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Design & Fabrication of Water Optimized - Solar Panel Cleaning Robot

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Abstract: ***Maintaining a power capacity of solar cell is the main thing for exercising solar power system. Most common problems in solar power system are dust, beach, creature's pollen and crops burning. These challenges have a huge impact on the power generation capacity of solar panel. The thing of the robot's conception design is to make a machine that's easy to install, adaptable in terms of configuration, and requires lower labourers and functional charges. The robot is equipped with helical comber skirmishes which are driven by dc motor so that the robot is enforced with a water sprinkle in order to clean the panels far and wide it moves through. In this design, a system contains a length dimension unit and bedded control schemes in order to drive a movement directly and to localize the positions of the robot.***

I. INTRODUCTION

The adding demand for renewable energy has propelled the global proliferation of solar panels. Still the effectiveness of solar panels is significantly impacted by the accumulation of dust, dirt, and other particulate matter on their shells. This issue is particularly pronounced in thirsty and semi-arid regions, where dust deposit can reduce solar panel effectiveness by as important as 20% - 40%. The pressing need for a sustainable, effective, and water-conservative cleaning result for solar panels has led to the development of innovative robotic systems.

This paper focuses on the design and fabrication of a water- optimized solar panel cleanser robot, aimed at addressing the inefficiencies and environmental enterprises associated with conventional cleaning styles. The proposed robot leverages advanced mechatronic systems and innovative design principles to insure optimal cleaning with minimum water operation. The integration of detectors, microcontrollers, and perfection engineering allows the robot to navigate the solar panel arrays autonomously and acclimatize to varying situations of dirt, and execute drawing cycles with high effectiveness.

The design process emphasizes the need for a feather light, durable, and cost-effective result that can operate under different environmental conditions. By incorporating water-effective technologies similar as fine mist sprayers and controlled water inflow systems, the robot is able of significantly reducing water consumption compared to traditional cleaning styles. Also, the robot's design incorporates renewable energy sources, icing its operation is sustainable and environmentally friendly.

This paper details the design considerations, engineering challenges, and fabrication processes involved in creating the water-optimized solar panel cleanser robot. It also presents the results of performance tests conducted under colourful environmental conditions, demonstrating the robot's effectiveness in maintaining solar panel effectiveness and its implicit for large- scale deployment. By addressing the critical issues of water operation and drawing effectiveness, this exploration contributes to the advancement of sustainable practices in solar energy conservation and offers a feasible result for enhancing the performance and life of solar panels worldwide.

II. LITERATURE SURVEY

This exploration aims to design and develop the Solar Panel drawing Robots by studying Solar

Panel drawing Robots movement which work suitably with Wireless Joystick, Sensor Sonar using Gear Motor and Arduino microcontroller [1]. Regular cleaning, especially in high dust areas, is essential for maintaining optimal power generation. The proposed solar panel cleaning robot operates autonomously. It is self-powered by a solar PV panel mounted on the robot, and can be controlled remotely via the Internet of Things (IoT)[2] .The proposed research paper offers a promising solution to this challenge by automating panel cleaning, through control system schematic and rigorous testing which are necessary to ensure robustness and autonomy [3].We have developed a microcontroller-based SPCR system that is cost-effective and lightweight, specifically designed to mitigate the negative effects of dust accumulation on PV panel output [4].

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The performance of PV panels is evaluated under dusty conditions and post-robot cleaning, ensuring fair comparisons of current production and efficiency under sunlight, while also assessing the functionality of a developed mobile app for system performance monitoring [5]. This paper showcase a detailed comparison of solar panel cleaning with regular traditional methods and with the robot, which in conclusion states an increase of 1.5% - 2% in efficiency [6].

III. OBJECTIVE

1) Design and fabricate a cleaning robot to maintain efficiency of solar panel which is lost due to environment.
2) To provide an easier solution for cleaning panels plotted on roofs.
3) To minimize wastage of water.
4) Provides safe & soft cleaning.
5) Construct a multifunctional robot
6) To build environment friendly cleaning system.

IV. METHODOLOGY

A. *Methodology and Planning*

Following are schematics showing the methodology and planning used to approach the design and manufacture of the final product

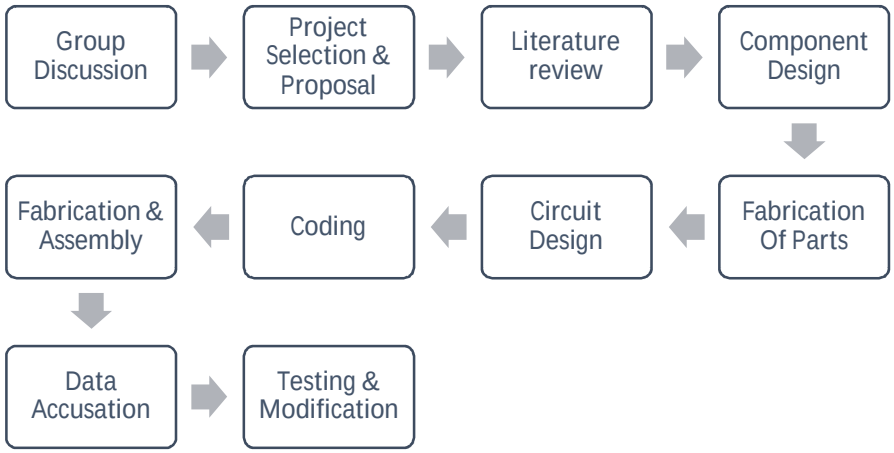


Fig.1. Flowchart of Methodology and Planning

V. DETAILS OF COMPONENT

List of components:

Table 1. Component name

Sr. No	Component Name	Quantity
1	Chassis	1
2	DC motor	4
3	Arduino	1
4	Motor Driver Shield	1
5	Bluetooth Module	1
6	Water pump	1
7	Roller	1
8	Water Tank	1
9	Battery	6
10	Jumper Wire	50

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1) Chassis



Fig.2.Chassis

The chassis or frame is the main support component in a car's structure. It bears the forces experienced by a car while it's standing still or moving at high speeds. A vehicle chassis is like a human skeleton; it provides the structural shape and support to the entire body of a vehicle. The role of this structure is to keep the car intact while experiencing the forces of driving, turning, braking, etc. A chassis consists of a rolled sheet frame that supports an artificial object in its construction and use and can also provide protection for some internal parts. An example of a chassis is the underpart of a motor vehicle, consisting of the frame on which the body is mounted.

2) DC Motor

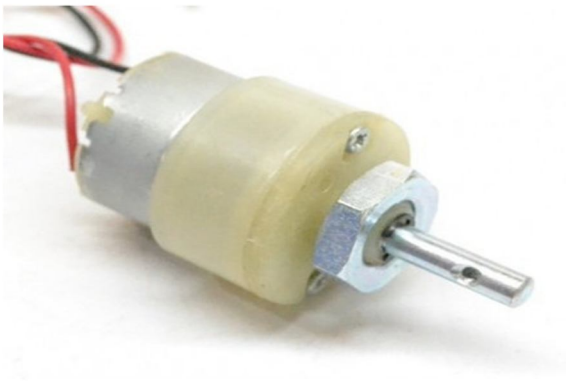


Fig.3.DC Motor

A machine that converts DC power into mechanical power is known as a DC motor. It mainly consists of three main parts: the magnetic field system, armature, and commutator. Other parts of a DC motor include the yoke, pole shoe, field or exciting coil, armature core and windings, bearings, and shaft.
A DC machine works on the principle that "when a current-carrying conductor is placed in a magnetic field, the conductor experiences a mechanical force." The direction of the force is given by Fleming's left-hand rule in this project, a DC motor is used to produce rotational torque in a vehicle. It is usually converted into linear motion.

3) Arduino UNO R3:
Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. It is easy to use even for beginners. Hugely popular, you will find numerous tutorials and projects to help you get started and build your favourite electronics project.

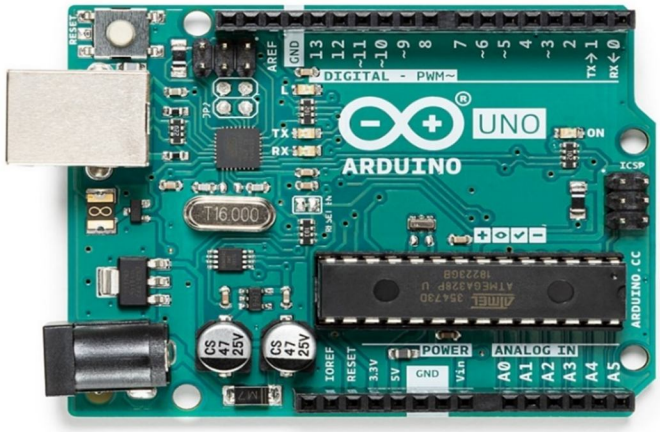


Fig.4 Arduino UNO R3

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (6 of which can be used as PWM outputs and 6 as analog inputs). Programs can be loaded onto it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, making it very easy to get started working with embedded electronics. The R3 is the third, and latest, revision of the Arduino Uno.

4) Motor Driver Shield

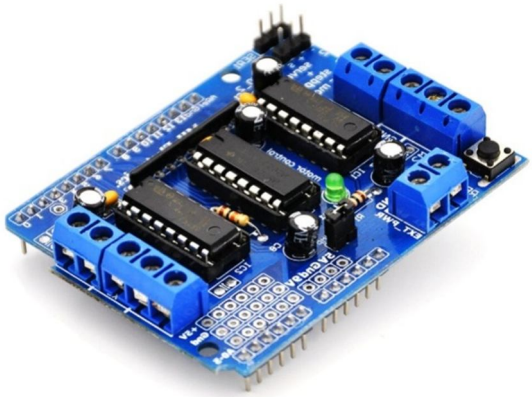


Fig.5 Motor Driver Shield

If you intend to build your own robot, you'll need to control various motors like DC motors, stepper motors, and servos, and there's no better option than the L293D Motor Driver Shield. It is capable of controlling all of these motors; there is no need for additional modules.

The brains of the shield are two L293D motor drivers and a 74HC595 shift register. The L293D is a dual-channel H-Bridge motor driver that can control two DC motors or a single stepper motor. The 74HC595 shift register, on the other hand, extends the Arduino's four digital pins to the eight direction control pins of the two L293D chips.

The shield supports a motor voltage range of 4.5 to 25 volts. This power can be shared with the Arduino or used separately. To choose between the two, a special jumper labeled PWR is provided near the two-terminal power connector. The output channels of both L293D ICs are broken out to the edge of the shield with two 5-pin screw terminals labeled M1, M2, M3, and M4. A total of four DC motors operating at 4.5 to 25V can be connected to these terminals.

Unfortunately, the servo motors are powered directly from the Arduino's 5V supply, which is generally a bad idea. Doing so can cause the Arduino's on-board 5V regulator to overheat and can also introduce electrical noise on the 5V supply. On the plus side, it has a 100uF capacitor on these power pins, which helps a little.

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5) Bluetooth Module

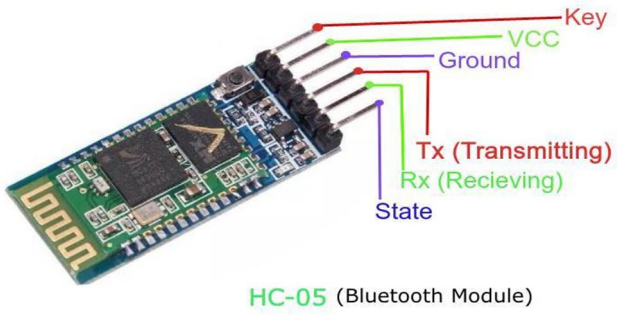


Fig.6 Bluetooth Module

It is used for many applications like wireless headsets, game controllers, wireless mice, wireless keyboards, and many other consumer applications. It has a range of up to <100m, which depends on the transmitter and receiver, atmosphere, geographic, and urban conditions.
It uses serial communication to communicate with devices. It communicates with the microcontroller using a serial port.
The HC-05 has a red LED that indicates connection status, showing whether the Bluetooth is connected or not. Before connecting to the HC-05 module, this red LED blinks continuously in a periodic manner. When it gets connected to another Bluetooth device, its blinking slows down to once every two seconds.
This module works on 3.3V. We can connect a 5V supply voltage as well since the module has an onboard 5V to 3.3V regulator.
As the HC-05 Bluetooth module has a 3.3V level for RX/TX and the microcontroller can detect the 3.3V level, there is no need to shift the transmit level of the HC-05 module. However, we need to shift the transmit voltage level from the microcontroller to the RX of the HC-05 module.

6) Water Pump



Fig.7 Water Pump

DC water pumps operate on direct current and can be powered by either a 12V or 24V DC power supply. You can also use a solar panel and a dry battery to power a lower-rated DC water pump. A USB interface can power a battery-powered mini water pump as well. The next step is to select a DC power supply.
The power supply voltage is the most important aspect of DC water pump performance. The voltage you use to power a pump affects its working current, and a DC submersible pump must have a constant power supply.

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Otherwise, the pump motor will experience back-current, which the excessive is starting current the pump requires when it stops. Likewise, the power supply voltage will fluctuate when the load on the pipeline changes, resulting in a chaotic working cycle

7) Roller



Fig.8Roller

Floor rolling brushes are used for rubbing and scrubbing floors. These brushes are designed and manufactured using premium-grade bristles and the latest machinery under the strict supervision of seasoned professionals. Our quality controllers thoroughly check these brushes on various parameters to ensure their flawlessness. We offer these floor scrubbing brushes in different sizes, shapes, and designs according to the specific requirements of clients at an industry-leading price range.

8) Water Tank



Fig.9 Water Tank

A plastic water tank is a large-capacity container designed to store water for household, agricultural, irrigation, and industrial manufacturing use. Various types of water tanks are produced to meet the needs of specific applications. For instance, this water tank is used to supply water from the tank to the roller via pipes to clean the roller, as well as to clean panels of dust and mud.

9) Battery



Fig.10 Battery

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A lithium-ion or Li-ion battery is a type of rechargeable battery that uses the reversible reduction of lithium ions to store energy. The negative electrode of a conventional lithium-ion cell is typically graphite, a form of carbon. This negative electrode is sometimes called the anode as it acts as an anode during discharge. The positive electrode is typically a metal oxide; the positive electrode is sometimes called the cathode as it acts as a cathode during discharge. Positive and negative electrodes remain positive and negative in normal use whether charging or discharging and are therefore clearer terms to use than anode and cathode, which are reversed during charging.

Generally, the negative electrode of a conventional lithium-ion cell is graphite made from carbon. The positive electrode is typically a metal oxide. The electrolyte is a lithium salt in an organic solvent. The anode (negative electrode) and cathode (positive electrode) are prevented from shorting by a separator. The anode and cathode are separated from external electronics with a piece of metal called a current collector. The electrochemical roles of the electrodes reverse between anode and cathode, depending on the direction of current flow through the cell.

10) Jumper Wire



Fig.11 Jumper Wire

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other electronic components to make it easy to change a circuit as needed. Fairly simple. In fact, it doesn't get much more basic than jumper wires.

VI. COMPONENTS ASSEMBLY

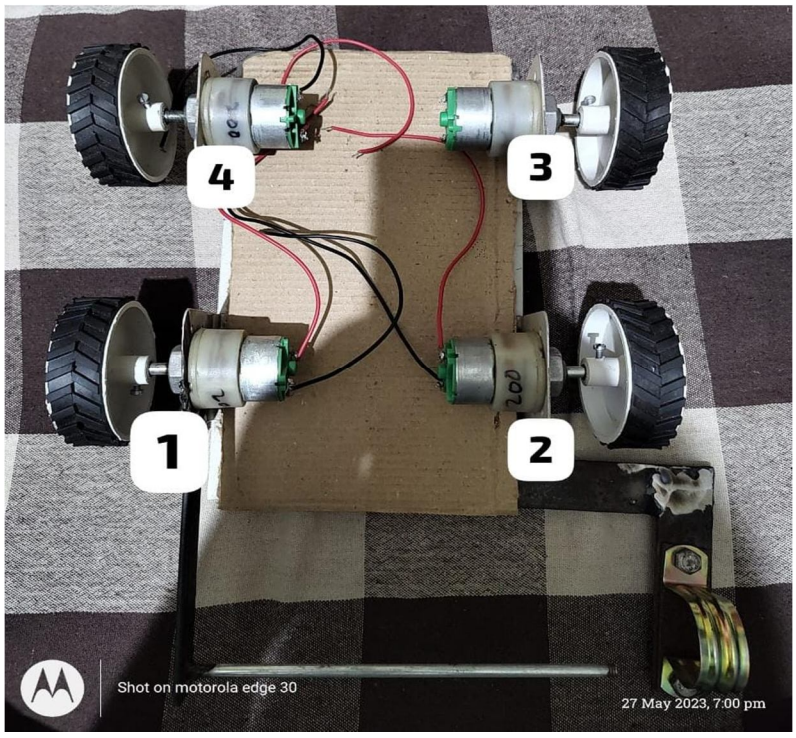


Fig.12 Components Assembly

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VII. CIRCUIT DIAGRAM

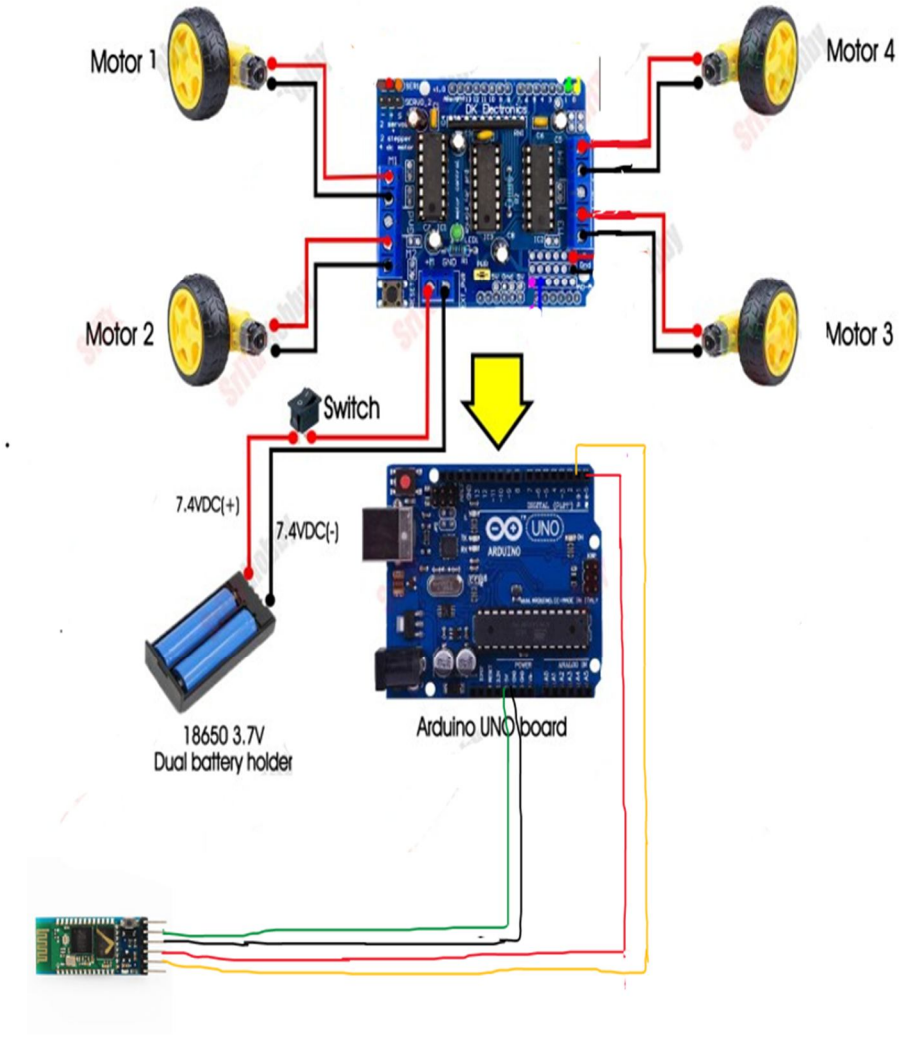


Fig.13 Circuit Diagram

Working

Assemble the robot, make the necessary connections, and upload the code to Arduino. If you understood the HC-05 Bluetooth Module tutorial, then understanding the Bluetooth Controlled Robot project is very easy. First, pair the Bluetooth module device with your phone using the Bluetooth RC controller Android app. I have used four keys: Forward, Reverse, Left, and Right. The corresponding data associated with each key is as follows: when a key is pressed, the corresponding data is transmitted to the Bluetooth Module from the phone over Bluetooth communication. In the Arduino code, the Arduino Uno receives this data from the Bluetooth Module (based on the key pressed) and performs a simple switch case operation, with each case associated with appropriate instructions to the Motor Driver shield, labeled M1, M2, M3, and M4.

Switch on the system. Use the Bluetooth RC Controller to connect the Bluetooth module. The Bluetooth module name is HC-05. Pair the Bluetooth module, open the app, and connect to HC-05. Place the robot on the solar panel. Switch on the roller motor, causing the roller to rotate, and then switch on the water pump. The water is expelled through the water pipe. The front side of the robot has holes to dispense water. We control the direction using the Bluetooth RC Controller app, operating the robot like a game. The robot cleans the solar panel by controlling forward, backward, left, and right directions through the app. After cleaning the solar panel, turn off the system.

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VIII. ILLUSTRATION OF WORKING METHODOLOGY

The Block Diagram of working methodology of Wall Climbing paint Robot fabricated for this project are given below

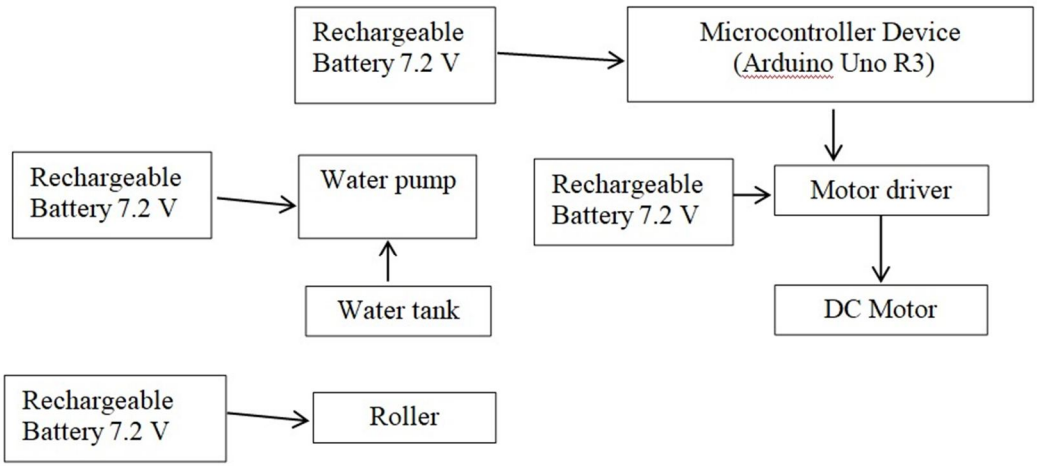


Fig.14 Working Methodology Flowchart

IX. LAYOUT OF ROBOT CONTROLLING REMOTE

Our robot controlling remote has been designed with the following layout on the internet. With this open-source web platform, developers can create and modify their own customized graphical user interfaces (GUIs) for controlling ESP32 with a tablet or Smartphone. By application, the GUI operates on the phone or tablet. Our graphical user interface is made to

1) Control the direction of the Robot.
2) Easy to connect with ESP32 Bluetooth.
3) Turn off and Turn on the whole controlling system.

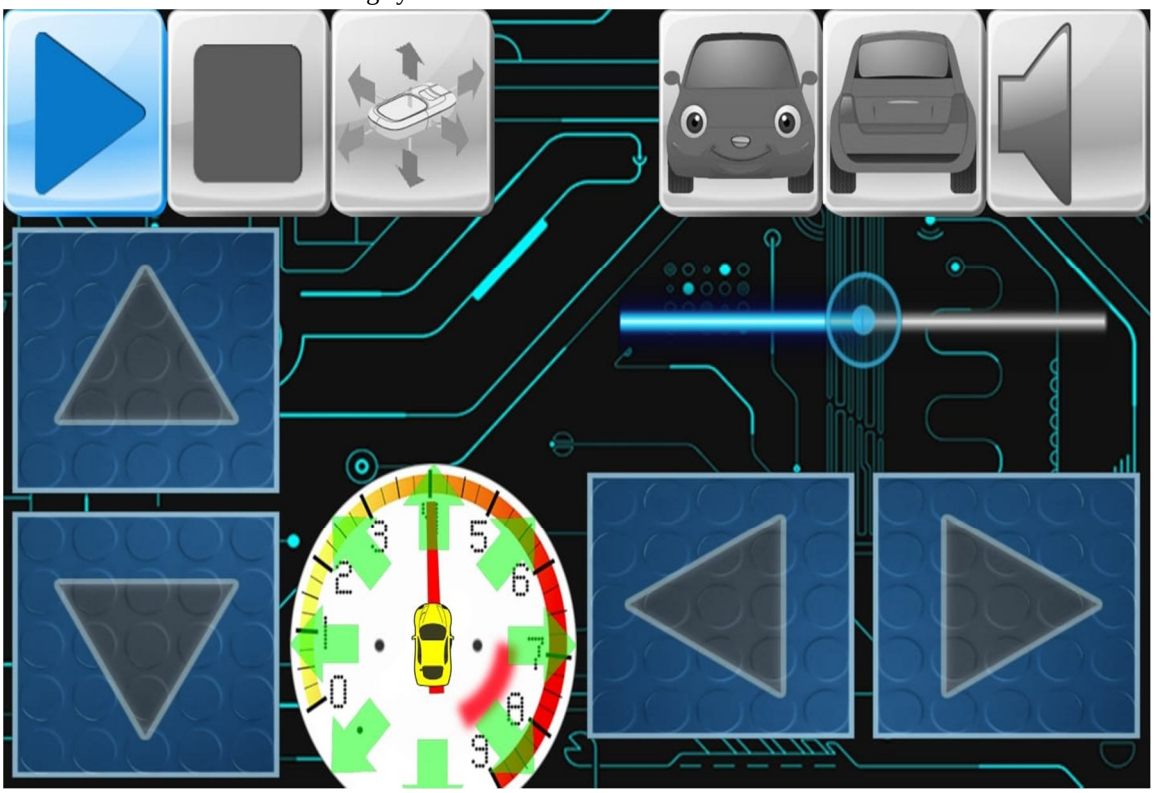


Fig.15. Layout of Robot controlling Remot

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Working Model:

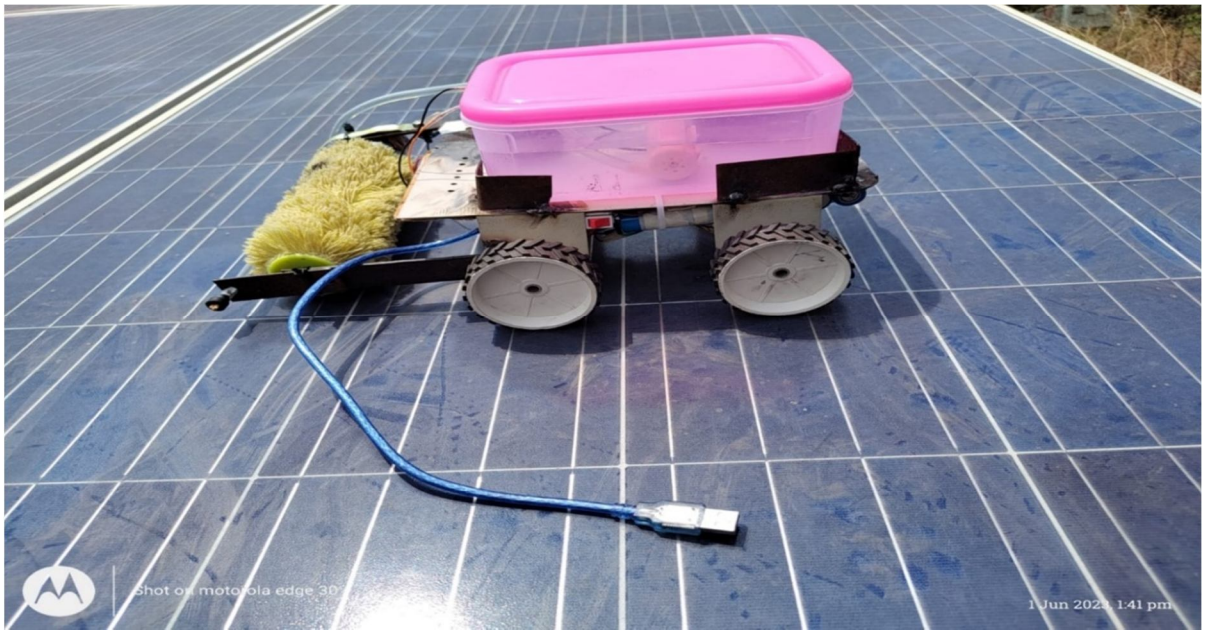


Fig.16(a) Final Model

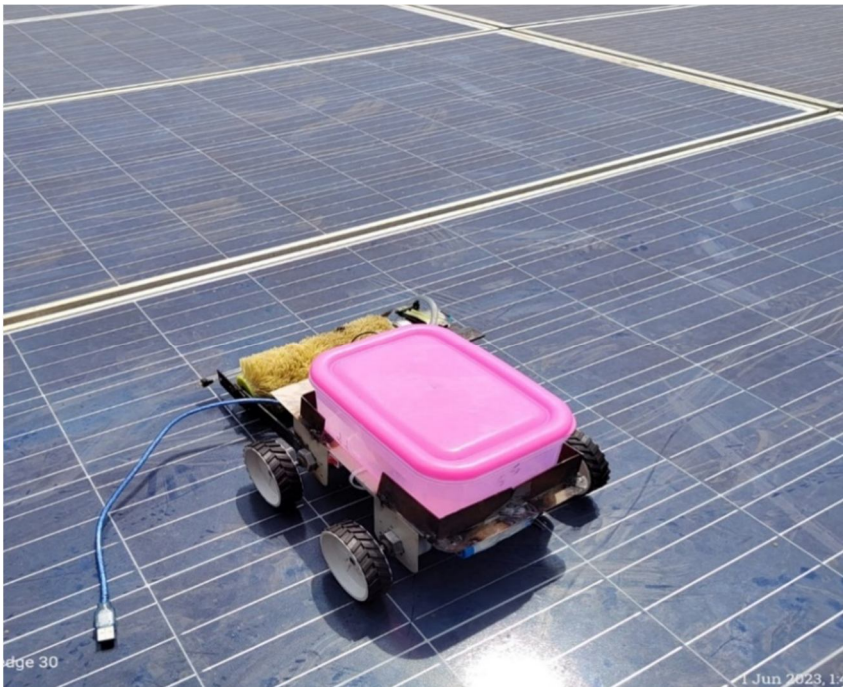


Fig.16(b) Final Model

X. COST DETAIL

Cost of All Components:

Sr. No.	Component Name	Quantity	Price
1	Arduino Uno R3	1	2000/-
2	Motor driver shield	1	300/-
3	Chassis	1	600/-
4	DC Motor	5	1500/-

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5	Roller	1	225/-
6	Submersible pump	1	350/-
7	Water tank	1	150/-
8	Jumper wire	50	100/-
9	Supporting frame	1	400/-
10	Battery	6	1400/-
11	Water pipe	1	30/-
12	Bluetooth module	1	300/-
13	Wheels	4	400/-
14	Cable wire	1	50/-
15	Paint and Brush	1	100/-

TOTAL	7905/-

XI. FUTURE SCOPE

Increase the grip of the wheels, change the wheels type.
Write a program for automatic on/off roller and water pump.
Increase the battery capacity and performance.

XII. CONCLUSION

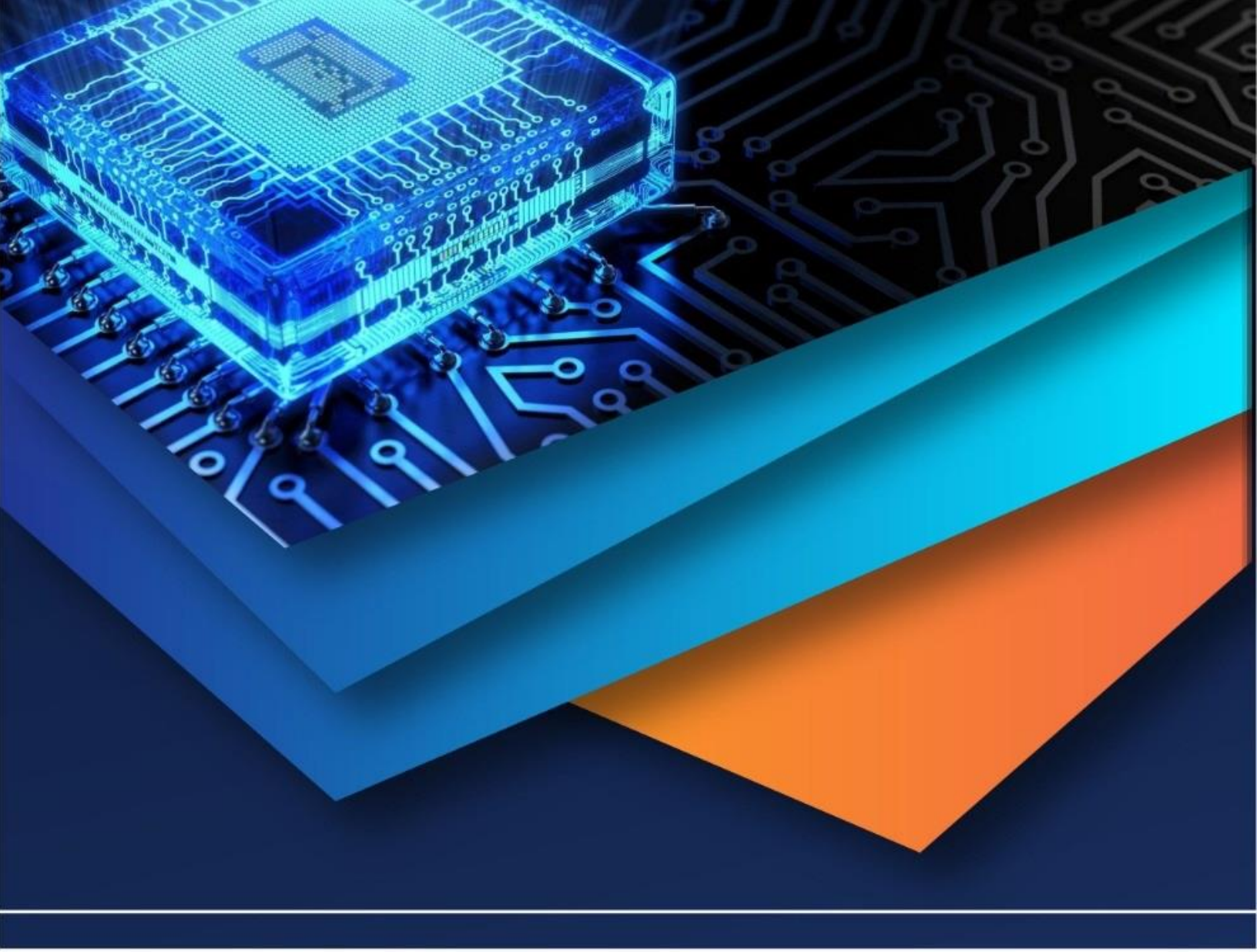
The Solar Panel Cleaning System project aimed to provide a better solution for maintaining solar efficiency. The main objective was to develop a machine that can clean a solar panel through a proper control system. This project involved developing a prototype to tap into a new and growing market. The project team encountered many obstacles along the way.

Designing the control system required learning Arduino Uno R3 configurations, C language coding, and its interaction with the electrical components. Using soldering boards to implement the designed circuit, hardware wiring, motor driver shield, and machinery were new experiences. Despite these challenges, the project achieved the desired design with the planned control and mechanism. The DC motors were controlled by both drivers to manage speed and direction. The roller cleaned the panel. Additionally, control code for the DC motors and the water pump was written and implemented in the system. However, the prototype was not completed due to the challenges and limitations mentioned earlier.

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