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Review Article

Review of the Literature on Robotic Solar Panel Cleaning

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Abstract

The cleaning robot contributes to improving the effectiveness of solar panels in a variety of applications, including solar panels for homes and other sectors. In the energy industry, photovoltaics (PV) is a new technology that converts solar irradiance—the radiant energy from the sun—directly into electricity. Here, the photovoltaic cells take the energy contained in the photons emitted by the sun and transform it into usable energy. The energy industry has seen a radical transformation thanks to PV technology, which has made it possible to generate clean power and move toward more environmentally friendly energy practices globally. The collection of dust is one of the major issues, however, that has an impact on the energy performance of panels. In areas with high levels of air pollution, particularly in Africa, this is a severe problem. But because some of the panels are hard to access and dangerous, maintaining the panels is a serious issue that is usually overlooked. Solar panel cleaning robots, an ingenious solution that combines cutting-edge technology to navigate and clean solar panels effectively and efficiently without the need for physical labor, were developed as a result. Solar panels are outfitted with a range of tools for cleaning dust, grime, and other impurities from their surface that are common in Africa in order to maintain their performance at its peak.

Keywords: Arduino Microcontroller, Photovoltaics (PV) Panels, Sun, Cleaning Robots, Dusts.

Introduction

Finding environmentally friendly ways to meet our energy demands is more crucial than ever, as climate change and global warming threaten the future of our world. One of the most efficient clean renewable energy sources is the production of electricity from solar energy. Solar energy is harnessed by solar panels to create power. Given that they don't have any moving parts, solar panels are among the most affordable and low-maintenance ways to generate electricity. The efficiency of a solar panel, which measures how much power the panel produces in relation to its theoretical maximum efficiency, was researched in Reference [4]. The study tested a solar panel's cleanliness and tracking mechanisms in a variety of settings, including fixed and clean, filthy and fixed, dirty and tracking, and clean and tracking. It has been demonstrated that dust collection on the solar panels' surfaces lowers their efficiency, even with integrated sun-tracking. The increased rate of light transmission boosts the efficiency of the cleaned solar panel [5]. Compared to keeping the solar panel stationary and clean, tracking it can cause an efficiency loss of up to 50%. Large-scale power plants lose megawatts more frequently due to dust buildup on solar panels [6]. A 1% decline in proficiency may have a considerable impact on the Internal Rate of Return (IRR). In contrast, low-level dust buildup might not have a negative effect on small solar plants [7]. In the energy industry, photovoltaics (PV) is a new technology that converts solar irradiance—the radiant energy from the sun—directly into electricity. Here, the photovoltaic cells take the energy contained in the photons emitted by the sun and transform it into usable energy. The energy industry has seen a radical transformation because to PV technology, which has made it possible for the globe to move toward more sustainable energy practices [1, 2]. This opened the door for the photovoltaic sector to make tremendous industrial progress in earlier times, and it continues to do so as technology advances. One can observe a significant advancement in technology if they follow the development of laboratory scale models, experimental scale models, and current real-time running power plants in the PV business. In order to solve the issues with energy demand at the load centers themselves and minimize the need for lengthy transmission and distribution, these PV technologies have arisen and become a crucial component of many other sectors. Commercial PV technology development led to the creation of big utilities or multi-megawatt power facilities. Utility solar power plants are currently being developed in large and broad numbers on open spaces, rural and urban structures, and water surfaces. Building integrated photovoltaics (BIPV) and building applied photovoltaics (BAPV), a new type of PV technology, have been developed in recent years in response to improvements in PV technologies pertaining to contemporary infrastructure [3]. A study on various dust-removal methods has been conducted. For instance, [15, 16] suggested using a nylon brush with an automated robotic system to remove dust particles from the surface of solar PV panels, while [17] discussed the energy losses brought on by the deposition of dust particles on solar panels. The research conducted by prior researchers revealed a sizable level of power loss [18]. The intensity of power loss worsens when PV-based power generation is used on a big scale. Here, a low-power wide-area network (LPWAN) based on a network of ESP8266 node MCUs associated with a set of sensors in various configurations was attempted to be used to develop an automated cleaning system. The results of the experiment were successful enough to be implemented in large industrial-scale solar PV power plants. After a year of solar system installation, the solar PV panel's efficiency has dropped to 40% [19]. High temperature, panel pitch and orientation [20], deposition of dust, snow, sea salt, and bird droppings [21], among other factors, are blamed. Among these, the buildup of dust and other debris on solar PV panels causes a 50% reduction in system efficiency [22]. By offering a suitable cleaning method, these particles can also be removed from the panel's surface. A number of research projects were conducted to implement various software-based prototype cleaning techniques. The production was raised by around 35% by using arm controllers [51–55, 57–58, 60] and gear motor-based cleaning techniques. A microcontroller-based automatic dust cleaning system was created to clean the panel every two hours, increasing efficiency by roughly 1.6% to 2.2% [23–29]. The operational cost is decreased and total efficiency can be raised by supplying a self-cleaning mechanism using software and hardware [30-41]. The cleaning mechanism works more efficiently when the accumulated dust on the panel can be identified and fed to it from the simulation. The performance of the PV panel was improved by a dust cleaning mechanism with a panel cooling system [42–45]. The overall system efficiency of solar street light panels with an automatic dust cleaning system that ran during the day and shut off at night was increased [46–49]. The majority of the established or proposed automated cleaning systems were found to be implemented with dry cleaning mechanisms to prevent short circuits and were permitted to run while dust built on the panels in the research investigations previously mentioned. Despite all of the benefits of solar panels, if impurities like dust, dirt, and dirt are allowed to accumulate, the efficiency of the panels could deteriorate. For solar panels to continue producing power at their peak efficiency, regular cleaning is necessary. Solar panel cleaning by hand is time-consuming and dangerous, though. Therefore, by guaranteeing that the solar panels are kept clean without endangering people, an autonomously operated solar panel cleaning robot could play a significant role in maintaining the effectiveness of solar power production. The cleaning robot contributes to improving the effectiveness of solar panels in a variety of applications, including solar panels in homes and other industries, particularly in harsh areas like Iraq. In this work, a small mobile solar panel cleaner robot is created with the intention of being used in Iraq's small and medium solar panel plants. The components used in the suggested design are readily available. This robot uses two different types of brushes and DC motors to move. One that is hard for tough dirt and one that is moist and gentle for dusting and polishing. We'll be using a water tank, a pump, sensors, and high-friction tank track wheels. Its whole construction will consist of a controller circuit incorporated within a metal chassis. The mobile robot will be wirelessly controlled and observed via a smartphone application. The controller, an Arduino Mega, will behave in accordance with the information received and transmitted [8]. Skilancer Solar Cleaning created a water-free Solar Cleaning Robot in 2017 to do away with the cost of water and the accompanying infrastructure, including tanker trucks, storage bins, hoses, and pipelines [52, 54]. Every day, it eliminates 99% of soiling. Three components are combined to ensure soiling is moved downward and off panel rows: controlled airflow over the panel surface, a specific microfibre that removes soiling gently, and gravity [9]. The Solar Cleano robot, created in 2017, also ensured a secure and eco-friendly solar panel cleaning environment. It can also be used to clean solar panels in desert regions with intense temperatures right after sandstorms. The solar plant personnel may remotely check on the robot's cleaning and operation status via dedicated web and mobile apps [10]. HELIOS, a drone-mounted [50] autonomous cleaning robot service that performs fully automated solar panel cleaning, will be unveiled by clean-tech startup ART Robotics in 2022. A brush and vacuum are used to clean a small, light robot that navigates on its own utilizing edge detection and accurate location estimate. Additionally, the cleaning robots from the solar panels are both deployed and collected by the Helios Drone [11]. Cleaning the floating solar panels, where hand cleaning is practically impossible, is an essential function of the automatic robotic cleaner. The gear motors and motor driver power the robot, and it also has another motor with a cleaning membrane attached to it so that it can be washed with water. The camera records footage of the solar panels and transmits it to the cloud for storage and use in damage and cleaning analysis [12-13]. The majority of places where solar panels are deployed are dusty. The panel's surface is covered in dust, which has gathered and blocked the sun's light. The panel's ability to generate electricity is reduced. In this case, cleaning solar panels on a regular basis is necessary to maximize solar energy. In this study, a cleaning robot is created to regularly remove dust particles from solar panels. A rotary brush and water spray are being used by the robot to clean a solar panel. Additionally added to increase the panel's efficiency is sun tracking [56, 59]. This study proposes a potential method for reducing the impact of dust on a solar PV panel's surface. In large-scale solar PV power generation, where many solar panels are connected in the form of arrays and each array requires a robot to carry out effective cleaning within the allotted time, a decrease in power output has been identified with an increase in particle deposition. An effective cleaning system in large-scale solar power plants requires autonomous automatic cleaning operation, self-control and monitoring of accumulated dust, as well as good coordination through networking between robots. To achieve the same, it is necessary to choose the right communication technology for real-time wireless networking of solar cleaning robots that consume little power and operate over a large area. Here, an attempt was made to implement an automated robot cleaning system using a low-power wide-area network (LPWAN) based on a network of ESP 8266 Node MCUs associated with a set of sensors under various configurations, which showed promising results for implementation in large-scale industrial solar PV power plants [14].

Conclusion

Numerous articles on the solar tracking system and the robots that clean solar panels have been evaluated for this study. Their development and the results of using them to clean the panels have been seen.

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