IOT BASED SOLAR PANEL CLEANING ROBOT*

BY

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ABSTRACT

This paper presents a very small-sized, cost-effective, fully automated, man-less solution for solar panel cleaning. Dust on solar panel has become a huge issue in the field of Solar Power. The efficiency of Solar Panel power generation is greatly affected due to dust accumulation. The robot designed in this paper provides an appropriate solution for dust cleaning. This IOT based design helps user to monitor the increase in power generation of each and every panel in a system after its cleaning through smart phone or webpage from any part of the world. One can clearly observe the increase in panel current as current output of each panel is made available to user via HMI panel. Best part of this system is that it detects the panel breakage. The results have been collected on the field and mentioned in this paper along with photographs.

KEYWORDS

Cost-Efficient, Small-Sized, Monitoring System.

I.INTRODUCTION

The perfect way of a clean and reliable energy future is nothing but Solar Energy. As no harmful emissions are released during the generation of Solar Power Plants, solar power can definitely be termed as an ecofriendly source of energy. On earth, we receive an enormous amount of energy every day. It is even more than the actual energy needed on earth. This is the main reason why all the countries are investing a good amount of money as well efforts for installation of solar power plants. Solar technologies are broadly classified into two categories: Active Solar Technology and Passive Solar Technology. And in the Active Solar technology field, Solar PV is gaining huge popularity. In the Solar PV technique, the Solar cell is used as a device that converts Solar energy into Electrical energy. These Solar Cells are arranged in an array format to form a solar panel. And these Solar panels are again arranged in an Array pattern to construct a Solar power plant.

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The efficiency of these Solar PV panels is greatly affected due to the accumulation of dust, dirt, and sea salt on the panel. This paper aims at developing a low-cost automatic robot that will smartly clean the panel. The project is divided into two parts: Cleaning System and Monitoring System. The cleaning task is completed according to the data received from the monitoring system. Wireless technology has been implemented in order to collect all the data from the 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 the panel. The system can be operated remotely and users can access all the information on the field from any part of the world.

Main objective of this Autonomous Solar Panel cleaning robot is to increase the efficiency of panel by conducting a proper dust analysis, detecting the dusty panel from an array, continuously monitoring the panel outputs and taking feedback from all the cleaned panels after execution of each cleaning cycle.

II.System Implementation

A)Autonomous Vehicle's Monitoring process

There are various factors involved in the monitoring process of IOT based Solar power cleaning robot. Monitoring process in this project is carried out for two main reasons:

i)Dust Analysis

ii)Detection of Breakage of Panel

i) Dust Analysis: For dust analysis, a continuous monitoring of panel current output is carried out. Existing solar panel cleaning robots clean all the panel at the same time. There is no provision of "Dust Analysis." Or in other words, cleaning of individual panel according to the dust accumulation on it is not carried out in existing system.

In this project each panel in row I s fitted with Current sensor ACS 712 and a node MCU. The current received from panel is directly fed to ACS 712 sensor and this current is then directed towards the node MCU input data pin in order to carry out proper dust analysis. The concept used in this scenario is that " If the current output of specific panel is low as compared to adjacent panels the panel is declared as dusty panel. "

There are various factors by which an individual panel is delivering the low output. For example, when panel comes into a temporary shadow zone due to clouds, it can definitely deliver a low output. So, there is a possibility triggering of unnecessary cleaning action frequently. To avoid this Node MCU is fed with such a program that if it observes low current output from specific panel, it will simultaneously check the current output of two adjacent panels of that particular panel. If it is found that both the adjacent panels are giving a good amount of current output

then a particular middle panel is declared to be the dusty one. This is then updated on HMI panel and robot receives a command to clean that panel.

ii) Detection of Breakage of Panel: This is another added advantage of this project that it predicts the breakage of panel by running an algorithm written through program within a controller. The cleaning systems used generally in the field of Solar Panel Cleaning mechanism does not provide this facility more often. In this algorithm, the output received from current sensor ACS 712 which fitted at each panel in row. An algorithm is written in Node MCU. Node MCU receives all the data from each ACS 712 sensor. As mentioned in dust analysis, Node MCU then compares the data received from individual panel with its adjacent panels and if the output from particular panel is low, it triggers cleaning action. After the cleaning is performed, Node MCU once again checks for ACS 712 output for the increase in current. If the current is not increased the program jumps into a state for that particular panel where it has been asked to wait for two hours.

After two hours if the current out of particular panel is not increased to a sufficient level as compared to its adjacent channel, program once again enters in 'two-hours waiting' loop. This process is continued for 48 hours that is for continuous two days. After monitoring the panel output for consecutive two days, if there is no improvement in an output, the panel is predicated to be break. This is then get updated on HMI panel along with the row number, panel number and exact location of this panel in the field through controller and wifi-module and user has been informed to visit the field and check for breakage of panel through text message along with all the information regarding that particular panel (panel location, its performance since last two days and its current panel output).

B)Autonomous Vehicle's Cleaning Process

Operation of Cleaning is carried out on the basis of dust analysis done by robot. As shown in figure 1, for the movement of robot on the row of panels rack and pinion arrangement is used.

Fig 1: Rack and Pinion Arrangement

A mechanical structure is built to hold the brush over a panel. Using rack and pinion arrangement robot reaches to a panel which is declared as dusty by a dust analysis method.

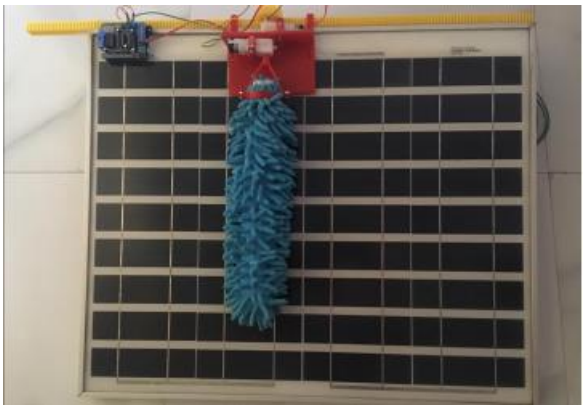

Fig 2: Mechanical Structure Holding the Brush

Once the robot reaches at dusty panel, a brush starts moving in circular direction as a mechanical structure holding a brush starts moving rotationally. A simple DC motor is used to rotate mechanical structure and hence the brush in order to carry out the proper cleaning process.

C)System Architecture

System architecture is divided into two parts in order to get clear understanding of its design procedure. Figure 3 shows the architectural part 1.

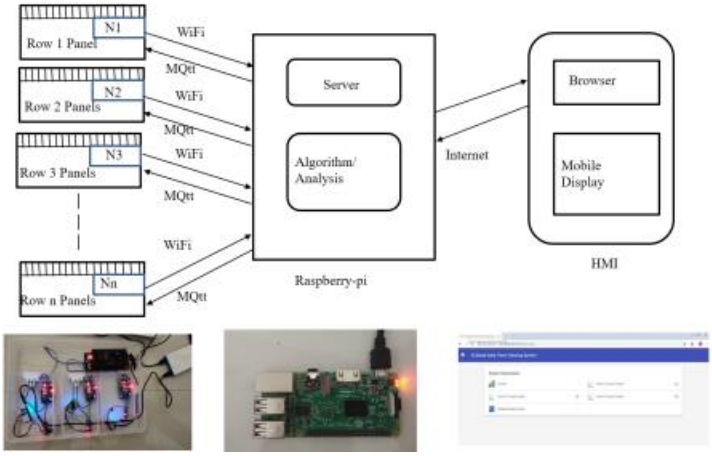

Fig 3: System Architecture Part-1

As shown in Figure-3, circuitry attached to each panel in a row is termed as Node [N] (explained in detail in architectural part 2) and is assigned with particular number. Each node has a current sensor to sense the current output of that particular panel and a node MCU to collect this data and sent it over the internet. Node MCU is basically acting like a Wi-Fi- module , it is not taking any kind of decision, it is just transmitting data over the internet. Node MCU uses MQTT

communication protocol. The data collected by Node MCU is sent to Raspberry-Pi. All the algorithm application and data processing is done at this stage. Decisions are made on the basis of dust analysis process and commands are issued by raspberry-pi to Node MCU via internet to run 'cleaning algorithm' for particular panel. Simultaneously all the data is updated on HMI panel by raspberry-pi. HMI panel can be a Mobile display or a browser.

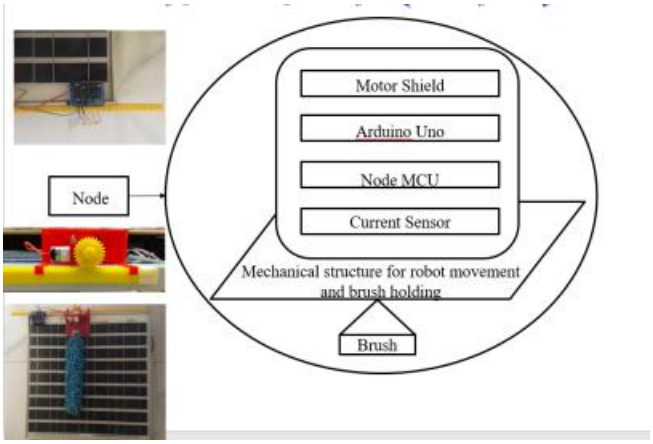

Fig 4: System Architecture Part-2

Figure 4 shows system architecture part-2. This part gives a detailed design of Node. A node is a circuitry connected to each panel. It consists of Motor shield, Arduino Uno, Node MCU Current Sensor, Mechanical structure for robot movement and brush holding and a brush. Motor shield is used to move robot horizontally over a row of panel and to rotate a brush over dusty panel. Arduino Uno is used to control all the actions of motor. It triggers motor according to the signal received from Node MCU.

Node MCU is used as Wi-Fi module. All the data are transmitted and received using this Node MCU. A current sensor ACS 712 is employed to collect the current output of each panel to run a proper dust analysis. A plastic mechanical structure is used for brush holding as shown in figure 4. It is built using a 3D printer. For robot horizontal movement over a row of panel, a rack and pinion arrangement is employed. Lastly a regular cleaning brush is used to clean the dusty panel.

D)Field Results

The result was collected by spreading the dust over a panel, collecting its current output, then letting the robot to clean the panel and again checking for its increased efficiency. Figure 5 shows the current output with 100% dusty panel.

Fig 5: 100% dusty panel output measurement

Figure 6 shows a current output after robot cleans it. Increase in the output efficiency is clearly visible with results shown on ammeter.

Fig 6: Cleaned panel with increased output

CONCLUSION

This robot mainly deals with how much panel efficiency is affected due to dirt, dust, sea salt and bird dropping. It helps user to solve this issue. The robot 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 IOT 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

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