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FUZZY FLOOR DUST CLEANING ROBOT PROTOTYPE BASED ON ARDUINO

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Abstract

The design of a Floor Cleaning Robot Based on Arduino Uno R3 aims to make it easier for humans to clean the dust on the floor efficiently. This robot consists of several series of components including Arduino Uno r3: Arduino Uno r3, sensor ultrasonic, motor servo, This robot consists of several components including Arduino Uno R3, ultrasonic sensor, servo motor, motor shield driver, dc motor, and vacuum blower motor. The entire system synergizes in the process of cleaning the dust on the floor and all of them are connected to a power source in the form of a dc battery, which supplies a voltage of 7 volts for the Arduino circuit and 12 volts for the vacuum blower. The working principle of this robot starts when the ultrasonic sensor can measure and distinguish the closest distance between the robot and an obstacle, at the same time the servo motor will move up to 180° to assist the ultrasonic sensor in detecting obstacles, both the front, right, and left sides of the robot. This Floor Cleaning Robot is programmed by adapting fuzzy logic artificial intelligence, the fuzzy rules used in this robot aim to control the speed of the robot based on the obstacle distance detected by the ultrasonic sensor. Fuzzy logic executes the data and continues the command to drive the motor so that the robot can work efficiently cleaning dust on the floor by minimizing the occurrence of collisions against obstacles. Dust suction carried out by the vacuum blower motor is not included in the Arduino circuit, because the vacuum blower motor requires an input power of 12 volts. It is not possible to unite it to the Arduino circuit because the power it has is only 7 volts, but these two separate circuits can still synergize well in the process of cleaning the dust on the floor. The results of observations and experiments show that the fuzzy logic embedded in the Arduino as the brain of the dust cleaning robot on the floor works quite well.

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1. Introduction

The robot is a combination of various kinds of mechanical equipment, which is controlled by electronic equipment and can move according to certain functions. By using Arduino and Bluetooth, we can design and build a remote control car based on android, a remote car controlled by Arduino. This is not only fun but also educates children at an early age to recognize control systems and assemble or assemble as part of increasing children's creativity and designing applications that will be installed on mobile phones/tablets that work with the Android operating system.

In this research, we design and build a prototype of a Floor Cleaning Robot with Bluetooth Network Control. We analyzed the system requirements needed to design this robot combined with the Arduino Microcontroller and the Android Operating System. So we produced a prototype robot that has the main feature of being able to suck dust. Several sensors are embedded so that the performance of this robot can be maximized in detecting objects.

Similar research on the Design of a Microcontroller-Based Vacuum Cleaner Robot has been carried out. Among them, the use of the system made consisting of a DC motor, ultrasonic sensor, and vacuum cleaner using several kinds of microcontrollers including the AT89S52 microcontroller [1], Arduino Uno [2][3] ATMega 8535 [4][5], then motor shield as a motor driver. However, the robot being developed is still a series of robots consisting of electronic components equipped with simple sensors. That's why we built a cleaning robot by utilizing the fuzzy logic in it. This is so that the robot that is created is more precise and the accuracy of the robot's work is better.

The use of fuzzy logic in robots is not only recently developed. This has been done by previous research where fuzzy was created for automation in robots [6], In this context a navigation system for autonomous car robots using intelligent fuzzy logic techniques will be presented. Fuzzy logic control is able to imitate the human experience of the best way to control the system without the need for accurate model equations, and can handle any disturbance in the system [7].

Arduino IDE is an abbreviation of Integrated Development Environment, or in simple language it is an integrated environment that is used to carry out development. It is called an environment because it is through this software that Arduino is programmed to perform the functions embedded through programming syntax. In previous projects we have used this type of Microcontroller for many things including automatic watering of plants [8][9]

2. Research Methods

2.1. Study Literature

Arduino IDE is an abbreviation of Integrated Development Environment, or in simple language, it is an integrated environment that is used to carry out development. It is called an environment because it is through this software that Arduino is programmed to perform the functions embedded through programming syntax.

At this stage, data collection will be carried out from the literature related to this research. Literature is obtained from existing books, journals, or thesis. The literature contains information on the manufacture of Arduino-based automatic dust cleaning robots using fuzzy algorithms.

2.2. Robot Design

At this stage, an analysis of the results of data collection from the literature related to this research is carried out. The system design is carried out using the C . programming language. The design in the

research to make a dust cleaning robot on the floor using electronic components is based on certain considerations. This media tool must-have criteria such as:

A. Individuals can perform quickly and efficiently by involving machine power.
B. To make the room cleaner and more awake. Standard components used are easy to get.

2.3. Robot Making

The steps for making the use of a dust cleaning robot on the floor are as follows::

A. The initial preparation is done by preparing the tools, as well as the auxiliary components used.
B. The cleaning process is carried out using a Vacuum Clenare that has been designed.
C. The system will be active when the switch on the robot is turned on.
D. The system will detect possible obstacles using ultrasonic sensors and the servo motor will actively work/move forward, left, and right at an angle of 180 °, and the vacuum cleaner will work automatically to clean the dust on the floor. The system will not activate if the switch on the robot is not turned on / the battery on the robot has run out.

2.4. Trial and Evaluation

At this stage, a trial process is carried out to find out the results of making a dust cleaning robot using a fuzzy algorithm that has been made and knowing the smoothness when running the cleaning robot.

3. Results and Discussion

The first definition of the system is to be designed thoroughly. This means that there must be a clear description of the scope of the discussion, where the medium is in the form of a context diagram.

3.1 Context Diagram

A context diagram is a general explanation of the system designed. The way the system works can be seen from the Context Diagram can be seen in Figure 1:

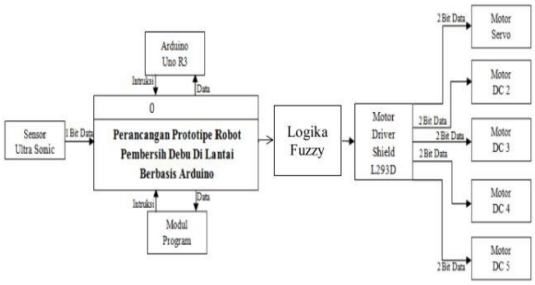


Figure 1. Context Diagram

3.2 Data Flow Diagram

The data flow diagram is a more detailed description of the designed tool. DFD is a program workflow on the Dust and Floor Cleaning Robot system Via Bluetooth Smartphone. Image data flow diagram level 0 can be seen in Figure 2:

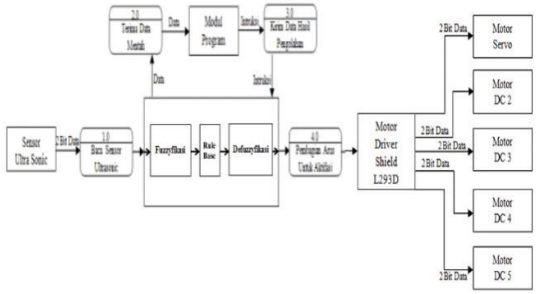
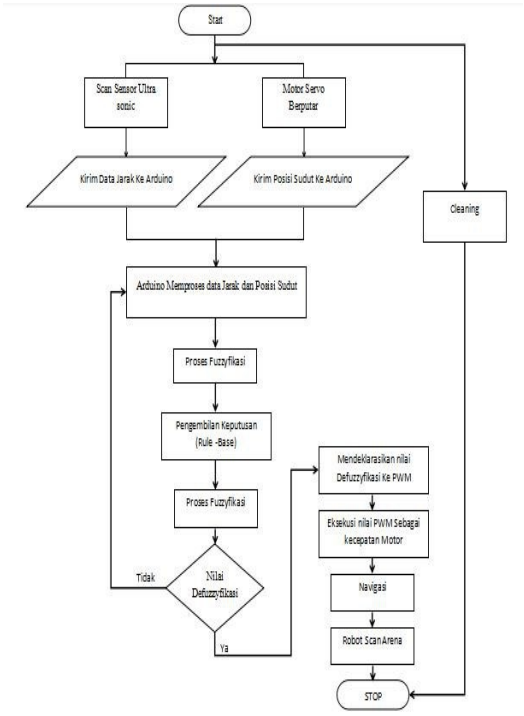


Figure 2. Data Flow Diagram

3.3 Overall Flow Chart

The designed program module has a structure of good quality, it is necessary to start by determining the logic of the program. The core of the program to drive the dust-cleaning robot on this floor is processing data that comes from the output of ultrasonic sensor readings in the form of the presence or absence of obstacles or reflected waves generated, reception of ultrasonic sensors in the form of logic "1" is the input logic where there is an obstacle and the robot must turn otherwise logic "0" is a safe distance between the robot and the obstacle.

The basic logic of the description of the dust cleaning robot on this floor is to use a flowchart as shown below:



Picture 3. Flow Chart

3.4 Tool Physical Design

The tools made are prototypes and miniatures of a real piece of equipment. Figure 4 shows the overall physical design of the tool using a flowchart as shown below:

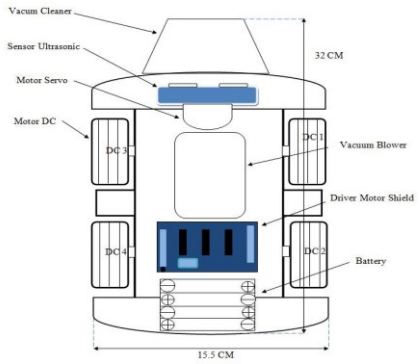


Figure 4. The physical design of the tool, top view

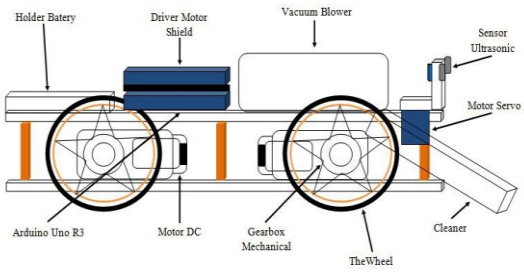


Figure 5. The physical design of the tool side view

3.5 Tool Working Principle

The system designed is a prototype on a medium scale and from the results of the overall electronic circuit design concept in Figure 6 it can be concluded in the form of how the tool works as follows:

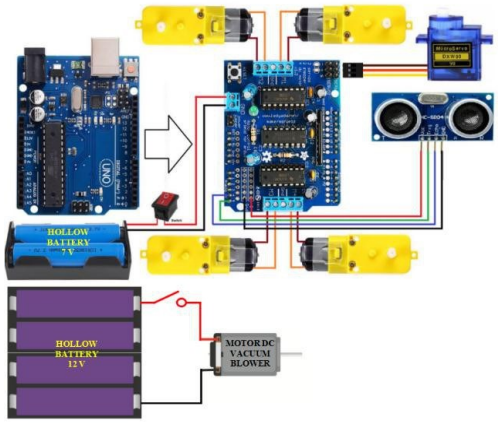


Figure 6. Overall Electronic Circuit Concept

Explanation :

1. The system begins by pressing the ON button on the device, where a 3.7 Volt DC will be channeled through the L293D motor shield drive to activate the Arduino and divide the current to other components including determining the direction of rotation of the dc motor.
2. Then the ultrasonic sensor will automatically measure the distance to the obstacles that are in front of the right and left of the robot.
3. When the ultrasonic sensor takes measurements, the next step for Arduino with the embedded fuzzy logic program activates the servo motor. Intend to move the ultrasonic sensor

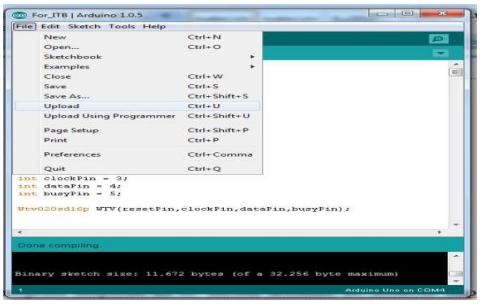
towards the left and right, each of which is 90° from the starting point so that the ultrasonic sensor can measure or determine the distance between the robot and obstacles, and this step aims to minimize the assembly cost which initially uses 3-4 ultrasonic sensors.

4. In automatic control, the robot will automatically run according to the rules of the fuzzy logic program design that is made, if there are obstacles in front of it. right and left of the robot, the system will automatically overcome the robot's obstacles by controlling the DC Motor 1, DC2, DC3, and DC Motor 2 so as not to hit the obstacle.
5. The function of the motor shield itself is as a conductor and current divider throughout the system components, this motor shield also functions as the first protection in the event of an excessive current jump which is channeled by the hollow battery then this tool also acts as a regulator of the rotation of the dc motor which functions as a robotic wheel.
6. Next is the process of activating the vacuum cleaner on the robot by pressing the button on the switch which will directly send a current of 12 volts from the hollow battery to the vacuum blower dc motor, the DC motor will be active and the vacuuming process will be carried out, and to turn off the dust suction process simply by pressing the button on the switch once again to stop the vacuuming process on the robot.

3.6 System Test

System testing is carried out starting from testing the module tool to testing the dust cleaning robot on the floor as a whole. The testing of the tool is carried out in stages in the following order:

a. Arduino Uno R3 Module System Testing



b. Arduino Uno R3 Module System Testing

This test is carried out to see the response of the sensor input voltage to the obstacle distance read by the HC-SR04 Ultrasonic sensor on the robot. The value read by the sensor is converted into a pulse voltage value, which follows the pulse distance of the obstacle, the tool used is a Digital Multimeter.

In this test, what is tested is the value of the sensor input voltage, the value that appears on the 5.03 Volt 5-volt multimeter, so that when compared to this sensor datasheet, the input voltage is 5 volts, it has an error of 0.59%.

$$\%error = \frac{Read\ Value}{Real\ Value} * 100$$

$$\%error = \frac{5.03 - 5}{5.03} * 100 = 0.59\%$$

c. Servo Motor Test

This test is also carried out to see the input voltage on the servo motor. To determine the stability of the voltage on the servo motor because if the voltage is less or more than 4.8 Volts - 5 Volts, the performance of the servo motor becomes less good and can even cause damage to this servo motor.

In this test, what is tested is the value of the servo input voltage, the value that appears on the multimeter is 5.01 volts 5 volts. so that when compared to the datasheet of this sensor, the input voltage is 5 volts, it has an error of 0.19%.

$$\%\,error = \frac{Read\ Value - Real\ Value}{Read\ Value} * 100$$

$$\%error = \frac{5.01 - 5}{5.01} * 100 = 0.19\%$$

d. Voltage Source Test

This test is very important because we have to know the value of the voltage as a power source for the performance of this system. Is the standard for the performance of the microcontroller, DC motor driver, and others, or is it still not up to the standard for the performance of the equipment for this system After getting the current and voltage values for each component, the robot then looks for the power used by the robot when operating.

Table 1. Data of Voltage Source Measurement Results

NO	Condition	Current (mA)	Source Voltage (V)	Power (mW)
1	Standby	430	8	3.44
2	Servo Operate	12,25	5	61.25
3	Ultrasonic Operate	3,4	5	17

Calculate the error of this system, it can be done by dividing the output by the input. It is known that the input is 8 volts and the output is 4.46 volts/motor (system conditions use fuzzy logic), the output value is 5.4 volts/motor (system conditions do not use fuzzy logic), and the solutions.

$$error\,(Fuzzy) = \frac{output}{input} = \frac{4.05v}{8v} = 0.5$$

$$error\,(Without\ fuzzy) = \frac{output}{input} = \frac{5.4v}{8v} = 0.67$$

e. Testing Output Driver Shield

This test is carried out by measuring the DC motor output voltage at slow, normal, and fast conditions. This is so that we can find out how much voltage is used by this robot in slow, normal, and fast conditions, and can measure how long it can be used for the robot to work optimally. The following is a picture and table of the Defuzzification output of the driver for DC motors. DC motor speed is obtained by the following comparison formula.

$$\frac{V1}{rpm1} = \frac{V2}{rpm2}$$

Table 2. Driver Defuzzification Output Measurement Data For DC Motor

NO	Variable Fuzzy	Voltage (Volt)	Motor Speed DC (rpm)	PWM(0%-59% duty cycle or 0-150)
1	Slow	2,29	80	95
2	Normal	3,28	109	123
3	Fast	4,05	135	144

f. Vacuum Blower Motor Testing

In this test, what is tested is the value of the Vacuum Blower input voltage, the value that appears on the multimeter is 12.05 volts ≈ 12 volts. So when compared to the datasheet of this sensor, the input voltage is 5 volts, and it has an error of 0.19%.

$$\%error = \frac{Read\ Value - Real\ Value}{Read\ Value} x\,100$$

$$\%error = \frac{12.05 - 12}{12.05} * 100 = 0.41\%$$

g. Robot Comparison Testing Using Fuzzy Logic.

This test serves to find out whether the program created is running well or not. This test is done by looking at the robot's response to obstacles, then it is calculated using a stopwatch how long it takes the robot to work from the starting point to the endpoint reaching the finish. The following is a table of robot testing results in the arena.

Table 3. Comparison of Robot Measurement Results Using Fuzzy Logic

Trial Order	Using Fuzzy Logic		Without Using Fuzzy Logic	
	Dust cleaning time (S)	Collision On Obstacle	Dust cleaning time (S)	Collision On Obstacle
1	300	7	180	2
2	223	5	197	1

3	189	3	147	0
4	208	3	264	3
5	170	1	235	3
Experimental Average Results	218	4	205	1

In this section, the results of the study are explained and at the same time, a comprehensive discussion is given. Results can be presented in numbers, graphs, tables, and others that make readers easy to understand. The discussion can be carried out in several sub-chapters. It is strongly recommended that comparisons with results from other published articles be provided to provide more context and to reinforce claims of novelty.

4. Conclusion

Based on the results of the system design and manufacture of this tool, the following conclusions can be drawn :

1. The use of Arduino Uno R3 using the C programming language and combined with Fuzzy Logic is proven to be able to control or monitor the activity of the dust cleaning robot on the floor Penggunaan Arduino Uno R3 by using a programming language C and combined with Fuzzy Logic proven to be able to control or monitor the activity of the dust cleaning robot on the floor
2. The robot continues to work optimally using only one sensor, the ultrasonic sensor.
3. Ultrasonic sensors are faster in detecting obstacles or obstacles around the robot.
4. Servo motor can work optimally rotating up to 180°.
5. L293D ultrasonic sensor, servo, and driver shield communication can work well without any instruction collision.
6. The DC motor is proven to be successful in running the robot movement for the movement of the dust cleaner on the floor.
7. A vacuum Cleaner is proven to be able to suck dust well on robots.
8. Batteries have proven to be successful as a storage medium and input power source in all robotic systems.

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