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Dust cleaning device based on Ultrasonic sensors using Arduino Mega

Firzan Pratama Anamendra[1], Oriza Candra[1]
[1]Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

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ABSTRACT

This study develops an automatic vacuum cleaner based on ultrasonic sensors with Arduino Mega as the main control unit. This system is designed to improve cleaning efficiency with automatic navigation that can detect and avoid obstacles without requiring a line path as a guide. This tool can move automatically using ultrasonic sensors to detect obstacles around it and adjust its direction of movement so as not to hit objects blocking its path. This tool integrates an HC-SR04 ultrasonic sensor, DC motor, L298N motor driver, and a relay to control the vacuum cleaner. Testing was carried out on an area of 120 cm × 120 cm divided into nine boxes, with an average cleaning result of 8.4 papers/box. These results indicate that the tool has effective and reliable cleaning capabilities. With this innovation, automatic vacuum cleaners can provide a practical solution for people in maintaining home cleanliness efficiently.

Corresponding Author:

Firzan Pratama Anamendra
Department of Electrical Engineering, Faculty of Engineering, Universitas Negeri Padang
Kampus UNP Pusat, Jl. Prof. Hamka, Air Tawar, Padang 25131, Indonesia
Email: firzan812@gmail.com

1. INTRODUCTION

Technological advances have brought significant changes in various aspects of human life. The busyness of modern society often causes limited time to do household chores [1]. One of the jobs that is often neglected is cleaning the floor, especially after a long day of work. Therefore, an automatic solution is needed that can help maintain the cleanliness of the house efficiently [2],[3]. Floor cleaning robots are an innovation that can help overcome these problems. Various studies have been conducted to develop robotic systems that can work automatically. Several previous studies have used microcontrollers such as Atmega 8535 and Arduino Uno [4]-[7]. However, there are still limitations in the effectiveness of navigation and the coverage of the cleaning area.

This research proposes the development of an ultrasonic sensor-based dust cleaner using Arduino Mega. This system is designed to improve cleaning efficiency with sensor-based automatic navigation. Arduino Mega is used as the main control center with DC motor and relay integration [8]. Ultrasonic sensors function as obstacle detectors [9]. Algorithm and programming use Arduino Mega. This system is made in miniature form with its mechanics made of acrylic. Through this approach, the cleaning tool is expected to be able to work more effectively and independently. This study aims to design and develop a more efficient automatic dust cleaner. This tool is expected to help people maintain home cleanliness more practically. In addition, this research can contribute to the development of automation-based household technology. With this innovation, home cleaning activities can be done more easily and quickly.

2. METHOD

In general, this tool consists of three important parts that are interconnected with each other, namely hardware, software and mechanics. These three parts must be in sync with each other so that the intent and

purpose of making this tool is achieved as expected. The hardware part consists of a distance sensor circuit, Arduino Mega, motor driver circuit, relay circuit, vacuum cleaner, the software part consists of a flowchart and program for line detection, obstacles and robot control programs on the microcontroller while the mechanical part is the mechanical design of the dust cleaning robot. The overall system block diagram is shown in Figure 1.

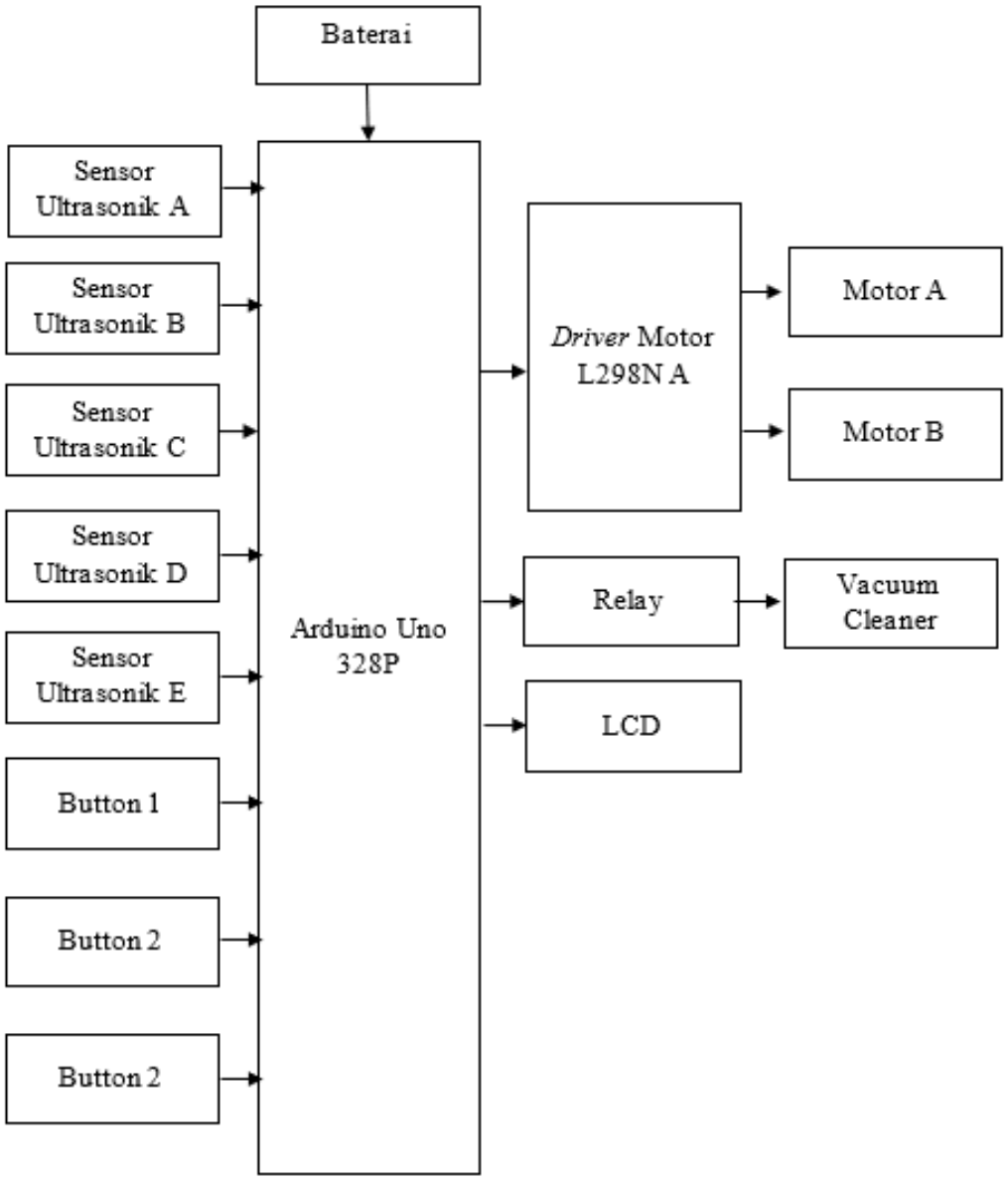

Figure 1. System block diagram

This dust cleaning system integrates various components and technologies to clean dust automatically. Arduino Mega serves as the main control brain, which is responsible for controlling all the operations of the tool [8],[9]. DC motor is used as the main driver of the robot, allowing movement according to instructions from Arduino [10]-[12]. The motor driver used in this research is the L298N A motor driver. In addition, the HC-SR04 ultrasonic sensor is used as a distance sensor to detect objects around the robot [13]-[15]. If the sensor detects an obstacle, the robot will automatically change direction to avoid collision. With an ultrasonic sensor-based navigation system, the robot can move independently without requiring a line path as a guide. A relay circuit is used to control the vacuum cleaner when cleaning is needed in the area navigated by the robot, the relay will activate the vacuum cleaner to clean the dust. A 5 Vdc battery is used as the main power source of the tool, which provides energy for all components and hardware. The working principle of this tool can be seen in the system design flowchart shown in Figure 2.

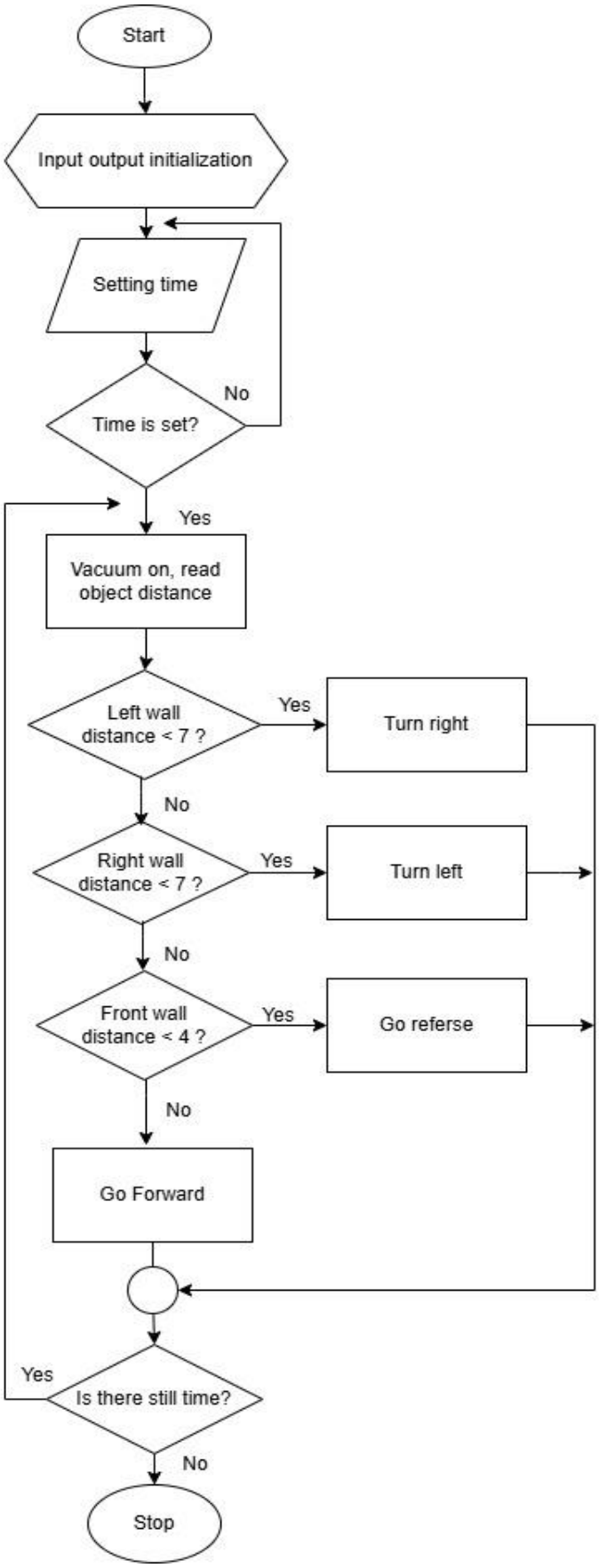

Figure 2. Flowchat system

Based on Figure 2, Arduino Mega starts system initialization and is ready to receive further instructions. In the initial stage, the user is given the option to set the operating duration of the tool using the time setting button. This button allows the user to choose how long the tool will operate in minutes. After the user determines the desired time, the system will store the value in the Arduino Mega memory. After the operating time is set, the tool is ready to work automatically. When the tool starts operating, the HC-SR04 ultrasonic sensor will continue to be active and monitor the area around the tool. This sensor is used to detect the distance between the tool and the object in front of it. Data from the ultrasonic sensor is sent to the Arduino Mega for processing. If the sensor detects that there is an object or obstacle within a certain distance, such as a wall or furniture, the Arduino Mega will immediately take action to avoid the obstacle. This system works by changing the direction of movement of the tool through commands sent to the motor driver. The DC motor connected to the motor driver will move the tool to turn in a safer direction, so that the tool can continue to move without hitting objects around it. This tool does not use a line sensor, so it does not rely on a particular path for navigation. Instead, the system works based on data from the ultrasonic sensor which continuously analyzes the area around the tool. This allows the device to operate in a variety of environments, including rooms with dynamic layouts, without the need to install guide lines on the floor. The obstacle avoidance algorithm used in the Arduino Mega ensures that the device can move efficiently, avoid collisions, and find the optimal path to clean the area effectively.

In addition to the navigation function, this tool also has an automatic cleaning feature. When the tool moves, the Arduino Mega will control the relay to activate the vacuum cleaner. This vacuum cleaner functions to suck up dust, dirt, and other small particles from the floor surface. This cleaning process runs simultaneously with navigation, so that the tool can efficiently clean all areas that can be reached. As long as the tool continues to move, all of these processes run automatically and continuously until the time specified by the user runs out. Arduino Mega continues to calculate the operating time based on the initial settings set by the user. When the operating time reaches the selected limit, the system will turn off the vacuum cleaner and stop the movement of the tool slowly. By integrating various components, such as a timer button, HC-SR04 ultrasonic sensor, DC motor, motor driver, relay, vacuum cleaner, and Arduino Mega as a control center, this tool is able to work intelligently and independently. Not only can it detect obstacles and adjust the direction of movement, but it also ensures that cleaning runs effectively according to the duration set by the user. All actions and decisions in the system are controlled by Arduino Mega, which functions as the main brain in coordinating each component to work optimally. The design of the tool in this study can be seen in Figure 3.

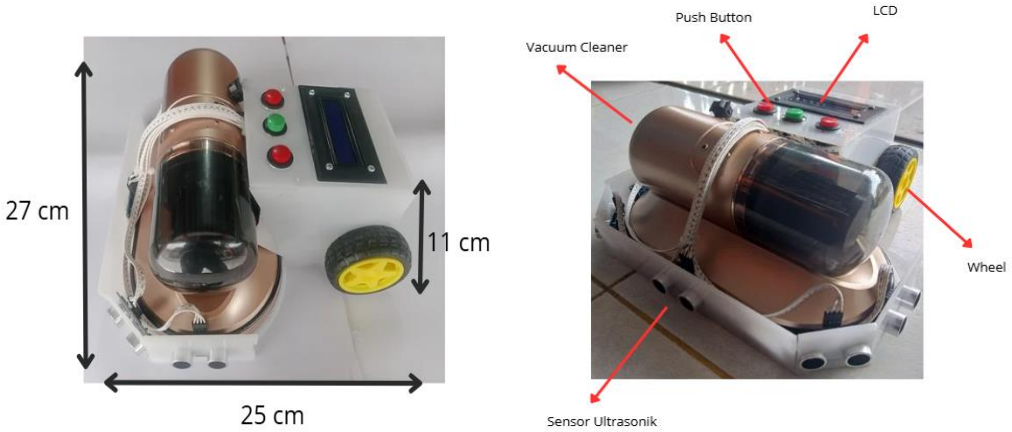

Figure 3. Device design

So that the software program is designed later to be used on the robot. Electronic design needs to be done consisting of several electronic circuits, namely consisting of the L298N motor driver circuit and relay. The motor driver circuit is useful for reversing the direction of motor rotation, as well as regulating the speed of motor rotation by adjusting the input value of Pulse Width Modulation or pulse width value (duty cycle), the greater the value of the duty cycle given, the faster the motor rotation, and vice versa if the smaller the value of the duty cycle given, the slower the motor rotation. While the relay circuit is used to control the vacuum cleaner, namely by connecting or disconnecting the electric current on large devices such as vacuum cleaners. In this context, the relay is activated by the Arduino Uno to turn the vacuum cleaner on and off according to the cleaning needs of the area passed by the robot. The overall circuit shape is as seen in Figure 4.

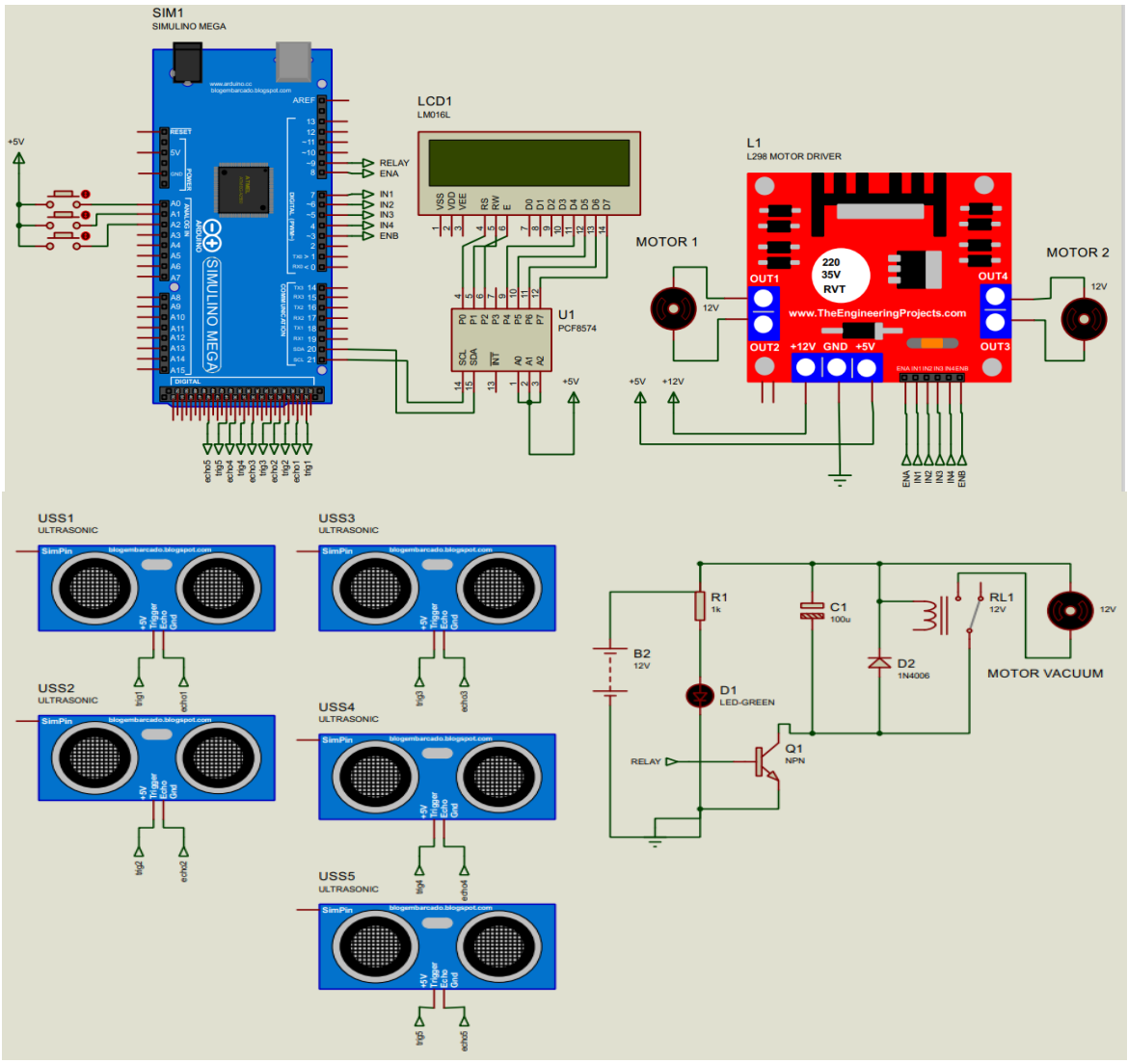

Figure 4. Electronic circuit system

3. RESULTS AND DISCUSSION

In this study, the vacuum cleaner was tested on an area measuring 120 cm × 120 cm, which was divided into nine boxes of the same size. Each box contained 10 pieces of paper as a testing medium. The test was carried out for 60 seconds for each trial, and the results were recorded based on the number of boxes passed by the vacuum cleaner and the total number of pieces of paper that were successfully sucked up. Table 1 describes the test results. From the data in Table 1, the average number of papers vacuumed in all tests was 8.4 papers/box and in general, the vacuum cleaner was able to reach 7 boxes in one test cycle.

Table 1. The performance of vacuum cleaner

Test	Skipped Box	Total Paper Sucked	Average paper/Box
1	6	52	8.66
2	6	50	8.33
3	7	54	7.71
4	7	61	8.71
5	6	54	9
6	7	52	7.43
7	7	63	9
1	6	52	8.66

4. CONCLUSION

This research has successfully designed and developed an automatic dust cleaner based on ultrasonic sensors controlled by Arduino Mega. The sensor-based navigation system allows the tool to move independently without requiring a guide path, and is able to detect and avoid obstacles. This tool can move automatically using ultrasonic sensors to detect obstacles around it and adjust its direction of movement so as not to hit objects that block its path. The test results show that this tool can clean areas with high efficiency, with an average suction of 8.4 papers/box. With this success, the developed tool has the potential to be an innovative solution in the field of household automation and can be further developed by increasing suction power, energy efficiency, and integrating artificial intelligence for more optimal navigation.

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