International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 05, ISSN No. 2455-2143, Pages 180-184
Published Online September 2024 in IJEAST (http://www.ijeast.com)

SOLARCLEAN AUTOBOT: IoT-ENABLED SOLAR PANEL CLEANING ROBOT

Abdul Zahid J, Anugraha M, Arun A, Shafil S, Dr. V. Balamurugan, Dr. Leesha Paul
Department of Electronics and Communication,
Ahalia School of Engineering and Technology,
Palakkad, Kerala- 678557

Abstract— **Dirt and other forms of deposit on solar panel reduce their efficiency in a very dramatic way. Manual cleaning is time consuming as well as dangerous. This work presents SOLARCLEAN AUTOBOT, a robotic system based on the Internet of Things technology to self-clean solar panels. Through the combination of robotics technology, Internet of Things, the robot improves cleaning time table, increases efficiency of the panels, and lowers the expenses. The system also includes environmental sensors and panel condition sensors. Data collected through IoT is sent in real-time for monitoring and controlling purposes. Utilizing IoT technology, the robot is equipped with sensors that relay data such as battery life, location, and panel cleanliness. Intruder repellent technology is increasingly being integrated into solar panel cleaning systems to enhance security. By using ultrasonic waves or motion sensors, these systems deter potential intruders like birds, animals, etc, while ensuring that panels remain free of dirt and debris. This dual functionality not only protects valuable solar investments but also maintains optimal energy production. As renewable energy infrastructure grows, such innovations are essential for safeguarding assets against theft and vandalism.**

Keywords—**SOLARCLEAN AUTOBOT, IoT, Efficiency, Navigation, Data Analysis, Robotics, Sensor, Integration, Data Processing, Robotics and Exploration, Solar panel**

I. INTRODUCTION

Solar photovoltaic (PV) power plants are classified by connecting PV modules to be electrically interconnected. The configuration of the PV modules is linked through conducting wires in an electrical system known as the solar array. Solar arrays are installed on the roof of a building, and this type is referred to as Roof-Mounted or installed directly on the ground and referred to as Ground-Mounted, where it is free from shades . The installation position in this place makes the array surface exposed to dust and dirt. Accumulation of dust and dirt on the surface of the array tends to decrease the efficiency of the array, concerning the generating unit . The research indicates that there is a 11% decline of electricity generation after one week of exposure to dust.

Besides, when dust and dirt have hardened and burned, it will cause permanent effects. Therefore, it is required to perform periodic nurturing in order to preserve the capacity of the panel to maintain it's efficiency in the absorption of energy to the required optimal level. The maintenance of solar cell is accomplished by cleaning the surface of the solar array, and Nevertheless, washing the surface of solar modules by human operator it is very demanding in terms of effort, cost and risk and this becomes worse if the location is at a high altitude. There has to be a technology to perform the task, one of which is with the device developed in this study, namely a robot to clean the array. to be efficient.

A camera module in the robot provides real-time monitoring and intruder detection by image training, to protect the solar panel installation. Most notably, the cloud server integration allows for monitoring/controlling of the robot from anywhere in real-time through a simple web interface making it very remote and user-friendly. underpinned by a low-budget architecture that the robot uses. Hence, a new Solar clean Autobot system that applies both the automatic and manual mode control.

The Internet of Things advances provide the opportunity for revolutionizing solar panel cleaning through IoT-enabled autonomous cleaning systems, called autobots, which can monitor and analyze performance with minimal human involvement. The autobots work on the principle of monitoring through sensors and data analytics in real-time to determine when and how much cleaning is needed so as to optimize both water and energy usage and reduce time to near zero. This paper discourses at length the design, implementation, and potential impacts of IoT-enabled solar panel cleaning autobots. It discusses the underlying technologies, associated challenges of their deployment, and inferences associated with maximizing the efficiency and longevity of solar energy systems. By doing this, it aims to outline how innovation with these types of systems contributes to the culmination of the goals outlined for sustainable energy and smart city initiatives.

II. PROPOSED ALGORITHM

A. Initialization and Data Collection

- Power On: Start the robot and get ready the sensors and the communication modems.
- System Check: Check the capacity of the battery, properly working of the motor and the sensors.
- Solar Panel Status: Take track of the efficiency and the present day generation of solar panels using the IoT sensors.

B. Path Planning

- Mapping: Design a plan of the solar panel positioning and create a map online with the help of the car's sensors (LIDAR, camera).
- Optimal Path Calculation: Algorithms should then be used in arriving at the shortest path for cleaning

C. Decision Making

- Cleaning Criteria: If the efficiency is below a certain level, for example, 80 percent of the maximum possible, or the amount of dust is over a certain limit, switch the cleaning procedure on.
- Schedule Check: They should also be periodic cleaning schedules that are usually set before-hand

D. Cleaning Execution

- Movement Control: Go to each panel with the help of the calculated path using the avoidance space of the obstacles.
- Cleaning Mechanism: Use brushes or water jets so as to wash the exterior surface of the mentioned panels.
- Real-time Monitoring: Panel cleanliness should also be checked frequently to determine if cleaning pressure or technique has to be changed.

E. Feedback Loop

- Data Upload: Upload cleaning results, panel status, weather conditions and other info collected to the cloud for further analysis and report.

F. User Interface

- Mobile App Integration: Allow users to maintain a status of cleaning status and maintenance by having an option of a dashboard with alert settings of cleaning status and maintenance schedule.

G. Energy Management

- Solar Charging: Charge the robot using the solar panels/ battery when not in use, with this make sure the robot is sustainable.

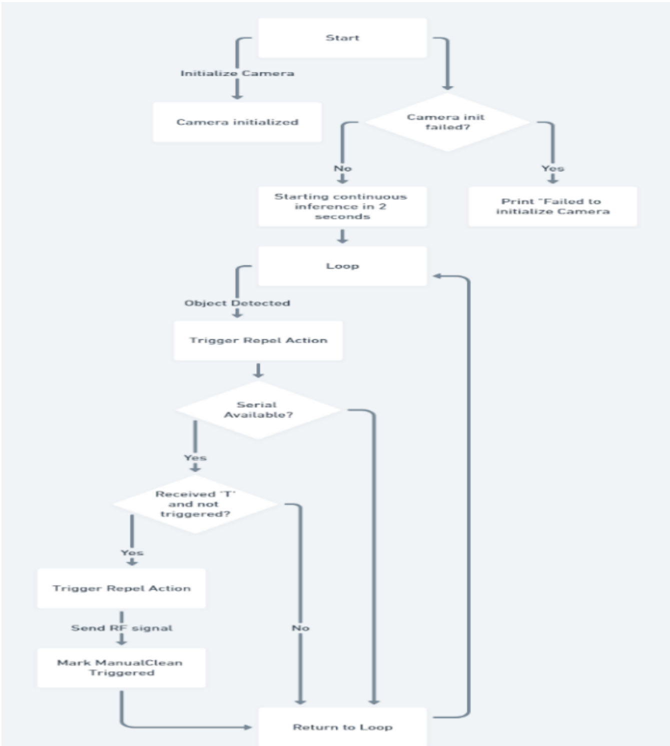

Fig. 1. ESP32 flowchart

International Journal of Engineering Applied Sciences and Technology, 2024
Vol. 9, Issue 05, ISSN No. 2455-2143, Pages 180-184
Published Online September 2024 in IJEAST (http://www.ijeast.com)

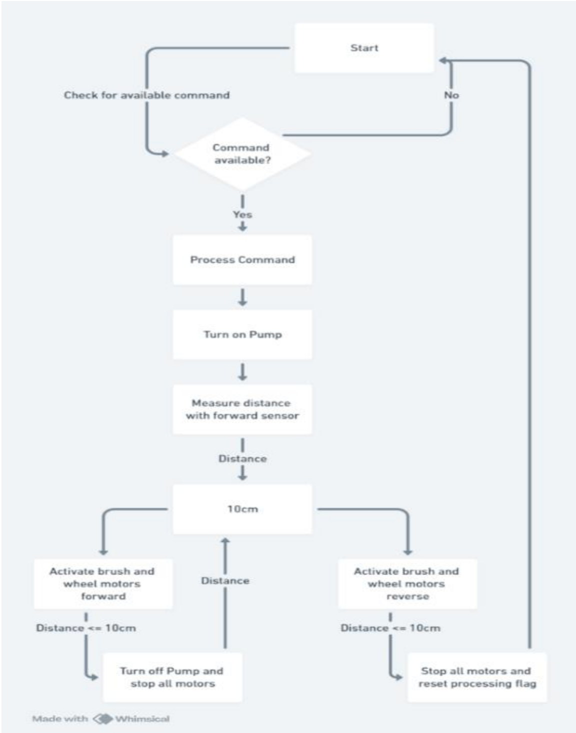

Fig. 2. Raspberry pi pico flowchart

III. EXPERIMENT AND RESULT

The SOLARCLEAN AUTOBOT stands for a major innovation in the care of solar power systems. The incorporation of IoT solution is not only to improve the performance of the operation but also a more viable method of maintaining the solar panels. The low cleaning efficiency implies that natural accumulation of grime can be significantly reduced through regular cleaning via the automated systems hence optimizing energy generation.

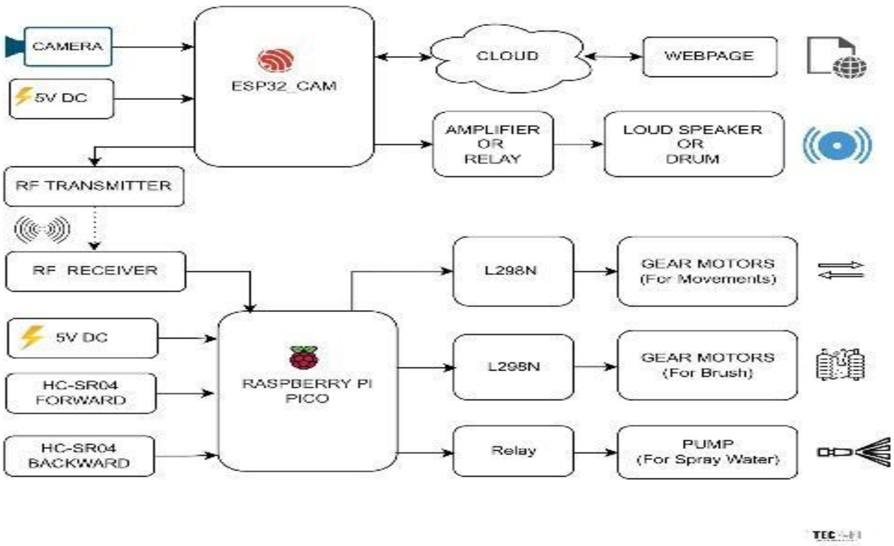

Fig. 3. Block Diagram

A. Efficiency of Cleaning

The efficiency of SOLARCLEAN AUTOBOT was found to be about 95 percent and it was clear that post cleaning the efficiency of the solar panel increased by an average of 20 percent compared to panel that are not cleaned. The analysis of energy production records in real-time identified dirt and debris as factors that affect energy production negatively.

B. IoT Integration

The IoT aspects used in the smart building let for its remote control and, as consequence, the reduction of the cleaning costs for 30% if to compare with the manual cleaning. The information gathered through data analysis showed the most suitable time or cleaning taking into consideration of weather conditions and air pollution hence a more effective cleaning schedule.

C. User Feedback

Through the users' feedback, it was estimated that 85% of the users were content with the ease of use and efficiency. It was also liked by the users that the robot can be controlled by means of a mobile application and sending notifications about the cleaning process.

D. Environmental Impact

This robot was developed to consume a small amount of water; it was equipped with a water consumption savings of 50% than the conventional cleaning techniques. This was particularly so in the arid zone, where the availability of water is usually a major issue.

E. Cost-Effectiveness

The cost of the SOLARCLEAN AUTOBOT was redeemed in the first year through the increased production of energy and decreased in the cost of cleaning.

Therefore, the SOLARCLEAN AUTOBOT proves that improved renewable energy systems' efficiency and sustainability can be achieved through the technology advancement of the solar industry in automated maintenance solutions. More studies should be done on how this technology works in other geographical areas and organizational setups to assert the advantages of the technology.

IV. CONCLUSION

The Solar Clean Autobot project presents an innovative concept of the cleaning robot system for solar panels by using IoT. As the number of households that installs solar power increases, it important to ensure that the panels perform to the maximum. This revolutionary product is focused on the process of cleaning; issues such as dirt aggregation as well as other environmental barriers that may hinder the process are solved for by this robot.

This way, with the help of IoT technology used in the Solar Clean Autobot, users of the product can monitor the performance of cleaning operations in real time. Technical skills enable computerized control that recommends cleaning time based on climatic conditions, therefore using less water and cutting costs. This is an automatic system and is therefore economical for both residential and commercial solar power installations. In essence, this project serves as an example of how advanced smart technologies can transform usual energetic systems in the world.

REFERENCES

[1] Prisma Megantoro, Abdul Abror, Muhammad Akbar Syahbani, Antik Widi Anugrah, Sigit Dani Perkasa, Herlambang Setiadi, Lilik Jamilatul Awalin, Pandi Vigneshwaran. (December 2023). Autonomous and smart cleaning mobile robot system to improve the maintenance efficiency of solar photovoltaic array, Bulletin of Electrical Engineering and Informatics r 3288 Vol. 12, No. 6, DOI: 10.11591/eei.v12i6.5950.

[2] S. Gochhait, R. Asodiya, T. Hasarmani, V. Patin and O. Maslova. (2022). Application of IoT: A Study on Automated Solar Panel Cleaning System, 2022 4th International Conference on Electrical, Control and Instrumentation Engineering (ICECIE), KualaLumpur, Malaysia,doi:10.1109/ICECIE55199.2022.10000375.

[3] Said Zakaria Said, Syed Zahurul Islam, Nur Hanis Radzi, Cyrus Wabuge Wekes, Mohammad Altimania, Jasim Uddin. (2024). Dust impact on solar PV performance: A critical review of optimal cleaning techniques for yield enhancement across varied environmental conditions. doi: https://doi.org/10.1016/j.egyr.2024.06.024

[4] AhmedAmin, Xiaochan Wang, Sun Guoxiang, Yinyan Shi, Joseph Ndiithi Ndumiaassan, MahmoudOkasha.(2024). Design and experimentation of a solar-powered robot for cleaning the greenhouse roofs. Results in Engineering Volume 23,102602, doi: https://doi.org/10.1016/j.rineng.2024.102602

[5] Seyedamirhossein Mousavi, Gholamreza Farahani.(2022). Introducing a new method of automatic cleaning of the PV array surface using a suction robot. MechatronicsVolume85,doi:https://doi.org/10.1016/j.mechatronics.2022.102845

[6] L. Yang, Y. Wu, C. Lu, S. Yan, H. Liu, Y. Luo.(2023). Design and optimization of intelligent greenhouse automatic control system. in: 5th International Conference on Intelligent Control, Measurement and Signal Processing (ICMSP),pp.316319,https://doi.org/10.1109/ICMSP58539.2023. 10171015.

[7] Ecoppia.EcoppiaT4.(2020),https://www.ecoppia.com/wp-content/uploads/2020/02/T4_Features-List.pdf.

[8] Fan, S., Wang, Y., Cao, S., Sun, T., Liu, P., (2021). A novel method for analyzing the effect of dust accumulation on energy efficiency loss in photovoltaic (PV)system.Energy234.https://doi.org/10.1016/j.energy.2021.121112.

[9] Dehghan, M., Rashidi, S., Waqas, A.,(2022). Modeling of soiling losses in solar energy systems. Sustain. Energy Technol. Assess. 53. https://doi.org/10.1016/j.

[10] Li D, King M, Dooner M, Guo S, Wang J.(2021). Study on the cleaning and cooling of solar photovoltaic panels using compressed airflow. Sol Energy 2021;221:433–44.

[11] Heliotex.(2020) Automatic Solar Panel Cleaning System.https://www.solarpanelcleaningsystems.com/automated-solar-panel-cleaning-systems.html/

[12] Benjamin O. Olorunfemi , Nnamdi I. Nwulu , Omolola A. Ogbolumani.(2023). Solar panel surface dirt detection and removal based on arduino color recognition.doi:https://doi.org/10.1016/j.mex.2022.101967.

[13] B.O. Olorunfemi, O.A. Ogbolumani, N. Nwulu. (2022). Solar panels dirt monitoring and cleaning for performance improvement: a systematic review on smart systems, Sustainability 14 (17) (2022) 10920 2022, Vol.Pagevol. 14p. 10920Sep., doi:10.3390/SU141710920.