ISSN: 0974-5823 Vol. 7 No. 2 February, 2022

International Journal of Mechanical Engineering

ROBO for Monitoring and Cleaning of Solar PV modules using Artificial Intelligence

M.S.Sivagama Sundari

Assistant Professor, Department of Electrical and Electronics Engineering, Amrita College of Engineering and Technology, Nagercoil, Tamil Nadu, India

Abstract

Solar modules degrade with time, resulting in losses in electric power output and a reduction in system efficiency. The performance of a solar plant and its owner's profit might be reduced by up to 15%-17% if it is not cleaned properly. The existing human-powered cleaning approach necessitates a considerable amount of manpower, as well as human and equipment safety concerns. Also included in this cleaning procedure are machinery and unsatisfactory cleaning. As a result, cleaning costs rise dramatically, reducing efficiency.

This paper discusses an automatic cleaning approach that uses a ROBO machine with camera, IR sensor, and other cleaning attachments, as well as a power supply unit for ROBO, to overcome the numerous restrictions found in traditional cleaning methods. The ROBO must be installed near any of the solar modules. The ROBO's inbuilt GPS updates the date and time on a regular basis. The ROBO's scanner scans the solar module's surface on a regular basis, according to the timer set by the programmer. The image scanned by the ROBO is added to the cleaner's library, and it is added in a chronological order with time and date. Internally, the image added to the ROBO's system is processed to determine the amount of dust deposited. The cleaner, using software programming, determines whether the dust deposit is small, medium, or large. Depending on the system's decision, it may either remain motionless or send a command to ROBO to begin wiping first and then cleaning the surface with pure water. When the cleaning is finished, it scans and compares again. It comes to a halt when it is satisfied with its own decision-making ability. Otherwise, it's clean and stops once more. There is no need for a scan this time, and the user can choose whether or not to quit. If the cleaning is flawless, it's time to call it a day. If the cleaning isn't up to par, the Engineer in Charge is notified and must take action. The likelihood of obtaining optimal inference increases as a result of this automatic cleaning procedure, as does the efficiency of solar systems. This proposed method improves the performance enhancement of solar modules.

Keywords: Photovoltaic (PV), IR sensor, Light Dependent Resistor (LDR), Light Emitting Diode (LED)

1. INTRODUCTION

Due to the global increase in energy demand and the exponential exhaustion of fossil resources, new systems of electricity production have favoured the development of new systems, and solar energy has undoubtedly been one of the most widely used in housings, owing to its simplicity and ease of implementation through the use of photovoltaic panels. Semiconductors, of which silicon is the most prevalent, are utilised to create PV cells. When light strikes the cell, some of it is absorbed by the semiconductor material, which knocks the electrons loose and allows them to move freely, resulting in the generation of current. However, the performance of PV panels has always been a concern due to dust accumulation.

Dust accumulation, such as bird droppings, soil, and leaves, is one of the elements that affects PV panel efficiency because it reduces the quantity of irradiation in the PV modules, resulting in lower than ideal efficiencies. Other factors that affect PV panel performance include, but are not limited to, panel cracking, which is common during production (manufacturing) and heavy winds, discoloration, which reduces sunlight penetration and thus reduces efficiency, soiling, which is most prevalent in dusty environments, and hot spots due to high temperatures, which reduce output power.

The energy and efficiency produced by photovoltaic modules are proportional to the available irradiance and spectral content of the sun, therefore PV module cleaning is critical for enhancing performance and irradiance. PV panel cleaning aids PV system users in achieving maximum power generation by thoroughly exposing the PV cells surface area to maximum light intensity. If not cleaned, the collected dust reduces the performance of the solar PV module by shading the front surface and blocking solar energy from reaching the PV panel surface. PV panels must consequently be kept clean in order to capture as much solar energy as possible. Monitoring the performance of the PV panel can be done by measuring the panel's output power, determining its efficiency, and automatically cleaning the panel when a certain threshold is achieved.

2. LITERATURE REVIEW

Over the last few decades, the solar business has grown at a rapid pace, but solar panel cleaning and possibility planning has received the smallest amount of attention. The concept of cleaning the dust on the solar panel only at night has been explained by the author Vamsi Krishna et al. The idea of cleaning the residue on solar photovoltaic performance [1] has been elucidated by M.

Mani et al. It investigates the impact of residue on the execution of PV frameworks. To avoid the impact of aggregated residue on solar panels transmittance, Kutaiba Sabah et al. described Self-cleaning solar panels. This research is a combination of two ideas. The first is the prospect of reduced aggregated residue impacts on the level sunlight-based plate. The next method is to use an auto-cleaning robot to reduce the amount of dust that has accumulated [2]. J.Zorrilla-Casanova et al. have presented their findings on the analysis of residue misfortunes in solar modules. The goal of this study is to assess the costs associated with the accumulation of residue on the outside of PV modules. To that end, irradiance values calculated by two mSi cells have been recorded at regular intervals over the course of a year [3]. The impact of cleaning solar panels with water and surfactants has been explained by the authors. The goal of this study is to remove dust from PV panels using just water and energy [4]. In this investigation, the impact of cleaning on PV panels using only water as a surfactant was tentatively investigated using a non-compressed water framework [5],[6]. This will help us think about how cleaning affects the appearance of PV panels. The authors have clarified the Effects of Dust on the Performance of PV Panels in this study by using two forms of artificial dust, such as dried mud and bath powder, instead of genuine residue to address residue accumulation. The utilisation of typical residue accumulating was kept at a strategic distance from since it is unlikely to be all around appropriated on the exterior of a solar-powered PV board, where it would be exposed to the climate and the residue settlement may be exposed to the breeze effect [7],[8]. Quantifying the reduction in photovoltaic panels energy yield due to the wonders of normal air pollution removal in this PV applications, which has gotten a lot of attention in recent years, involves a promising sustainable power-based arrangement, ready to significantly contribute to the world's ever-increasing energy interest. Since monetary and functional impetuses have fueled their growth, private applications now account for a significant portion of the global PV market [9],[10]. The impact of dirtying on energy creation for large-scale photovoltaic plants has been clarified by A.M. Pavan et al. This can assist us in considering the activity and assisting mindful in selecting the appropriate washing timetable and technique for their plants in order to avoid wasting money, and this work aims to assess the impact of dirtying on energy creation for large-scale ground-mounted PV plants in the southern Italian field. The findings of this study suggest that both the type of filth and the cleaning method have an impact on pollution-related disasters [11]. The authors have developed a microcontroller monitoring system for monitoring crucial module characteristics like as temperature, voltage, and current, as well as reducing the negative effects of dust and module temperature on SPV system performance. The performance of the system is also improved utilising the perturb and observe method and a buck boost converter[12],[15]. Abdulsalam et al. focus on mechanical measures such as module vibration, air and water jets, and combinations of these, as well as the working PV carport placed, to enable for water recovery and reuse within the test bed [13]. Aashika et al suggested strategies that leverage Artificial Intelligence and Computer Vision to prevent soiling, hence boosting the efficiency of solar technologies, and an end effector is used to carry out the cleansing process [14].

3. PROPOSED METHODOLOGY

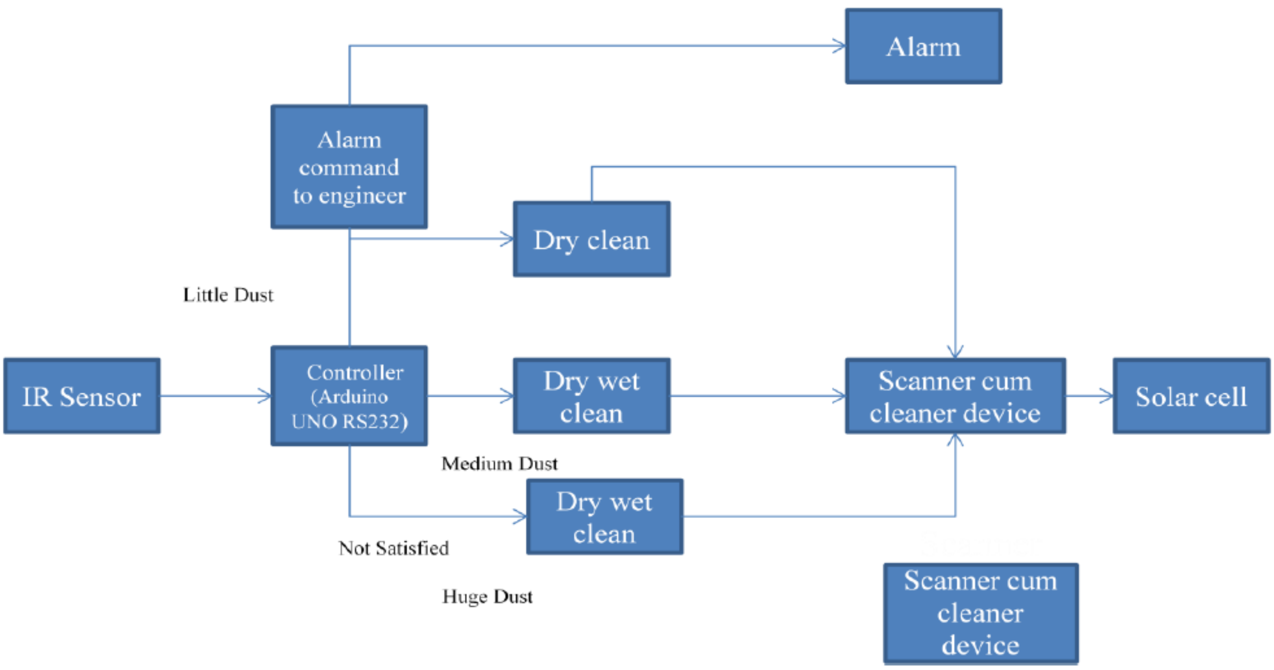

Fig.1.Block Diagram of the proposed method

The block diagram of the proposed method is shown in fig.1. The accumulation of soil and other ubiquitous particles can harm the solar system and diminish its performance. As a result, system cleaning should be done on a regular basis. The current manual cleaning process is really laborious. The major goal of this study is to use Arduino Uno to autonomously clean the surface of PV cells from onsite ubiquitous particles such as dust, bird droppings, sand, and tree leaves. It is made up of two parts: a controller and a cleaner. The PV cell's surface is detected by the proximity IR sensor. If there is any dust or other ubiquitous particles on the surface, the sensor sends an instruction to the controller unit (Arduino Uno), and the controller unit's output is transferred to the cleaning unit. The cleaner unit gets to work. Whether or whether the system is completely cleaned, the cleaning procedure continues. This will improve the system's efficiency and the PV cell's life span. The sensor is attached to the cleaner's sidewalls. The cleaner unit is made up of a wiper that is powered by DC motors.

4. HARDWARE IMPLEMENTATION

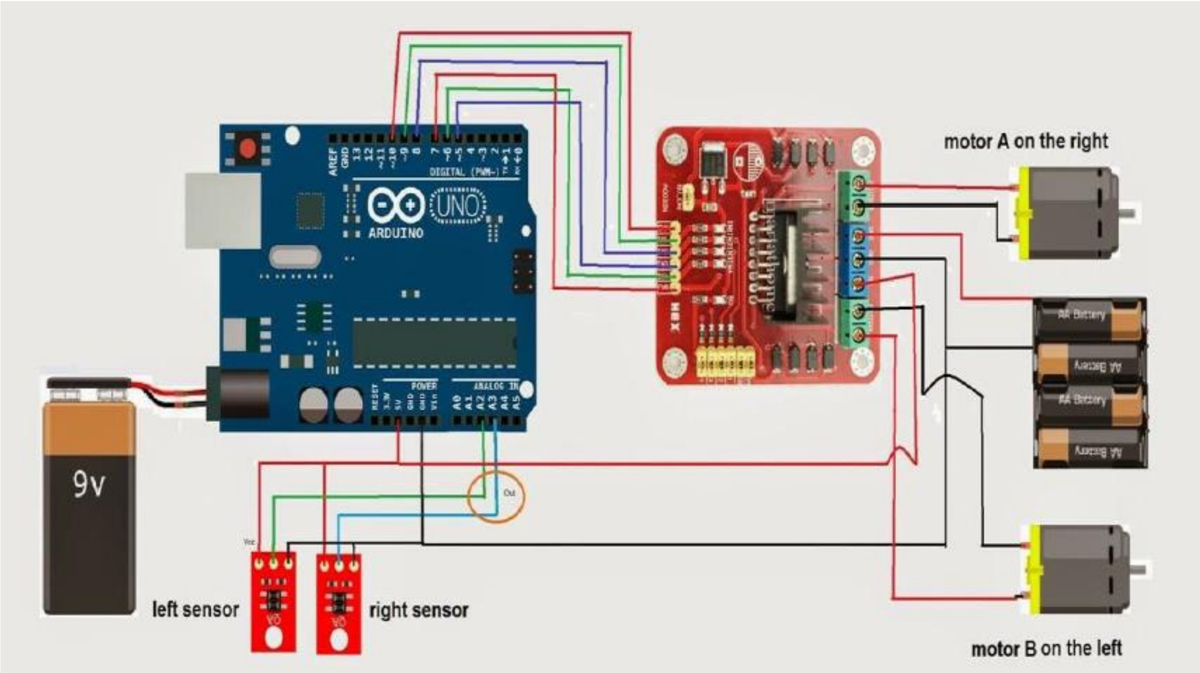

Fig.2.Hardware Circuit Diagram of the proposed method

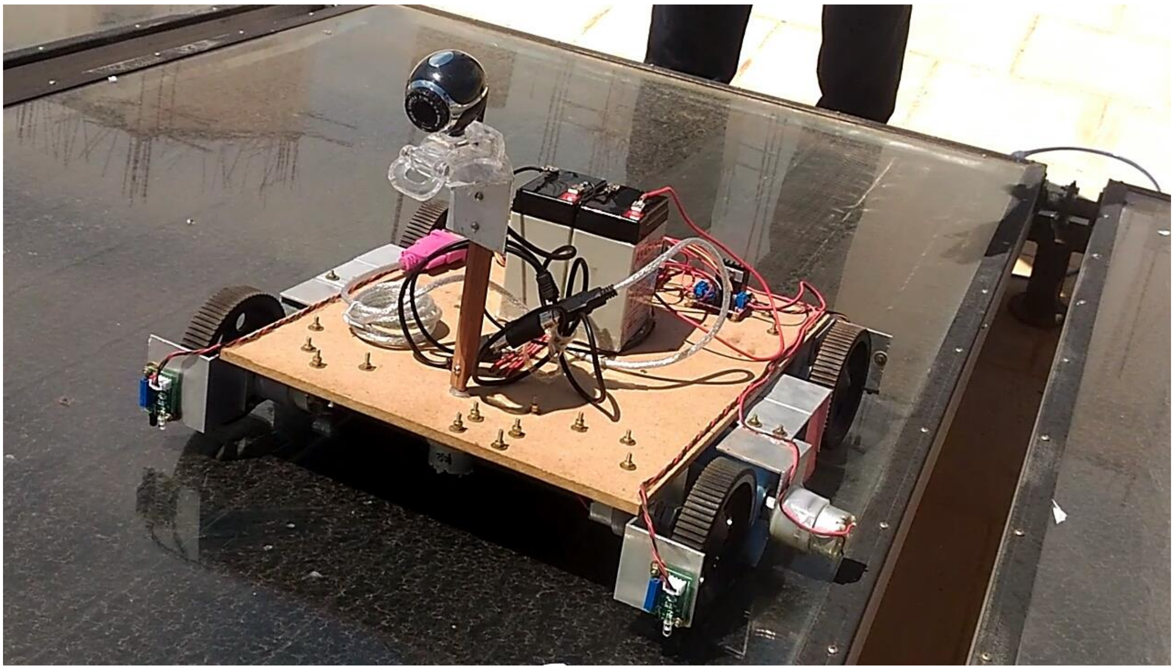

Fig.3. Hardware Implementation

The hardware circuit diagram and implementation of the proposed method are shown in fig.2. and fig.3.

A solar panel captures sunlight and uses it to generate power or heat. A circuit is formed by connecting interconnected silicon cells. Six DC gear motors are employed in the automatic cleaning of solar PV modules. ROBO is moved by four gear motors, with two more gear motors used for camera rotation and brush movement. There are two L298 driver circuits in operation. The four gear motors that control ROBO's movement are driven by driver circuit 1. The motor, which is connected to the camera and brush, is driven by a separate driver circuit. The ROBO must be installed near any of the solar modules. The image of the solar panel was captured using a camera. The camera scans the image for a predetermined amount of time and determines the amount of dust on the modules by comparing the fresh image to the standard image already stored in it. The data is sent to the ROBO's internal memory and, at the same time, to the plant's chief engineer. The ROBO begins automatically and does the task based on the software defined setting. Image scanning, image processing, data verification and processing, and instruction to cleaner are all parts of the system. The ROBO's scanner scans the solar module's surface on a regular basis, according to the timer set by the programmer. The image scanned by the ROBO is added to the cleaner's library, and it is added in a chronological order with time and date. Internally, the image added to the ROBO's system is analysed to determine the amount of dust deposited. The cleaner, using software programming, determines if the dust deposit is small, medium, or large. Depending on the system's decision, it either does nothing or sends a command to ROBO to start wiping first and then cleaning the surface. When the cleaning is finished, it scans and compares again. It comes to a halt when it is happy with its own decision-making capacity. Otherwise, it's clean and stops once more. There is no need for a scan this time, and the user can choose whether or not to quit. If the cleaning is flawless, it's time to call it a day. If the cleaning isn't up to par, the Engineer in Charge is notified and must take action. The Water Pump is a small submersible pump motor that runs on a 2.5V to 6V power source. It can pump up to 120 litres per hour while drawing only 220 milliamps.

5. SIMULATION

```
#include <AFMotor.h>
AF_DCMotor motor(2, MOTOR12_64KHZ); // create motor #2, 64KHz pwm
void setup() {
Serial.begin(9600); // set up Serial library at 9600 bps
Serial.println("Motor test!");
motor.setSpeed(200); // set the speed to 200/255
}
void loop() {
Serial.print("tick");
motor.run(FORWARD); // turn it on going forward
delay(1000);
Serial.print("tock");
motor.run(BACKWARD); // the other way
delay(1000);
Serial.print("tack");
motor.run(RELEASE); // stopped
delay(1000);
}
int LED = 13; // Use the onboard Uno LED
int obstaclePin = 7; // This is our input pin
int hasObstacle = HIGH; // HIGH MEANS NO OBSTACLE
void setup() {
pinMode(LED, OUTPUT);
pinMode(obstaclePin, INPUT);
Serial.begin(9600);
}
void loop() {
hasObstacle = digitalRead(obstaclePin); //Reads the output of the obstacle sensor from the 7th PIN of the Digital section of the arduino
```

```
if (hasObstacle == LOW) //LOW means something is ahead, so illuminates the 13th Port connected LED
{
Serial.println("Stop something is ahead!!");
digitalWrite(LED, HIGH);//Illuminates the 13th Port LED
}
else
{
Serial.println("Path is clear");
digitalWrite(LED, LOW);
{
delay(20)
// put your setup code here, to run once:
}
```

6. CONCLUSION

In this paper, an Arduino-based autonomous monitoring and cleaning system for solar cells is described. A solar panel, Arduino, and motor shield controller are used in this method. At a tilt angle of 35 degrees, the output power of a fixed solar panel loses roughly 25% of its rated yield, and this can be more depending on the dust type. The dirt and bird droppings create a hotspot in the panel, which can cause it to fail temporarily. Cleaning a solar panel with water improves cleaning efficiency by eliminating the majority of dirt that has accumulated on the panel. When comparing the expenses of manual and automatic cleaning, it is clear that automatic cleaning is more cost-effective and less time-consuming, especially in systems with a large number of solar panels. Cleaning the solar panel on a regular basis also guarantees that it operates at a high level of transmittance at all times.

The robot's software can be improved in the future, for example, when it cleans any PV panel surface, it can save information about PV cells (amount of dust, location). The focus of future research should be on replacing the automated cart system with a flying mechanism such as a quad rotor. The robot cleaning subsystem can be equipped with a quad rotor that allows it to fly from one solar panel to the next. This system can be operated remotely or can be fully programmed for use in an outdoor setting.

REFERENCES

1. M. Mani and R. Pillai, Impact of dust on solar photovoltaic performance: Research status, challenges and recommendations, Renewable Sustainable Energy Rev.vol in 2010.
2. Kutaiba Sabah and Sabah NimmaFaraj, "Self-cleaning solar panels to avoid the effect of accumulated dust on solar panels transmittance,"International Journal of Science and Research (IJSR), in 2013
3. J. Zorrilla-Casanova, M. Piliougine, J. Carretero, P. Bernaola, P. Carlene, L. Mora-Lopez and M. Sirach-de-Cardona. Analysis of dust losses in photovoltaic modules world renewable Energy Congress in 201and .Sweden, 8-13 May 2011.
4. Kapila, V. Class Lecture. Polytechnic Institute of NYU, Brooklyn, NY. 2012.
5. K.A Moharram, M.S Abd, H.A Kandil and H EI- Sherif, Inuence of cleaning using water and surfactants on the performance of photovoltaic panels, Energy Convers.Manage in 2013.
6. M. DinÃ§er and M.E. Meral, Critical Factors that Affecting Efficiency of Solar Cells, Smart Grid and Renewable Energy in 2010.
7. D.Thevenard and S. Pelland, S, Estimating the uncertainty in long-term photovoltaic yield predictions, Solar Energy in 2013.
8. S.A. Sulaiman, H.H. Hussain, N.S.H. Leh, and M.S.I. Razali, Effects of Dust on the Performance of PV Panels, World Academy of Science, Engineering and Technology, 58, 588-593, 2011.
9. H.K. Elminir, A.E. Ghitas, R.H. Hamid, F. El-Hussainy, M.M. Beheary, and K.M. Abdel-Moneim, Effect of dust on the transparent cover of solar collectors, Energy Conversion and Management, 47, 31923203, 2006.
10. J.K. Kaldellis and A. Kokala, Quantifying the decrease of the photovoltaic panel’s energy yield due to phenomena of natural air pollution disposal, Energy, 35, 4862-4869, 2010.
11. A.M. Pavan, A. Mellit and D. De Pieri, The effect of soiling on energy production for large-scale photovoltaic plants, Solar Energy, 85, 1281136, 2011.
12. Kangana Hazarika and Pradyumna Kumar Choudhary, Automatic monitoring of Solar Photovoltaic(SPV) module, Materials today proceedings,Vol.4, Issue 14,pp 12606-12609, 2017.

13. Abdulsalam S.Alghamdi, Abubakr S.Bhagj, Luke S.Blunden and Yue Wu,Dust Removal from Solar PV Modules by Automated Cleaning Systems, Energies, 12(15), 2019.
14. Aashika Prasad, Rithika and Radhika P D , Illustration of automatic panel cleaning system, International Journal of Engineering Research and Technology, Volume 09, Issue 08, August 2020.
15. M.S.Sivagama Sundari, P.Melba Mary and V.K.Velvizhi, Maximum Power Point tracking for photovoltaic system by perturb and observe method using buck boost converter, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol. 2, Issue 6,pp.2433 -2439, June 2013.