p-ISSN 2715-2871
e-ISSN 2714-5247

Design of Wireless Remotely Operated Mobile Robot "Line Botic" for Cleaning Solar Panels

Ilmrrizki Imaduddin
Electrical Engineering
Nurul Jadid University
Paiton, East Java
ilmi.eeunuja@gmail.com

Ryoga Lybraocta Putra Wandanny
Electrical Engineering
Nurul Jadid University
Paiton, East Java
Wandanny/ryoga.wandanny07@gmail.com

Moh Agung Amir Faruq
Electrical Engineering
Nurul Jadid University
Paiton, East Java
Faruq/mohagungamirfaruq@gmail.com

Thoriq Tuzani
Electrical Engineering
Nurul Jadid University
Paiton, East Java
Tuzani/thoriqtuzani@gmail.com

Abstract*— In this research, we will design a wireless remotely operator mobile robot 'linesbotic' for cleaning solar panels, using the open loop method, simply an electric motor that works on the principle of two magnetic fields that produce movement. The aim is to be able to produce a force that drives torque. The motor is installed to carry out certain work that requires the right speed and direction of rotation, so that the speed and direction of rotation of the motor can be adjusted in such a way as to suit the intended use of the motor. The results of the design and software testing for each component can work well according to the list of programs that have been created, while for hardware testing with interference conditions from passing vehicles, road lampposts, trees and buildings with an average percentage of 47% can be achieved. running well, and while testing the joystick in the forward position at angular velocity (-0.0) and at linear velocity (1.0), the joystick in the backward position at angular velocity (-0.0) and at linear velocity (-1.0), the joystick in the right position at angular velocity (-1.0) and at linear velocity (-0.0), the joystick is positioned to the left at angular velocity (1.0) and at linear velocity (-0.0).

Keywords*—Wireless Remotely Operated, Cleaning Solar Panels, Linear Velocity.

I. INTRODUCTION

One of the factors that affect the energy production of a solar power plant is the cleanliness of the solar panels. Cleaning solar panels is a way of keeping them clean so they can produce the most energy. The review findings revealed a variety of cleaning methods and commercial products for solar panels. There are two different cleaning methods for solar panels: manual and automatic. The manual cleaning method is one that requires a person to run the solar panel cleaning service robot system. The general public sees solar panel cleaning service robots to remove dirt or dust. We can use robot cleaning services in various fun ways, including cleaning solar panels, which will make it easier for us to clean solar panels. The solar panel cleaning service robot is a tool attraction as well as a cleaning service robot that attracts the interest of people who use solar panels. When using a solar panel cleaning service robot it will be easy. Because you already use a remote to operate it, the cleanliness and safety of the solar panels must be prioritized in improving the quality of the solar panels. There may be a lot of miscommunication when panel members use manual systems. This is due to the high risk of failure associated with manual systems, such as when panel members use manual systems [1].

Bird droppings, dust, and water (salt) that stick to the surface of the solar panels cause the electricity to be generated is not optimal, so the panels need to be cleaned. These factors affect the performance of solar panels. This solar panel cleaning tool is a robot with an Outseal PLC Nano V.5.0 microcontroller. The system includes a DC motor that drives the robot and a cleaning roller drive, as well as an IR proximity sensor that automatically stops the robot if it crosses the solar panel boundary. The panel in question is an example of a module that can be used to add to the list of energy sources by converting energy from mat to AC or DC (Direct Current) [2]. The basic solar cell module is called a solar cell, which together form a photovoltaic panel, the interconnected elements that make up the electricity generator in a photovoltaic installation. The panel converts radiation into electrical energy with a photovoltaic effect [3].

In this open loop method, the electric motor simply works on the principle of two magnetic fields that produce movement. The aim is to be able to produce a force that drives torque. The motor is installed to carry out certain work that requires the right speed and direction of rotation, so that the speed and direction of rotation of the motor can be adjusted in such a way as to suit the intended use of the motor [4]. The Lora used in this test has the following features. The tested communication distance is up to 3 km. 100mW maximum transmission power, multi-level adjustable software. Supports global license-exempt 433 MHz ISM band. Supports broadcast date rate 0.3kbps~19.2kbp. Supports new generation LoRa technology based on SX1262. Low power consumption for battery supplied applications. Support 3.3V-5.5V power supply, above 5.0V power supply can guarantee the best performance. Industrial grade standard design, supports -40-85 °C for long time working [5].

One type of mobile robot, namely a differentially driven mobile robot or Differentially Driven Mobile Robot (DDMR), is a mobile robot that uses two independent driving wheels, so that the robot's translational and rotational movements are produced by a combination of the movements of two actuators, so that it can be stable. plus a free wheel (omnidirectional) which is usually called a castor wheel [6]. Pulse Width Modulation is a manipulation technique in motor drivers (or other large-current electronic devices) that uses the cut-off and saturation principles. Pulse-Width Modulation can also be interpreted as a technique for generating output signals whose periods are repeated in the form of highs and lows which can control the duration of the high and low signals as desired [7].

In research conducted by Milfiga Septa. The development of modern technology and the automation of electronic devices today makes work easier. Where the robot can clean and mop the floor of the house with a predetermined time, and this robot can find out the obstacles that are on the path that the robot will go through. This tool has Arduino Uno and Arduino Nano which function as the control center, RTC (Real Time Clock), where to set the robot's schedule to work according to a predetermined schedule, the DC motor functions as the wheel of the robot. From the tests that have been carried out the tool works well and according planned [8].

Next, research conducted by Jamaludin, Saepul, Didik, Ilham. The solar panel then finds out how the solar panel cleaning tool with an automation system performs. The design made with the working mechanism is to use an automated control system, namely Arduino, when the tool is turned on, the roller will work to clean and then click the push button, the tool will work to clean the solar panel. The distance sensor is to reactivate the motor driver in the opposite direction [9].

In research conducted by Muhammad Malik, the cleanliness of solar panels is one of the factors that influences the energy production of a solar power plant. This article reviews research developments and commercial products for solar panel cleaning. The results of the study show that there are various techniques and commercial products for cleaning solar panels. The techniques used in cleaning solar panels are divided into two, namely manual and automatic. The manual cleaning method is a method that requires human power to operate the system. Meanwhile, the automatic cleaning method is a method that is controlled directly by the system without requiring human power. Commercial solar panel cleaning products include a telescopic pole equipped with a brush and water pump, a robot that is permanently installed on the solar panel support construction which is equipped with dry clean and water clean methods, a robot with a portable system using a long roller brush, a portable robot that equipped with a vacuum cleaner with a remote system, to a mobile cleaning system using a robot arm [10].

In research conducted by Adyapaka Apatya. The development of robotics technology today has developed rapidly. Many types of work can be done with robots, especially if the work has a high level of accuracy. One job that requires a high level of precision and accuracy is the job of cleaning solar cell modules. In this research, a solar cell module cleaning robot has been designed and tested directly in the field. The purpose of designing this robot is to ensure the cleanliness of the solar cell module from partial shading. The design is made using two left and right motors equipped with a brush motor for the cleaning system. Another addition is that this robot is controlled by a wireless controller system based on radio frequency (RF) communication and is equipped with sensors to determine the water level, as well as sensors that can maintain the movement of the solar cleaner robot above the solar cell module when working [11].

The design of solar panel cleaning equipment is the next aim of this research, which also aims to study the performance of the automation system. So the reason I did this research is because solar panels have been widely used in various power plants or industries because the use of solar panels is environmentally friendly, including in my area. That's why I conducted research entitled Design Of A Wireless Remotely Operated Mobile Robot "Lensbotic" For Solar Panel Cleaning. The design working mechanism is controlled by an Arduino-based automatic control system. The robot is designed to be able to reach a distance of 50 meters

II. RESEARCH METHODOLOGY

A. *Research Flowchart*

In this chapter, we will explain the steps taken in the research. The summary is displayed in the flowchat in the image.

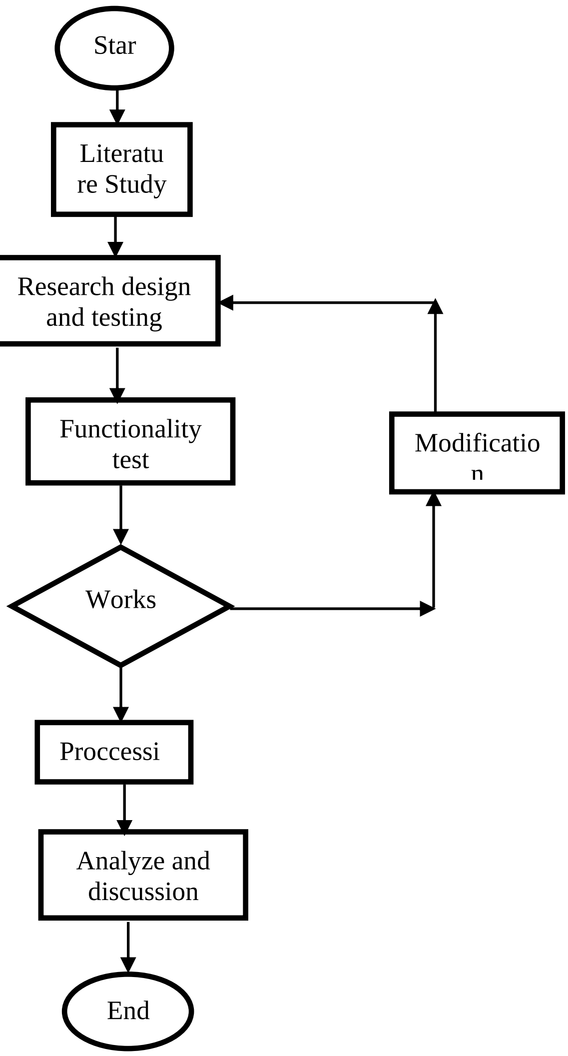
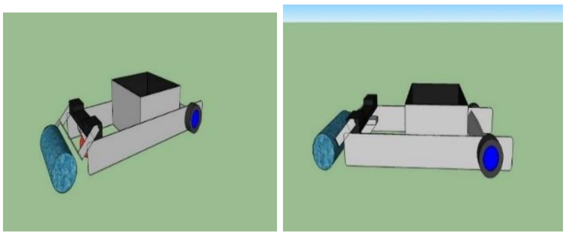


Figure 1. Research Flowchart

B. Mechanical Designs

In this mechanical design, we can use the cleaning service robot in a variety of fun ways, including cleaning solar panels, which will make it easier for us to clean solar panels. The solar panel cleaning service robot is a tool attraction as well as a cleaning service robot that attracts the interest of people who use solar panels. When using a solar panel cleaning service robot it will be easy. Because you already use a remote to operate it, the cleanliness and safety of the solar panels must be prioritized in improving the quality of the solar panels.



(A) (B)

Figure 2. Mechanical Design

C. Joystick Directions

1. Forward Position Joystick
The results of the data values obtained when the joystick is in the forward position. At the angular velocity (-0.0) and at the linear velocity (1.0), the left and right wheels move forward, as shown in the figure below:

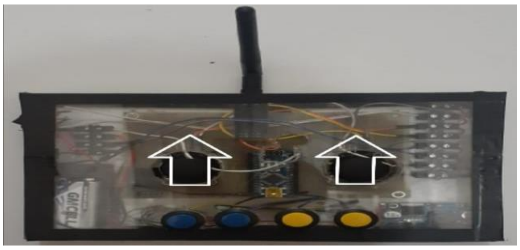


Figure 3. Joystick Forward Position

2. Reverse Position Joystick
The results of the data values obtained when the joystick is in the forward position. At angular velocity (-0.0) and at linear velocity (-1.0), the left and right wheels move backwards. As shown in the image below:

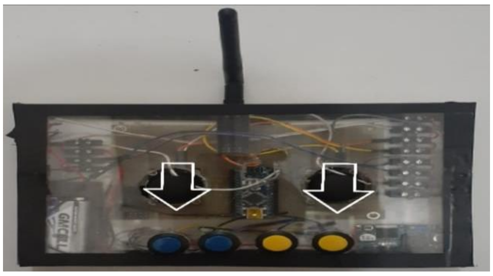


Figure 4 Joystick Reverse Position

3. Right Position Joystick
The results of the data value are obtained when the joystick is positioned to the right. At angular velocity (-1.0) and at linear velocity (-0.0), the left and right wheels do not move, as shown in this figure:

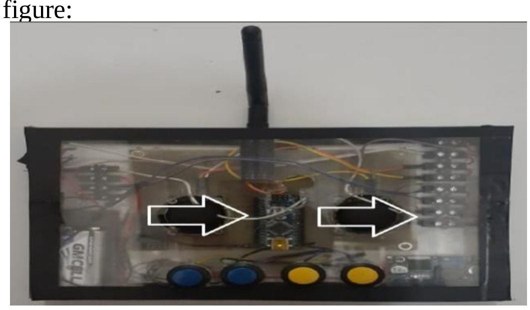


Figure 5. Right-Turn Position Joystick

4. Left Position Joystick
The resulting data values are obtained when the joystick is positioned to the left. At angular velocity (1.0) and at linear velocity (-0.0), the left and right wheels do not move. As shown in the image below:

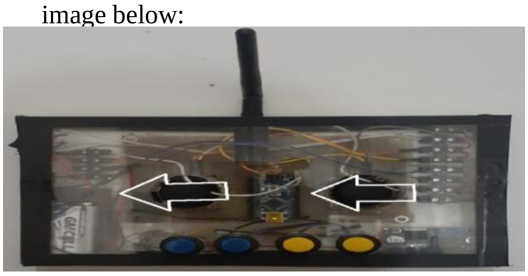


Figure 6. Left Turn Position Joystick

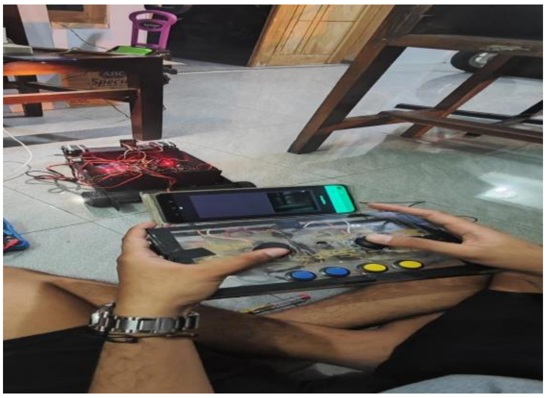


Figure 7. Cleaning Robot Design Results

p-ISSN 2715-2871
e-ISSN 2714-5247

Table 1. Table of the number of data received from 50 data senders

Distance (m)	Data Results								Average
	250	291	350	391	401	411	421	431	
Data received (max 50)	40	38	27	23	11	9	6	3	19,625
Percentage	80%	76%	54%	46%	22%	18%	12%	6%	39%

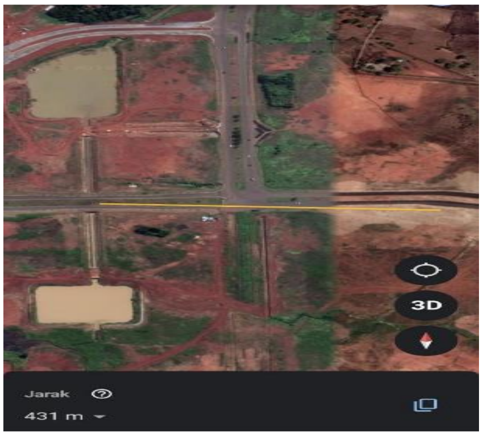


Figure 8. Satellite Schematic of Data Collection Locations

III. Results and Discussion

A. Design Results

The results of the Linesbotic robot design for cleaning solar panels can be seen in Figure 7. Where the robot can clean solar panels using Lora, which is 50 meters away.

B. Lora Maximum Distance Test Results

The purpose of this test is to plan the implementation of LoRa on solar panels. When the solar panels have obstacles that can interfere with signal communication, so that the optimal distance for placement and use of LoRa sensors or modules is known.

In the first test, testing was carried out on a road that has a lot of signal interference, so that LoRa signal reception does not get the optimal distance or according to LoRa specifications. Many things that interfere with LoRa signals include:

1. Vehicles passing
2. Street light pole
3. Tress
4. Building

After testing, the following data was obtained in Table 1.

From the data that has been obtained, the maximum distance that can be traveled to get a LoRa signal is 431 m from the distance received. This is because there are many distractions such as the volume of passing vehicles, street lamp posts, trees, and buildings. Then it can be seen that the intervals are irregular because in determining the location interval you have to adjust to the existing terrain, both avoiding the legality of the local area and obstacles that will become obstacles to the lora signal itself. At a short distance, a large percentage of data reception indicates strong signal strength.

Table 2. Robot Experiment Data

X	Y	S Forward	S Reverse	S Right	S Left	RPM	PWM
5	5	1	0	1	0	976	238
15	10	1	1	1	1	938	224
25	20	1	1	1	1	818	200
35	30	1	1	1	1	741	184
45	40	1	1	1	1	665	170
55	50	1	1	1	1	572	162
65	60	1	1	1	1	523	548
75	70	1	1	1	1	463	559
85	80	1	1	1	1	529	546
95	90	0	1	0	1	518	547

C. Robot Testing Results

The robot experiment was carried out directly on the solar panel and the parameters taken were the distance of the robot in the X and Y axes, and the sensor values up, down, right and left. So, the following data is obtained in Table 2.

Conclusion

After carrying out design, testing and analysis in this research, the author came to the conclusion that:
1. The results of software testing for each component can work well according to the program list that has been created.
2. As for hardware testing with traffic jams, road light poles, trees and buildings with an average percentage of 47%, it can run well.
3. While testing the joystick position forward at angular velocity (-0.0) and at linear velocity (1.0), joystick backward position at angular velocity (-0.0) and at linear velocity (-1.0), joystick position to the right at angular velocity (-1.0) and at linear velocity (-0.0), the joystick is positioned to the left at angular velocity (1.0) and at linear velocity (-0.0).

References

[1] Angquist, L. A. (2011). open loop control off modular multilevel converter using. *IEEE transactions on industry applications*, 47 (6), 2516 - 2524. https://doi.org/10.1109/TIA2011.2168593.
[2] Huang, X. Z. (2011). Brushless DC motor design for an aircraft electro-hydraulic actuation system. *IEEE International Eletrick Machines And Drives Converence,IEMDDC*, may,1153-1158. https:doi.org/10.1109/IEMDC.2011.5994765.

p-ISSN 2715-2871
e-ISSN 2714-5247

[3] Muhammad Hasan Basri, Sulistiyanto, Muhamad Imaddudin. Implementation of Shallot Pest Trap Model Based on Color Spectrum Using Photovoltaic Energy. Jurnal Penelitian Pendidikan IPA, 9(5), 3833–3838. https://doi.org/10.29303/jppipa.v9i5.3378

[4] Dio Pramanda, A. (2020). Arduino Based DC Motor Speed Control System With Open Loop Method. *JTEV (JURNAL TEKNIK ELETRO DAN VOKASIONAL* , Vol. 06 No.01 ISSN : 2302-3309.

[5] Abdillah, R. (2022). Lora Module Communication Performance in Multi Control Wet Dry Irrigation Techniques. Indonesian Agricultural Engineering Polytechnic *(PEPI).*

[6] Ahmad Nazrul Aziz, E. p. (.). Implementation of the v Control Method, Based on Integral Proportional for Motion Control of Differential Driven Mobile Robots. ITS Keputih Sukolilo Surabaya Campus 60111, Surabaya Electronics Polytechnic.

[7] Pitowarno, E. (2006). Robotics, Design, Control and Artificial Intelligence. Yogyakarta: Andi Publisher. [8] Yoski, M. &. (2020). Microcontroller-Based Trash Cleaning Robot Prototype With Ultrasonic Sensor. JIEIN: Indonesian electrical engineering journal, I(2), 158-161. https://doi,org/10.24036/jtein.v1i2.67.

[9] Purba jamaluddin, e. a. (2022). Design of a prototype of a solar panel cleaning tool with an automatic motion system. journal of mechanical engineering studies, 7.1.

[10] Muhammad malik al falah, n. s. (2021). Development Of Research And Commercial Products Solar Panel Cleaning Systems. Electrical Engineering Study Program, Faculty of Engineering, Udayana University, Vol, 8 No.4.

[11] Adyapaka Apatya, O. A. (2023). Design And Evaluation Of A Solar Photovoltaic Cleaning Robot Using Wireless Communication Based On Radio Frequency Communication. https://jurnal.pcr.ac.id/index.elementer, Vol, 9.No. 1.