

Artificial Intelligence Based Solar Panel Cleaning Robot

Gargi Ashtaputre¹, Amol Bhoi²

¹PG Student, Dept. of Electronics & Telecommunication, G.H.Raisoni Institute of Engineering & Technology, Pune, India

²Asst. Professor, Dept. of Electronics & Telecommunication, G.H.Raisoni Institute of Engineering & Technology, Pune, India

Corresponding Author: Gargi Ashtaputre

Abstract: The abstract should summarize the content of the paper. Try to keep the abstract below 200 words. Do not make references nor display equations in the abstract. The journal will be printed from the same-sized copy prepared by you. The efficiency of Solar PV panel is greatly affected due to the accumulation of dust, dirt and sea salt on panel. This paper aims at developing a low-cost automatic robot which will smartly clean the panel. The project is divided into two parts: Cleaning System and Monitoring System. Cleaning task is completed according to the data received from monitoring system. Wireless technology has been implemented in order to collect all the data from individual panel. The power output of each panel is monitored thoroughly and depending on the information collected at each node, the cleaning action is triggered. This system is also able to detect breakage of panel. The system can be operated remotely and user can access all the information on field from any part of the world.

Keywords: PV Panel, Monitoring System, Cleaning

Date of Submission: 02-06-2019

Date of acceptance: 17-06-2019

I. Introduction

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper. Solar energy is bright light and heat from sun that is controlled using numerous technologies like Solar Photovoltaic, Solar Thermal, Solar Architectures etc. Solar photovoltaic is becoming popular day by day. It is commonly said that after a few decades it is definitely becoming the mainstream source of electricity. Impressive research is going on in this field in order to increase the efficiency of solar power plant. Even though solar cell efficiency is mainly focused in this process, there are certain basic parameters which affects the solar power output. Some of these factors are shadow, snow, extremely high temperature, dust, dirt, bird dropping, sea salts etc.

Many researches have proved that even if the panels are maintained cleaned, it contributes to greater increase in power output of the plant. This paper has focused on the cleaning related issues like dust, bird droppings etc. Previously when solar power plant size was very less, people used to maintain or perform the cleaning process manually. But now a days, the size of plants has been so huge, people are building solar farms. It makes the cleaning process more laborious and expensive. Another aspect to this process is, employing labors for cleaning is only possible when power plants are installed on land. There are various plants which have been installed in sea, desserts or in such remote places where labor employment is either impossible or very expensive and tedious.

By considering all the aspect mentioned above, it is very necessary to employ a method of automatic cleaning process. With the advancement in technology, it has also been very necessary to develop not only an autonomous cleaning process but also a smart cleaning process. Now a day's internet connected mobile devices such as smart phones and tablets are now widely used. Thus by using the artificial intelligence, It is possible to convert the normal autonomous cleaning process into smart cleaning process.

Various efforts have been put by many researchers to develop such system in order to effectively clean the panels and also use artificial intelligence to meet the demands of users.

II. Design And Implementation

2.1. Robotic Cleaning System

As a significant number of research has been carried out in this area, various people have used different techniques to overcome the cleaning issue. When the number of panels were very less, employing people for cleaning was the only way adopted by most of the power plant owners. But as the days are passing the number of panels per power plant are highly increased. People are implementing solar farms which has several number

of panels. Monitoring all these panels and cleaning them manually was very tedious process. At least human employment for cleaning panels was possible when power plants are built on land. There are several examples where power plants have been built on to the sea. As people have huge problem of land availability, they are opting for the plant installation in sea. When power plants have been installed on land, user has to face issues like dust, dirt, bird droppings etc. Now when power plants which are installed in sea, the major issue is sea salt. Sea salt affects the efficiency of the panel output to a large extent. Sea salt also cause damage to aluminum strips which are needed to encase the panels. So removing sea salt from panel surface is as important as removing dirt from the panel. Sea salt minimizes the power output and efficiency of the panel and also reduces its life to a great extent. Providing AI base cleaning system for such plant have been proven best so far.

People have implemented automatic cleaning system in many ways. There are various robots available to clean the panel automatically. The structure of the robot available in the market are very different from each other in many senses. The basic criteria to differentiate these robots from each other is that some are using vacuum cleaning method and some are simple wiping technique. Employing vacuum operated robot causes additional cost inclusion. Then there various sizes in which these robots are available. Some robots are so huge that they cover whole vertical area of the panel. The aluminum strip rout is made available for such robots. They start cleaning process from one end of panel row and proceeds horizontally till the last panel. One robot per row is implemented in such cases. Another example of different sized robot is nothing but small sized robot. It is situated on top of the panel. This robot will move in path created by programmer of the robot. Very popular routing method is 'U' shaped path.

For charging these robots, a concept called 'Docking station' is used. The docking station is setup at the beginning of the solar panel. If the battery voltage falls below a particular threshold voltage, the robot returns to its docking station and charges itself. Station consists of a base and two aluminum strips mounted on it. These aluminum strips acts as a positive and negative terminal. When the charging process is being carried out, if the battery voltage exceeds the set voltage (or if reaches the reference limit), the charging circuit disconnects itself from the battery. Now once the charging is completed, the robot starts the cleaning process as per requirement.

2.2. Monitoring System

There are various robots which are smart enough to monitor the data of panel like dust, its output affected by dust etc. There are various robots available which uses dust sensing methods or dust analysis methods and some don't. When dust analysis method is not employed, the cleaning action is carried out on the basis of status of sun. In night, the robot performs the cleaning action and in day time it charges itself. In such cases, there is possibility of unnecessary cleaning. Even if the panels are cleaned, the robot cleans them again when sun has fall down. But the worst scenario than this is that panels will not be cleaned in day time even when sometimes it becomes very necessary to clean them. Due to accumulation of dust in day time, or due to bird dropping, the panel starts giving less power output than it is expected to deliver. In such cases even if is a day time it becomes very necessary to clean such panel. But the programming of robot is such that even if the output is affected to a great extent, the robot will not begin its cleaning until sun goes down. The system which is designed in this paper will use the dust analysis system to overcome this problem.

There are various monitoring systems used in different robots. The monitoring system selection can be decided based on various factors such as its geographical location, weather conditions, number of panels etc. For example, when the robot is employed in UAE area, the robot requirement mainly focuses on consideration of United Arab Emirates weather conditions. It frequently cleans the solar panel if any dirt or dust is spontaneously detected. As UAE has water availability issues, they mainly focuses on water-free robotic cleaning system. The robots there mainly consist of:

- Battery recharging by separate solar panels
- They uses brushes on both ends
- Four wheels for robot movement
- Sensors and
- Controller System

Dust Analysis methods is performed considering various parameters. Some commonly used methods are:

2.2.1. Uses Anemometer

It measures horizontal wind speed. The UAE weather condition is such that airflow due to wind affects the dust accumulation or dissipation at particular places of the solar panel. Powerful wind affects the solar panel generation. In case where the wind gust is taking place at the site, the panel efficiency decreases. They recommended that it is worthless cleaning a panels in such a windy condition. So the decision to leave the robot in stand-alone mode is taken on the basis of sensor conditions.

2.2.2. Uses Temperature-Humidity Sensor:

There are various sensors available in the market which are employed for temperature, humidity sensing. Commonly used such sensor is DHT22 digital low cost temperature and humidity sensor. In Gulf countries, the summer temperature is very high. This high temperature is often associated with a high humidity content at east and west coast. Humidity affects panel in a greater manner than dust accumulation. The irradiance level of sunlight which is required to achieve higher efficiency is reduced by water vapor particles. Panel surface could be moist and light scattered either by refraction, reflection or diffraction when water drops are hit.

2.2.3. Uses Optical dust sensor:

Optical air quality sensor is designed to sense the air quality and it bonds dust particles. The IR and LED in this device are encoded to allow it to defect reflected light in air. It detects very fine particles. It compares the data to existing one, then robot decided the time to begin the solar panel cleaning process. These are some of the commonly used methods used for cleaning the panel. As mentioned above these methods vary according to weather conditions, geographical location of panel implementation etc. The system which has been designed in this paper is basically a cleaning system. But this system is very modular.

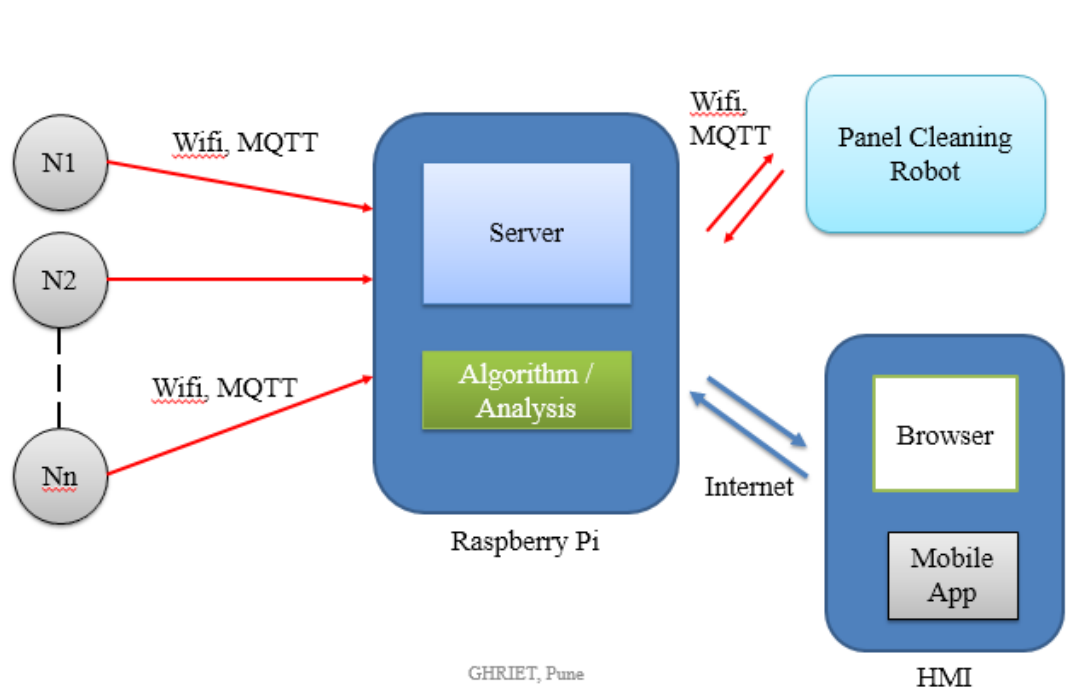
III. Design And Implementation

As mentioned earlier, the system which is designed in this paper is basically a panel cleaning system. But it will not just focus on cleaning. Panel cleaning would be just one part. The system is very modular. The system can be said to be smart system in a way that cleaning process is carried out on the basis of dust analysis method. Dust analysis can be said to be a heart of the system. Dust analysis is used for determining which panel needs cleaning. For determining “Dusty Panel”, an algorithm is developed which leads towards Cleaning of that specific panel.

3.1. Block Diagram

The following figure shows the System architecture of our project. Brain of our system is nothing but Raspberry-pi. This system can be extended to function in various formats.

Nodes have been used as preliminary base. Each panel is attached with one node. Node is nothing but a Node MCU. It has a combination of a controller and wi-fi. wifi will be used to communicate panel output generation status through communication protocol MQTT. This is also doing our dust analysis part. Each node consists of a current sensor and voltage sensor which communicate its output generation status continuously to the server.



GHRIET, Pune
Fig 1: Block Details

The current sensor used in this project is ACS 712. Voltage sensing task is carried out with help of voltage divider arrangement. So with these sensors, power output generation can also be determined. Now As this information is getting sent to server, that is Raspberry-pi controller, it will analyze this data and will conclude which panels are needed to be cleaned. This determination is carried out using a generic algorithm. So after determining the panels which are needed to be cleaned, this information is sent to our robot which has its own controller embedded in it. This is nothing but Node MCU.

According to the data received by Node MCU, the robot is expected to go on that specific panel and perform cleaning process. The robot is embedded with the sensor that is nothing but ultrasonic sensor. Robot is going to follow S-shaped path for its cleaning process. This is achieved by using edge detection mechanism. After Cleaning the panel, robot will send this data to server and server analyses the output generated by the same panel which is just being cleaned by robot. With the help of this analysis, system concludes the effect of cleaning process, a project is receiving.

Now third and very important part of our system is nothing but HMI. HMI is Human Machine Interface. The very basic component of HMI is GUI. In GUI, Browser and Mobile application will be processed. HMI can have variety of functions like voice commands, smart devices like ALEXA, Google Home etc. But in this paper only Mobile application and browser have been used.

Using this HMI, a lots of information will be conveyed to the user. A facility of manual control of the system has been given through this GUI. User can initiate cleaning process anytime he wishes to. Beauty of the system is that to initiate the cleaning process or to issue any kind of command, it is not necessary for user to stay on field. He / She can issue commands and then observe its results from any remote location.

The information which user receives at its own end can be listed as follow:

- Cleaning Process Status (Ongoing/Idle)
- Number of Panels Cleaned per day
- Number of Robots working currently
- Power Output
- Cleaning Average Time
- Light Status at Field (Day/Night)
- Robot Charging Status Information
- Number of robots Cleaning Currently
- Breakage of Panel (Yes/No)

If YES,

- Number of Row
- Number of Column

So, the user is well aware of all the conditions on field with above information being displayed on its computer or mobile.

IV. Conclusion

This paper emphasizes on how much panel efficiency is affected due to dirt, dust, sea salt and bird dropping. However our project helps to users to resolve these issues. The project is divided into two parts; Smart Cleaning which will be carried out through robot actions by using dust analysis method and the HMI which will communicate all the information to user regarding its current status and also allows user to operate on the field remotely. The cleaning is made smart using dust analysis algorithm. The AI based Solar Panel Cleaning Robot is capable of acquiring the values for individual panel current, voltage and hence determining the power output. The project not only focusses on simple cleaning but put extra efforts and leads to smart cleaning. This system is also very cost effective. This helps user to use renewable energy efficiently.

References

Journal Papers:

- [1]. B. Shrihariprasath and Vimalathithan Rathinasabapathy, "A smart IoT system for monitoring solar PV power conditioning unit", *Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave), World Conference on IEEE, 2016*
- [2]. Charith Perera, Chi Harold Liu, Srimal Jayawardena, "The Emerging Internet of Things Marketplace From an Industrial Perspective: A Survey", *IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING, January 2015*
- [3]. Jiju K. et. al., 2014. "Development of Android based on-line monitoring and control system for Renewable Energy Sources." *Computer, Communications, and Control Technology (I4CT), International Conference on. IEEE, 2014*
- [4]. Kabalci, Ersan, Gorgun A. and Kabalci Y., 2013. "Design and implementation of a renewable energy monitoring system." *Power Engineering, Energy and Electrical Drives (POWERENG), Fourth International Conference on. IEEE, 2013*
- [5]. Shaharin Anwar Sulaiman, et al, "Influence Of Dirt Accumulation on Performance of PV Panels", *Energy Procedi, Volume 50,2014*