high accuracy, and repetitive work [11], [14]. There are two types of robots, namely manual robots and automatic robots, one example of an automatic robot is

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a wheeled fire extinguisher robot with the ability to recognise walled tracks [15]. This robot is equipped with a microcontroller as a controller of a device made with high performance [16] the microcontroller used in this tool is Arduino nano as the controller of the wheeled robot and is equipped with HC - SR04 sensor, 5 Channel Flame sensor and DC motor whose speed is regulated using PWM.

PWM (Pulse Width Modulation) is a way to adjust the speed of a DC motor by setting it in a program that will be uploaded to the microcontroller [17], the value in PWM has a variation of 256 ranging from 0 - 255 changes in this value represent a duty cycle of 0 - 100% of the PWM output[18].

2. Literature review

2.1 related theories

In previous studies entitled "Fire-Extinguishing Robot Design by Using Arduino" which in this study uses a fan module as a fire extinguisher. The result of this study is that the extinguisher robot can detect and extinguish fires using a fan [19]. Suggestions in this study should use a water pump to extinguish the fire because using water is more effective in extinguishing the fire, using a water pump extinguishes burning wood and candles will be completely extinguished if using a fan burning wood can burn bigger or spread [19].

Then in a journal entitled "Fire Detection and Direction Control of Fire Fighting Robot"[20] In this study, the robot can only be controlled manually which is controlled using the HC - SR04 interface module and only uses a 1 channel fire sensor which can only detect at certain angles.

3. Study Methods

This study uses the experimental method [20]. Fig.1 illustrates the research stages carried out in this study starting from literature study, tool design, program design, tool making, tool testing, data collection and analysis. Hardware design is done by assembling all components according to the circuit schematic in Fig 2. The design results can be seen in Fig 4.

Then the next stage is to collect data and analyze the data which is then compared with the results of theoretical calculations. So that it can be known whether this tool already has an output value that is by the existing theory. The parameters of the components used in the fire extinguisher wheeled robot are shown in Table 1. Then the next stage is to collect data and analyse the data which is then compared with the results of theoretical calculations. So that it can be known whether this tool already has an output value that is in accordance with the existing theory.

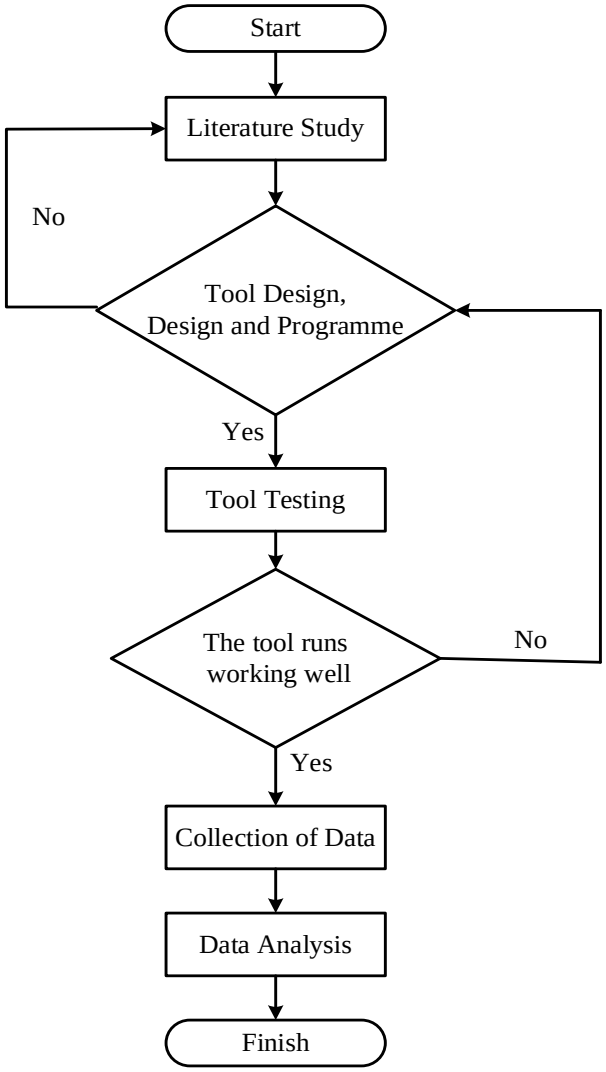


Fig. 1: Study Flowchart

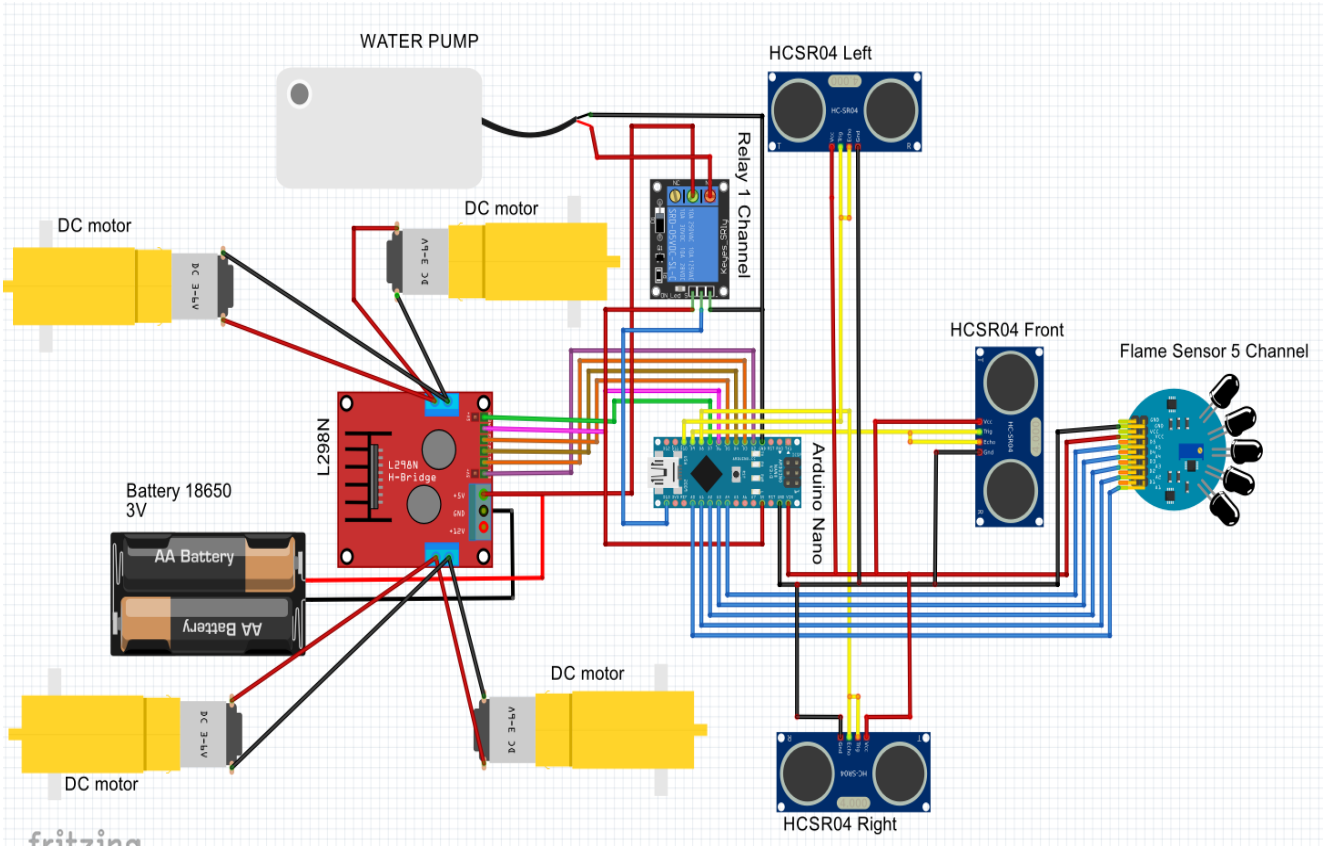


Fig. 2: Circuit Schematic

Table. 1: System Parameters

No	System Parameters	Parameter Value
1	Arduino Nano	5 V
2	Sensor HC – SR04	5 VDC
3	Flame Sensor 5 Channel	3.3 – 9 VDC
4	DC motor	12 VDC
5	Battery	3,7 V
6	L298N	50 V
7	Water Pump	3/ 4,5/ 5 VDC
8	Relay	5 VDC
9	Buzzer	5 VDC

Based on the block diagram in Fig 3, input from the battery serves as a source of electricity for all components of the fire extinguisher wheeled robot. The arduino nano microcontroller functions as the brain of decision making based on data received by the 5 channel fire sensor, HC - SR04 sensor, l298n motor driver, DC motor, relay, buzzer, and water pump. The buzzer will sound as long as the wheeled robot runs looking for a fire point using the HC - SR04 sensor as a wheeled robot navigation in a walled track with a l298n motor driver that functions to regulate the direction of rotation and speed of the DC motor. When the wheeled robot detects a fire point using a 5-channel fire sensor, the buzzer will stop sounding then the relay functions as a switch to activate the water pump.

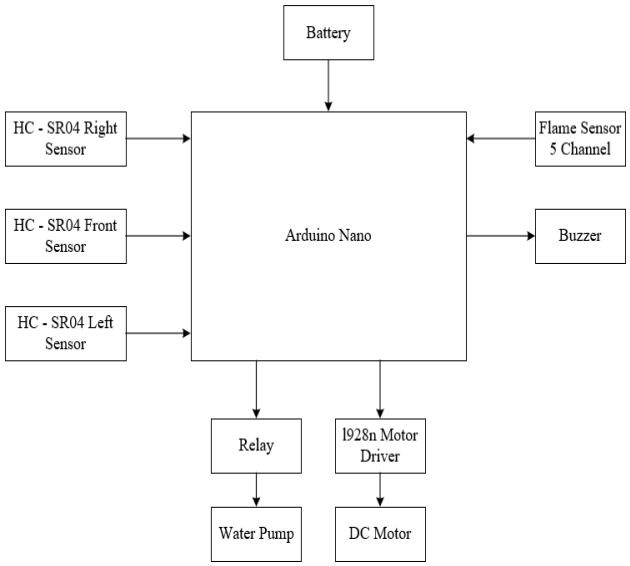


Fig. 3: Block Diagram

4. Results and Discussion

The research of wall follower-based fire extinguisher wheeled robot was started from 06 May 2024 to 28 June 2024. As for the research location, it was carried out in two places, namely the city of Cirebon, Pekiringan (-6.7013369, 108.5578203), and Kuningan, Sindangagung (-6.978186, 108.536414). Testing on the fire extinguisher wheeled robot is carried out in three stages, namely testing the 5-channel fire sensor using candles at different distances and angles, the output voltage data generated by the DC motor with different PWM values, and the duration required by the robot in extinguishing the fire at a certain distance.

Fig. 4 Fire Extinguishing Robot

The measurement results of the fire sensor at an angle of 90° can be seen in Table 2.

Table. 2: Sensor test results at 90° angle

Flame sensor Distance	Angel	LED Status on the Sensor
10 cm	90°	On
15 cm	90°	On
20 cm	90°	On
25 cm	90°	Off

The measurement results of the fire sensor at an angle of 60° can be seen in Table 3.

Table. 3: Sensor test results at 60° angle

Flame sensor Distance	Angel	LED Status on the Sensor
10 cm	60°	On
15 cm	60°	On
20 cm	60°	On
25 cm	60°	Off

The measurement results of the fire sensor at an angle of 30° can be seen in Table 4.

Table. 4: Sensor test results at 30° angle

Flame sensor Distance	Angel	LED Status on the Sensor
10 cm	30°	On
15 cm	30°	On
20 cm	30°	Off
25 cm	30°	Off

The measurement results of the fire sensor at an angle of 120° can be seen in Table 5.

Table. 5: Sensor test results at 120° angle

Flame sensor Distance	Angel	LED Status on the Sensor
10 cm	120°	On
15 cm	120°	On
20 cm	120°	On
25 cm	120°	Off

The measurement results of the fire sensor at an angle of 150° can be seen in Table 6.

Table. 6: Sensor test results at 150° angle

Flame sensor Distance	Angel	LED Status on the Sensor
10 cm	150°	On
15 cm	150°	On
20 cm	150°	On
25 cm	150°	Off

Based on Table 2 to Table 6, the results of measuring the distance of the 5-channel flame sensor with different angles obtained data results where the average sensor can read up to a distance of 20 cm and the size of the fire point affects the sensor detection.

Table. 7: Output measurement on DC Motor

Vin	PWM	Duty Cycle	Vout
11,28V	255	100%	9,02V
11,28V	191	75%	8,77V
11,28V	127	50%	7,82V
11,28V	64	25%	0V

Based on Table. 7, the measurement results at the output of the DC motor using a multimeter with a battery input of 11.28 V and a PWM value of 255 - 64 obtained different output voltages. The greater a PWM, the output produced by the DC motor is greater. To compare the output voltage generated from measurements using a multimeter, calculations are carried out using a formula. The duty cycle calculation can be calculated based on equation (1) .

$$Vout = DutyCyle \times Vin \quad (1)$$

Output voltage at PWM 64 or 25% duty cycle

$$Vout = DutyCycle \times Vin$$
$$Vout = 25\% \times 11,28V$$
$$Vout = 2,82$$

Output voltage at PWM 127 or 50% duty cycle

$$Vout = DutyCycle \times Vin$$
$$Vout = 50\% \times 11,28V$$
$$Vout = 5,64$$

Output voltage at PWM 191 or 75% duty cycle

$$Vout = DutyCycle \times Vin$$
$$Vout = 75\% \times 11,28V$$
$$Vout = 8,46$$

Output voltage at PWM 255 or 100% duty cycle

$$Vout = DutyCycle \times Vin$$
$$Vout = 100\% \times 11,28V$$
$$Vout = 11,28$$

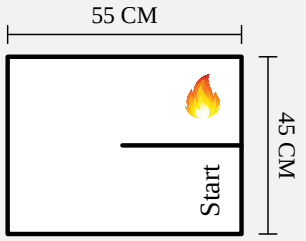
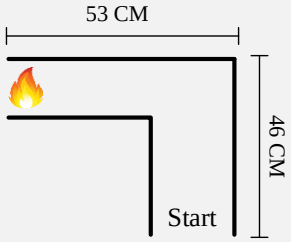
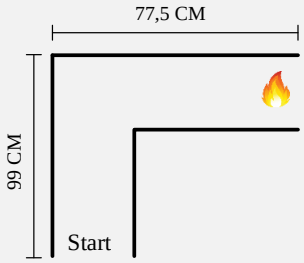
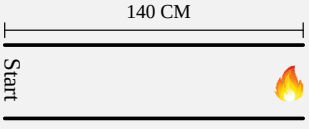
After a calculation is made in the formula and measurements are made on a multimeter, it can be seen a comparison of the output values in Table 8, because in each measurement there is a difference by the load factor where the voltage is divided by other components, such as relays, buzzers, HC - SR04 sensors, and 5 Channel flame sensors.

Table. 8: Comparison Table of output

Vin	PWM	Duty Cycle	Vout measurements	Vout calculations	Difference
11,28V	255	100%	9,02V	11,28V	2,26V
11,28V	191	75%	8,77V	8,46V	0,31V
11,28V	127	50%	7,82V	5,64V	2,18V
11,28V	64	25%	0V	2,82V	2,82V

The output generated from measurements using a multimeter produces a total of 25.61V while the output generated in the calculation using the formula (1) resulting in a total of 28.2V, then getting a difference of 2.26V at PWM 255, 0.31V at PWM 191, 2.18V at PWM 127, and 2.82V at PWM 64. In Table 9, the fire extinguisher wheeled robot successfully follows the wall follower track to find the fire point and takes time to extinguish the fire on the track with an average of 7.1 seconds with a PWM value on the DC motor of 200.

Table. 9: Fire Extinguishing Time Data

Track Plan	Extinguishing time
	The time taken to extinguish the fire by the car with 200 pwm on the DC motor is 7.25 seconds.
	The time taken in extinguishing the fire by the car with a pwm value of 200 on the DC motor is 6.02 seconds.
	The time taken in extinguishing the fire by the car with a pwm value of 200 on the DC motor is 7.80 seconds.
	The time taken in extinguishing the fire by the car with a pwm value of 200 on the DC motor is 7.15 seconds.
Average time to extinguish fire	7,1 Seconds

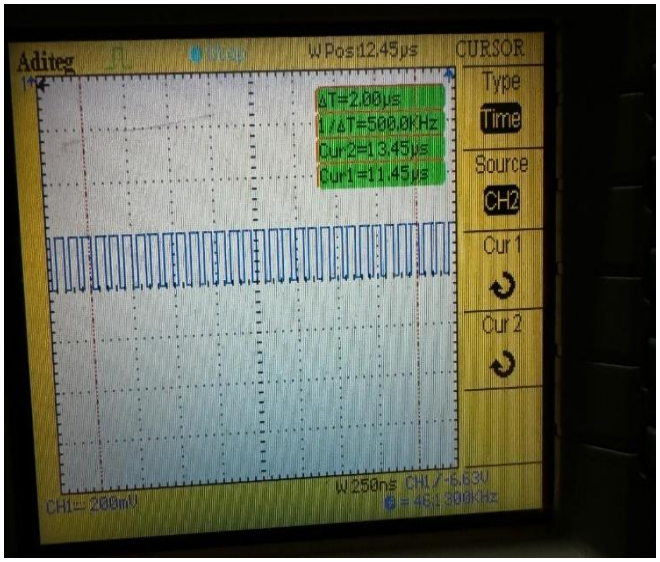


Fig. 5: DC Motor graphics on oscilloscope

In Fig. 5, a graph is obtained from measurements on a DC motor with a PWM of 200 using an Oscilloscope, and it can be seen that the period time obtained is 2.00 µs, to find out how much the resulting frequency can be calculated using equation (2).

$$F = \frac{1}{T} \qquad (1)$$

Where

$$F = Frequency$$
$$T = Timeperiod(ms)$$

Based on Fig 5, calculations will then be made to find the frequency with a period time of 2µs.

$$F = \frac{1}{T}$$
$$F = \frac{1}{2,00\mu s}$$
$$F = \frac{1}{0,002ms} = 500kHz$$

5. Conclusion

From the results of the study on the Wall Follower Based Fire Extinguisher Wheeled Robot Using a 5 Channel Flame Sensor, resulting in measurements on the 5 channel flame sensor can read the fire point with a certain distance and angle can be read by the sensor even though the size of the fire affects the status of the sensor reading, the output voltage generated by the DC motor with a PWM value of 64 - 255 produces different outputs, and the wheeled robot can extinguish the fire in the track with an average time of 7.1 seconds, then the 5 channel flame sensor on the wheeled robot can read on average at a maximum distance of 20 cm with angles of 60 °, 90 °, 120 °, 150 °, and the frequency generated by the DC motor with a PWM value of 200 is 500khz.

Conflict of interest: The authors declared "No conflict of interest"

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