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Differential-Drive Wheeled Robot Controller using Pulse-Width modulation in disinfectant sprayer robot

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Abstract. This paper describes dc motor control in disinfectant spraying robots using Pulse Width Modulation (PWM) applied to Koesnadi hospital in Bondowoso, East Java as a tool to help sterilize hospital building hallways during the COVID-19 pandemic. Differential drive wheel with caster wheel combination. The robot has a size of *L x W x H: 40 cm x 40 cm x 120 cm* moves at a set speed to get even spraying results, but that speed becomes unstable due to the linearly changing load of the disinfectant tube. Using PWM is expected to produce different robot speeds according to the load conditions carried by the robot. The Arduino Nano microcontroller as the main controller is used to manage pwm signal cycles as a reference for robot speed when performing disinfectant spraying tasks. The application of PWM to the disinfectant atomizer robot is explained by calculating the estimated time and speed with the observation of the reduction of load conditions on the robot.

1. Introduction

On December 31, 2019, the WHO China Country Office reported a case of pneumonia the etiology is unknown in Wuhan City, Hubei Province, China. On January 7, 2020, China, which identified pneumonia of unknown etiology as a new type coronavirus (novel coronavirus, 2019-nCoV). Additional cases for the number of 2019-nCoV / COVID-19 took place quite quickly and there has been a spread outside the Wuhan area and other countries [1]. On April 19, 2020, WHO reported that the number of cases globally was 2,241,778 people confirmed as COVID-19 [3]. With reports of confirmed cases of COVID-19 in Indonesia on that date, it was 6,248 with a death toll of 535, even though it was reported that on March 24, 2020 there were 579 patients who tested positive for COVID-19 with 49 cases died [3] [2]. With an increase in the number of confirmed cases, this shows the spread of this virus is very fast in several ways, one of which is the spread of this virus by touching the surface of objects that have been contaminated by this virus. This virus can survive on the surface of the object for up to 72 hours [4]. In the study of persistence of the COVID-19 virus on different surfaces show that the COVID-19 virus remained viable up to 1 day on cloth and wood, up to 2 days on glass, 4 days on stainless steel and plastic, and up to 7 days on the outer layerof a medical mask. Another study found that the COVID-19 virus survived 4 hours on copper, 24 hours on cardboard and up to 72 hours on plastic and stainless steel [8]. In addition, virus carriers that produce droplets through coughing, sneezing and talking can transmit

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directly or fall on the surface of objects which are then touched by other people [4]. One of the recommendations of the Centers for Disease Control and Prevention (CDC) is to clean and disinfect the surface of objects once a day, assuming that one person will eat with the outside world in various ways, one of which is the person who leaves and returns with bring goods in [4]. In this study, a wheeled robot was developed for disinfecting which was assigned to dr. Koesnadi Hospital in Bondowoso, East Java. The robot is designed with a 2 wheel drive system. Pulse Width Modulation (PWM) is used to help regulate the movement of the robot against the loads carried by the robot. With the system created, the robot can be controlled to adjust the movement speed of the robot to the heavy load conditions in the form of disinfectant liquid which is in line with the spraying carried out by the robot. Sprayer parts are made on both sides of the robot with 3 spray points each which aim to collect evenly to the object. In addition, the robot is also installed with an ultrasonic sensor to prevent the robot from crashing when. The output of this research is expected to contribute to the spread of disease outbreaks caused by the 2019-nCoV.

2. Related Work

Research in the robots for disinfectant spraying has been carried out, one of which is study conducted for disinfectant for livestock breeding (Feng, 2019; Wang, 2019). Study in this area discusses automatic robots consisting of a vehicle unit, a disinfectant spraying unit, a monitoring unit, and a controller unit, and supported automatic and remote operation. In this study a crawler robot was adopted as the carrier for the robot, and it could move along the line marked with the magnet and RFID label on the ground. A sprayer with gas-liquid extraneous mixture structure was developed to meet the need for the high-flow and long-range spray. the research show in the constant air speed, the droplet diameter was mainly determined by the liquid flux, and less affected by the spray distance. With the in-crease of liquid flux, the droplet diameter would get bigger. In year 2018, Priyanka K. and Mariyammal A. study on DC motor rotation control using Pulse Width Modulation (PWM) to demonstrate precise and accurate control of small DC motors. One of the results of this study is the speed will be in constant at different loads. In year 2016, Chery Mint and Nu Nu Win conduct to research mobile robot motion task is point to point motion task in an obstacle free indoor environment. The aim of this research is to reduce position error of two wheeled differential robot when the robot moves from one point to other point. This study mainly focused on the navigation system of two wheeled differential robot. The result of two wheeled differential robot navigation system can be used for mining application by moving from point to other point in desired distance and direction in order to find the dangerous mine if the robot control system is very robust. And then these mobile robot can be also candidates for farming applications, as well as for transportation in nuclear plants and factories [7].

3. System Design

3.1. Hardware Design

Robot is designed with dimensions of length = 40 cm, width = 40 cm and height = 120 cm using a two wheeled differential drive system. The rear drive uses 2 PG36 motors and is combined with caster wheels for the front wheels. The ultrasonic sensor is installed on the front of the robot with the height adjusted to the maximum average height of the human touch surface (about 120 cm). Disinfectant liquid tube is installed at the base of the robot with 6 liters disinfectant capacity. Robot design shown in figure1. For controlling the robot use a microcontroller based on ATMega328 that connected to all input and output devices on the robot. ATMega328 is an 8 bit microcontroller with a maximum clock of 16MHz. Microcontroller will translate the instruction data from the computer to the PG36 motor in a (pulse width modulation) PWM pulse value, while the BTS 7960 Module is a PG36 motor driver module that converts pwm into motor rotation. For microcontroller power supply using a 12 Volt Li-Po battery. The schematic of the circuit used in this robot shown in Figure 2.

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Figure 1. Robot Design

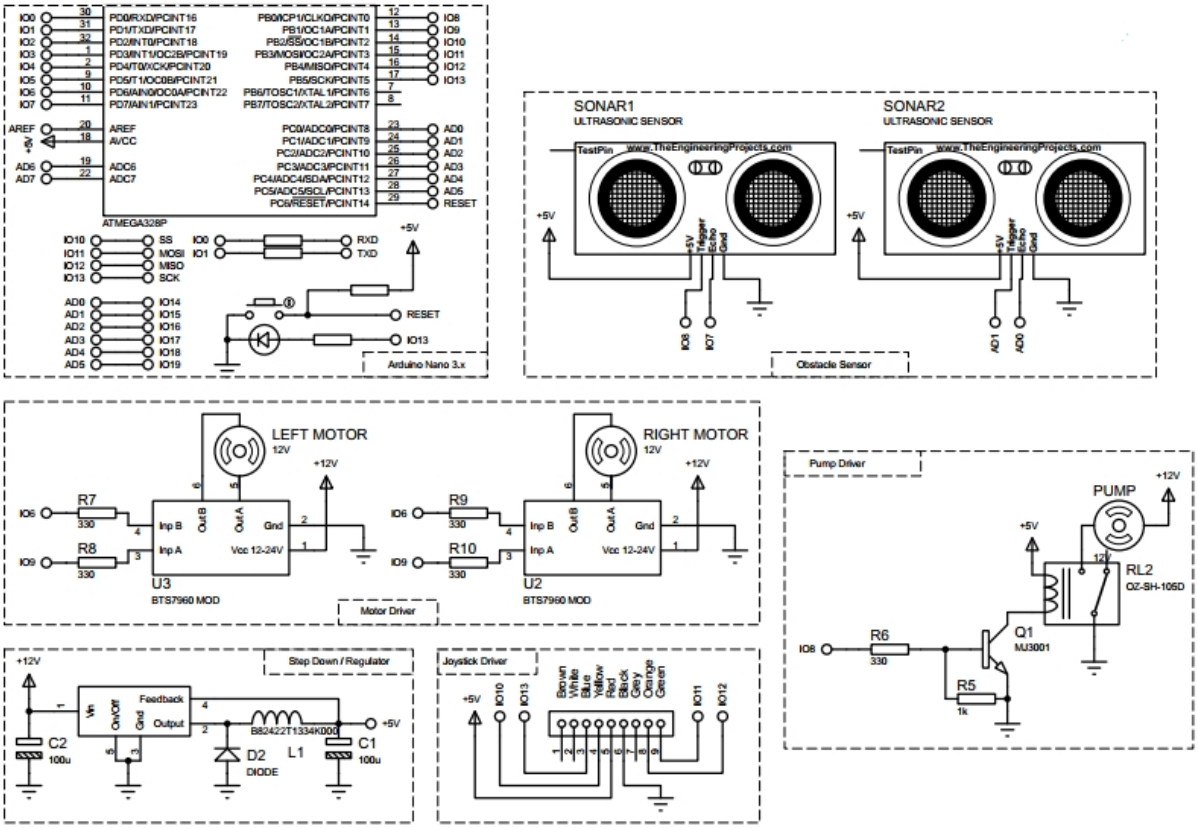

Figure 2. Robot scheme disinfectant sprayer

3.2. Software Design

Programming language in this research used arduino for robot control. The microcontroller receives data from the transmitter by Bluetooth communication, the received pulses are managed to control the DC 12V water pump and the PG-36 DC motor. The ultrasonic sensor sends a signal to the Arduino Nano to notify you if there are objects in front of the robot that can block movement. The system block is shown in Figure 3

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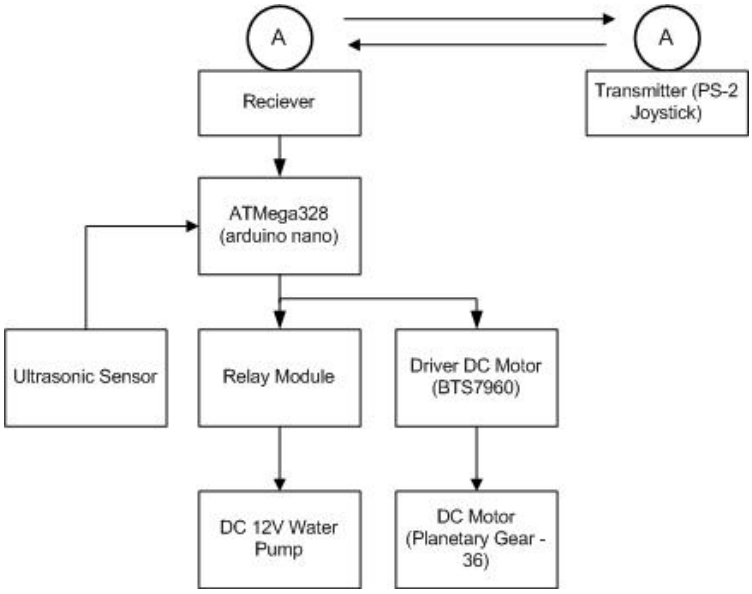

Figure 3. Block Diagram

One of the microcontrollers function is converting the data into PWM data for DC motor driver as the main driver and managing the PWM signal work cycle. Data protocol sent by the joystick controller is shown in Figure 4. The data is a combination of data from the direction of rotation and speed of the PG36 motor. Furthermore, the data is broken down into 4 variable values by the microcontroller.

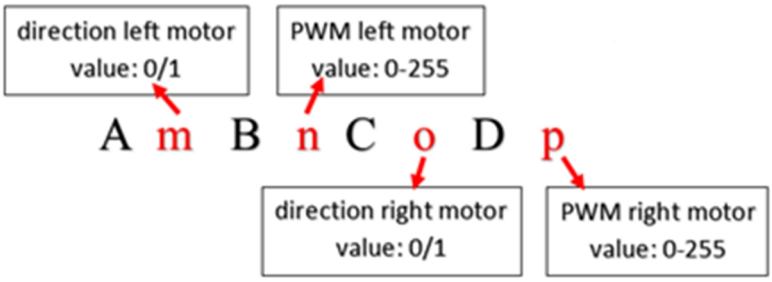

Figure 4. DC motor speed and direction data

PWM is a modulation technique used to encode a message into a pulsing signal by changing the duty cycle with fixed amplitude and frequency values. A pulse cycle is a high condition then it is in the transition zone to a low condition. PWM disinfectant sprayer in this robot using ON dan OFF technique with frequency of 1 KHz with equations:

$$T = \frac{1}{f}$$

$$duty\ cycle = \frac{t}{T} x\ 100\%$$

Where:
T = Signal period
f = Frequency
t = Pulse time

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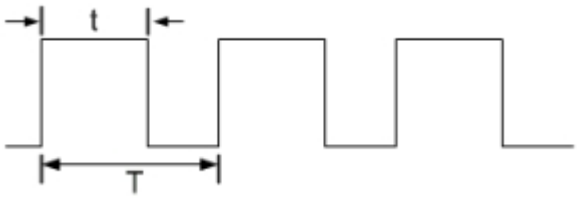

Figure 6. PWM signal

4. Result and Discussion

4.1. System Realization

Robot driving wheels use rubber wheels with diameter of 12 cm and the front uses canister wheels with a diameter of 8 cm. On figure 7 is a display of the results of the realization of the robot body when testing. The rear wheel is the driving wheel connected to the PG36 DC motor rotating based on the PWM value generated from the potentiometer rotation. The potentiometer produces analog data to be sent via Bluetooth communication and used as a parameter to regulate the duty cycle. More bigger potentiometer value produced, the faster the DC motor rotation. In the conversion in the duty cycle, if more bigger duty cycle or the so-called "high" state in one duty cycle period, then the motor rotation will be faster and applies to the reverse for the "low" state.

Figure 7. Robot when testing

4.2. Testing result

Testing activity in this research is carried out by running the robot running straight with a different weight of disinfectant fluid load. The track used for testing is walking straight at a distance of 30 meters. Test results show that the PWM system which is controlled from the potentiometer can be adjusted to the movement of the robot on the test track. In accordance with the capacity of the disinfectant tube, which is a maximum of 6 liters, in this test carried out by adjusting the movement speed of the robot based on the potentiometer rotation without spraying, then reducing the contents of the disinfectant tube continuously until 1 liter. Time reference for travel time is time period when robot move with a load of 6 liters disinfectant. Table 1 shows the results of the experiments carried out based on the load against the time achieved by setting the potentiometer rotation.

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Tabel 1. the results of the experiments

Testing Number	Distance (Meter)	Load (Liter)	Time (Second)	Description
1	30 Meter	6	15,2	Successful
2	30 Meter	5	14,3	Successful
3	30 Meter	4	14,5	Successful
4	30 Meter	3	14,2	Successful
5	30 Meter	2	13,8	Successful
6	30 Meter	1	14,1	Successful

5. Conclusion

Based on the test results, the use of potentiometers for PWM settings can be relied on to control robots with different load weights. From the experiment with a straight path as far as 30 meters with a reference time of 15.2 seconds, with different loads, the average travel time for the results of the experiment is 14.35 seconds. Thus, it is expected that when disinfectant spraying takes place by adjusting the rotation of the potentiometer for the speed of the robot, the results of spraying the disinfectant can be evenly distributed on surfaces that have contact with humans. With the results of evenly spraying disinfectants, it is hoped that it can reduce life cycle that sticks to the surface of objects

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