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Smart solar panel monitoring system Using image processing

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Abstract

In the present study, the dust is being deposited on the Panel where the efficiency and the output power decreases. So in order to increase the efficiency, we are proposing a system based on Image Processing. Image processing uses a camera and senses the dust which triggers the motor to clean the Solar Panel using Wiper. In addition to this, a webpage is also developed in order to check the Power moni]toring. In case if the automated cleaning process isn't responding, a operating button will also be present in the webpage to clean the Solar Panel manually.

Keywords: Image processing, Solar Power Monitoring, Webpage

1. Introduction

Solar energy is the cleanest and the most important source of Renewable energy. It generates Electrical energy from Light energy. At Present, the Solar Panel accounts for the efficiency ratings as 23% while the other panels show between 15% and 17%. In the United Arab Emirates region, dust on the Solar Panel is one of the main issues that reduce efficiency. It is classified into two types as Active and Passive solar. Photovoltaics (PV) is one of the examples for active systems where it generates electricity from sunlight directly via the electronic process known as photovoltaic effect Solar Panels. Dust accumulation is the major drawback in the functions of the PV module. UAE witnesses a large measure of residue storms consistently. Soiling is used to show the amount of dust and other pollutants accumulated on the PV module and lead

to form a thin coating and prevent the high power of light from falling on the module. Dust is a compact substance that is less than 250μm in radius. The dust settlement depends on factors such as location, weather conditions, dust properties, wind speed, and slant angle of a Solar Panel. Dirtying can become lasting when moistness condensates and makes dust stick on the outside of the Solar Panel. Residue deposition on the edge can cause concealing on the cells which will harm the covering also. Soiling in the PV framework can cause power misfortune up to 17% to 18% each year. Several methods are available for cleaning which depends on the weather, location, and type of mounting.

2. Literature Survey

DC Jordan (1) reviews that Degradation rates are needed to know to predict power delivery. The degradation rates measured in the last 40 years on individual modules. The rate is 0.5% per year.

K V Vidyanandan (2) assesses the impact of soiling

on PV module. Soiling is a large amount of dust and pollutants accumulated on solar panels which prevent the falling of large light on the panel. So efficiency reduces up to 17% - 18% per annum so efficiency can be increased by cleaning dust depends on location, wind speed, and weather conditions.

Javed (3) talks about regular cleaning of the panel and there will be a high difference between estimated yield and actual field.

Hussain (4) stated that power generated is reduced to 850 W/m², 750 w/m², 650 w/m² in different radiations. The output is reduced because solar radiation is blocked by dust particles.

J Antonanzas (5) stated various methods of forecasting solar power. The first method is obtaining accurate irradiance forecasts. The second method is predicting output using machine learning and statistical method and a hybrid model using first and second methods.

Brabec (6) reviews the advantages and performance of the statistical method since the output can arrive without previous data. Thus temporary and pixel resolutions cause errors.

Lorenz (7) found a new way to remove errors by the model yield statistics. This method is helpful for weather forecasting and improving resolution by inserting values.

Almeida (8) has scheduled the training sets for empirical distribution based on the same clearness index for each day with 30days' data collected.

B. M. A Mohandes (9) discussed about PV modules exposing to different climate conditions and more chance of gathering dust particles, industrial residue, bird droppings on the solar panel. Some cleaning products with chemical and other forms will attract unwanted dirt particles and prevents PV cells of a panel to enter solar irradiance.

M J Adinoyi (10) stated that various factors like PV module direction, coating, rough surface, slope influence dust gathering. It depends upon the size, weight, shape, and chemical properties of dust.

3. Effects Of Dust

A.A. Hachicha (21) audits the impact of residue on the force yield proficiency of sunlight-based PV framework under UAE environment conditions. The dust particles were little in size in which a large number of the particles were underneath 25mm greatly affecting the proficiency just as the electrical attributes of the photovoltaic framework. During high residue thickness, ISC steadily diminished. The testimony of the residue relies upon the direction and slant point of the photovoltaic board. Expulsion of residue is elevated because of the impact of gravity for example with expansion in the slanted point of the PV surface, dust statement increments. Precipitation is arbitrary in UAE yet it can help increment the photovoltaic proficiency and decrease the thickness of the amassed dust. The activity and support of PV modules can't rely upon rare precipitation and ought to be planned oftentimes relying upon the gathered residue thickness.

4. Dust Cleaning Agents

There are several processes for cleaning solar panels such as natural cleaning, automatic cleaning, and manual cleaning. In the process of natural cleaning by rain, wind, melting snow When it is raining, the dust particles lying on the panel are washed out by rainwater. During the wind, dust particles will be blown off the solar panel. On to the next in the process of automatic cleaning, there are many types like microcontroller-based sweeper which is used to control the brush or sweeper. Another type is automatic water spray is used to spray the water on the panel to clean the surface which can be controlled by a set of timer-based boards. At last, in automatic cleaning there are cleaning robots which will be placed on the panel which is used to detect the dust and clean the panel hence it costs high. In the manual cleaning process, it depends upon the person to clean the panel. The person may use a soft water cloth or water jet sweeper to clean the panel.

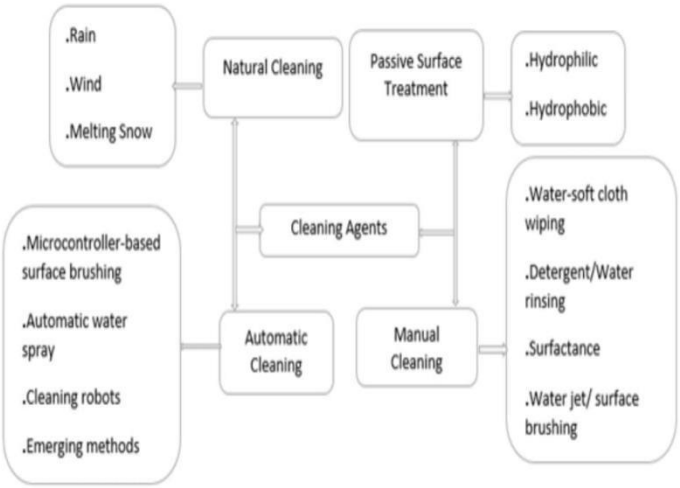

Fig.1

Hence we consider the overall methods to increase the efficiency. Here we explore the exclusive method for cleaning panels using a single line wiper with the help of a motor.

5. Components

A. Hardware Components

S.NO	COMPONENTS	SPECIFICATIONS
1	SOLAR PANEL Fig. 2	• Pmax 5W • Vmp 19.00V • Voc 22.76V • Isc 0.39A
2	RASPBERRY PI Fig. 3	• 1GB RAM • HDMI PORT (Full Size) • Micro SD card port (16 GB) • Camera port for connecting in Raspberry Pi camera
3	CAMERA Fig. 4	• 2MP
4	POWER SUPPLY CABLE Fig. 5	• 230V
5	MOTOR WITH WIPER Fig. 6	• Step Motor • 6.0V
6	ANALOG TO DIGITAL CONVERTER (ADC) Fig. 7	• **MCB 3008**
7	BATTERY Fig. 8	• 6V
8	ULN2003 STEPPER MOTOR DRIVER Fig. 9	• A-B-C-D LED is used to indicate the 4- Phase working condition.
9	CURRENT SENSOR Fig. 10	• 5V
10	VOLTAGE SENSOR Fig. 10	• 0-25V
11	ARDUINO NANO Fig. 11	• Operating Voltage : 5 V • Input Voltage : 7-12 V

B.Software Requirements

- RASPBERRY PI OS
- PYTHON 3
- WEB SERVER

Solar Panel **Fig. 2**

Raspberry Pi **Fig. 3**

Camera **Fig. 4**

Power Supply Cables **Fig. 5**

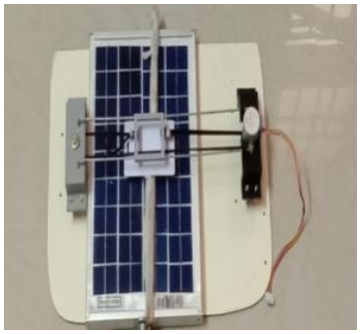

Fig. 6 Motor with wiper

ADC Fig. 7

Fig. 8 Battery

Fig. 9 ULN2003 Stepper motor

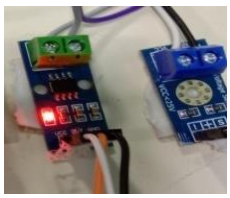

Fig. 10 Voltage & Current Sensor

Fig. 11 Arduino Nano

6. Existing System

In the existing system Arduino board, relay, DC motor with a motor drive is used to clean the solar panel. The panel is connected to the Arduino board. A relay and L293D are connected to Arduino. L293D motor module can drive the motor in both directions by varying the voltage. The power supply is given to the circuit. the motor driver drives the motor and a motor starts rotating to forward and backward directions. The microcontroller is programmed as per desired time interval. Data is seen on the LCD screen. Also in the existing system, we cannot monitor the status of the panel when it is required. So, to overcome such difficulties, we are proposing a new method where we can monitor the panel lively with a camera and can also see the required data on a webpage.

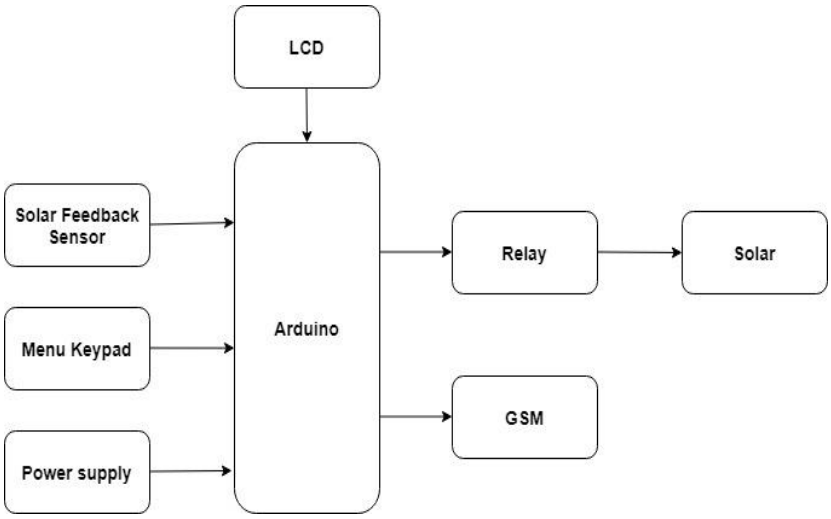

Fig. 12

7. Proposed System

In Proposed System, Image processing is used to detect the dust present in the Panel. Camera is installed on the Solar Panel to capture the image . If there is any dust found in the Panel, the Motor starts cleaning automatically. The condition of the Solar Panel such as Cracks, Moisture, Obstacles if any, can be seen in monitor in live. Also the Current and Voltage ratings can be monitored through Webpage remotely.

8. Block Diagram

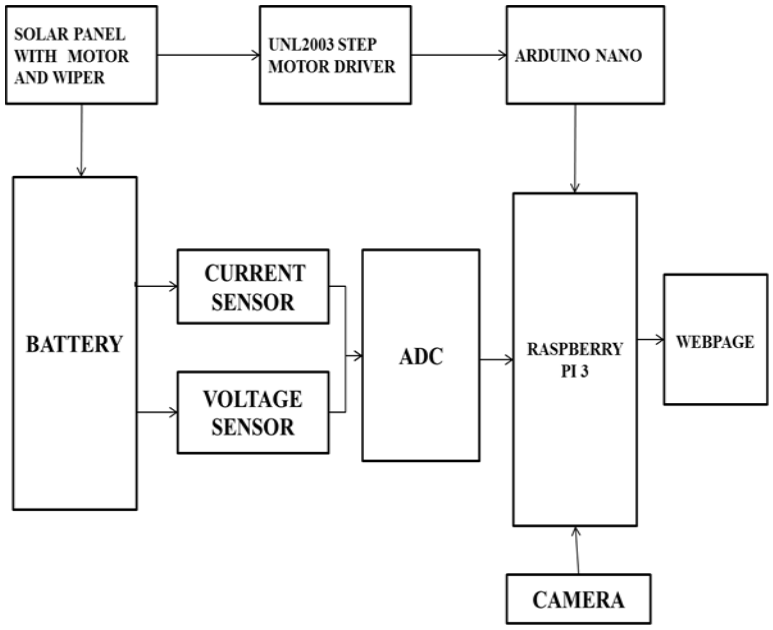

Fig. 13

9 Working

In this Project, the Image Processing Technology is used to detect the dust on the Solar Panel using Raspberry Pi. A Raspberry Pi 3 Model B+ is used in which a Camera is attached. The Camera captures the image (condition) of the Solar Panel and indicates 'Normal' or 'Abnormal'. If there is no dust present on the Solar Panel, it indicates as 'Normal', whereas if there is dust present on the Solar Panel, it indicates and 'Abnormal'. This process is done with the help of Arduino Nano which has a program and connected to Raspberry Pi. If the dust is identified, the ULN2003 Step Motor Drive triggers the motor to clean the Solar Panel with the help of a Wiper. A Battery is connected to the Solar Panel along with the current sensor and the voltage sensor. The Current sensor senses the current rating while the Voltage sensor senses the voltage rating. The output will be of an Analog form, so an ADC is used to display the output digitally and it is connected to Raspberry Pi. The output can be monitored through a webpage.

10 Flowchart

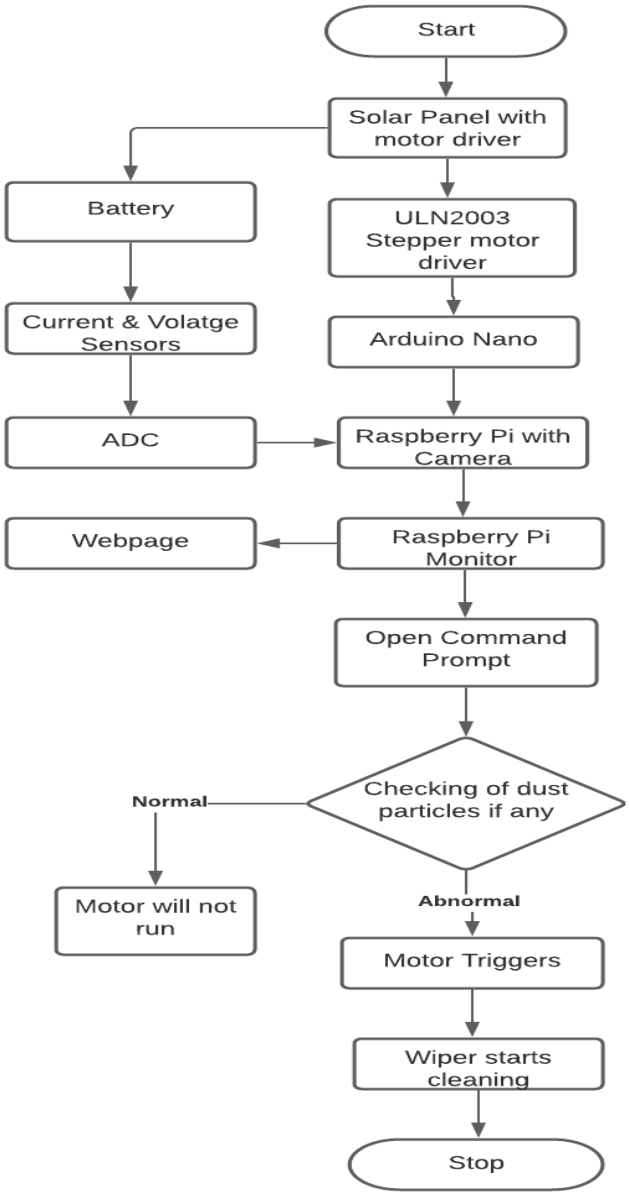

Fig. 14

11 Algorithm

STEP 1: Start the system with the help of a Power supply.

STEP 2: Solar Panel will obtain energy from the sun and that energy is stored in the battery.

STEP 3: The Voltage Sensor senses the voltage rating and Current Sensor senses the current rating and connected to the battery.

STEP 4: Output of the sensors will be of an analog form and it is converted to digital form with the help of ADC.

STEP 5: To display the digital data, ADC is connected to Raspberry Pi.

STEP 6: Motor is mounted to the panel and it is connected motor driver (ULN2003) which works with the help of Arduino Nano.

STEP 7: Python program is fed to the raspberry pi which will operate the motor using Arduino Nano.

STEP 8: Switch on the Monitor.

STEP 9: Open the Command Prompt.

STEP 10: Enter the following commands as given below

Cd rpi-vision/ (Press Enter)

source.venv/bin/activate (Press Enter)

Python3 solar.py (Press Enter)

The above code should be given to the Raspberry Pi Command Prompt to activate the Code.

STEP 11: Using a Camera, the dust particles are checked.

11.1: If Yes (Abnormal), Motor triggers and the wiper starts cleaning.

11.2: If No (Normal), Motor will not run.

STEP 12: Webpage can be used to check the ratings of Current and Voltage. (Fig. 17 & 18).

STEP 13: Motor stops running.

12 Conclusion

In this paper, a camera is utilized to catch a picture of the Solar Panel and reads the amount of the dust. If the amount of the dust exceeds certain limit, it triggers the motor which cleans the Solar Panel with the help of a wiper. Additionally, the parameters like battery capacity, voltage and current via sensors (Figure 8) can be monitored through Webpage from anywhere and at anytime. So through this paper, we can analyze condition of the solar panel effectively. The proposal of the project has been applied and we have taken some images in environment and result have been shown through images.

13. Result

Here, we have shown the output of the Solar Panel where the webpage shows the Voltage and Current rating. The Condition of Solar Panel will also be mentioned as 'Normal' or 'Abnormal'. When there is no dust on the Solar Panel, the camera senses and will mention as 'Normal' in the webpage, whereas when the dust is present on the Solar Panel, the camera captures and mentions it as 'Abnormal' and it triggers the motor to clean the panel.

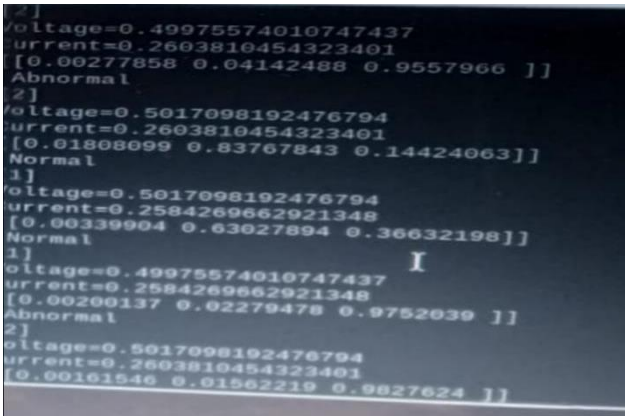

Fig. 15

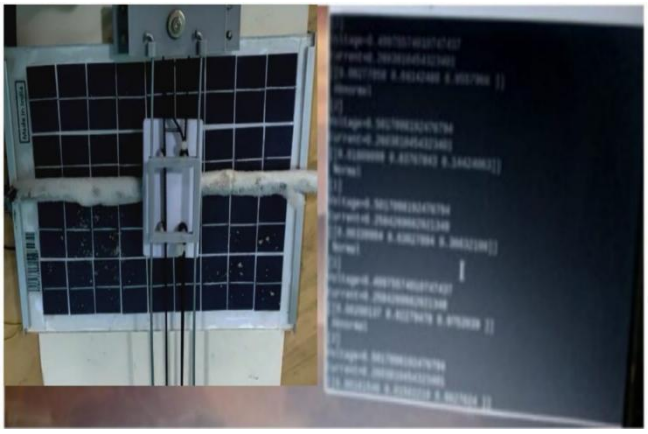

Fig. 16

Fig. 15 shows the output of the Solar Panel where it shows the status as 'Normal or 'Abnormal' along with the Voltage and Current rating.

Fig. 16 shows that the camera capturing the image of the Solar Panel along with the output.

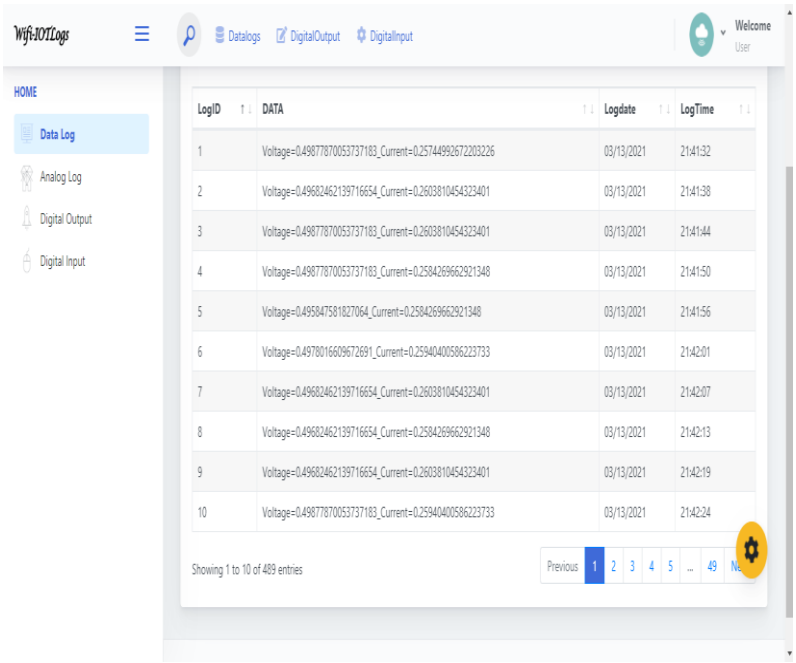

Fig. 17

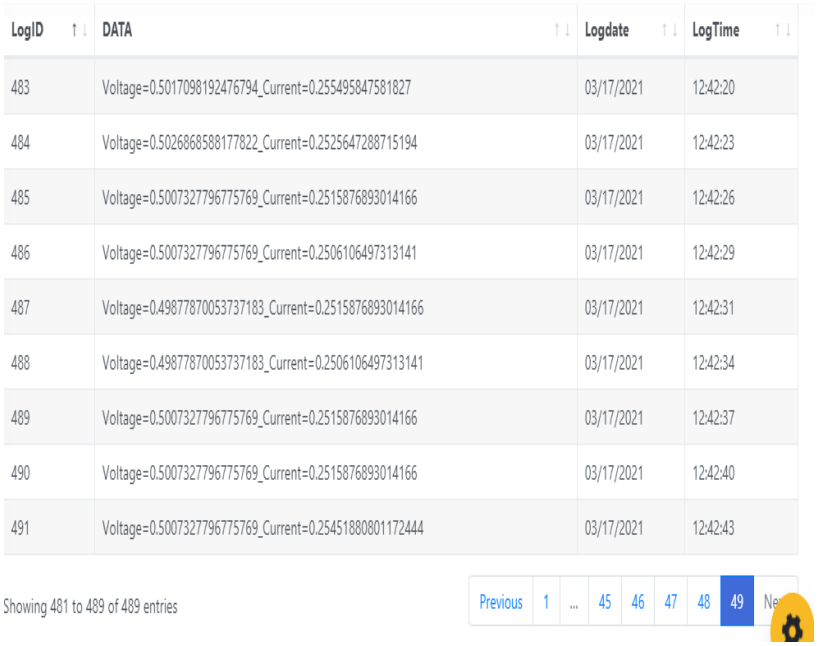

Fig. 18

Fig. 17 and Fig. 18 shows the Current and Voltage rating of the Solar Panel with the date and time mentioned in the Webpage

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