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Engineering

A FULLY PORTABLE AUTONOMOUS ROBOT FOR PV PANELS : CLEANING AND CRACK DETECTION

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ABSTRACT Growing demand in renewable energy has led the photo voltaic industry to expand notably in the last decade. However a big issue is that keeping the panels clean. The capability of generating electricity is limited due to the dust and dirt particles on solar panel arrays. Conventional methods of cleaning demands high labor work and large amount of water which indirectly increases the overall operating cost. This paper aims to design a portable automated cleaner that features a versatile platform which travels the entire length of a panel using an automated carrier cart. It is provided with a system to detect the cracks on panels. The mechanism mainly consists of ducted fan, roller brush, blower fan and water sprinkler to offer slippage free motion and cleaning on a glassy surface. The proposed system will be a promising alternative when applied to small plants. The system is both agile, flexible and cost effective.

KEYWORDS : Robotic cleaner, carrier cart, photovoltaic industry, solar panels

INTRODUCTION

Today's world is widely using solar energy for electricity generation and it is also a fast developing industry in India . The installed capacity of solar in the country has reached 25.21 GW on 31 December 2018.The government had a target of 20 GW capacity for 2022, but it is already achieved. India expanded its solar-production capacity 8 times from 2,650 MW on 26 May 2014 to over 20 GW on 31 January 2018.

Rooftop solar power accounts for 3.4 GW, of which 70% is industrial or commercial. In addition to its large-scale grid-connected photo voltaic (PV) initiative, India is developing off-grid solar energy for local energy needs. Solar products generally meet rural needs; by the end of 2015 just under one million solar lanterns were sold in the country, reducing the need for kerosene. That year, 118,700 solar home lighting systems were installed and 46,655 solar street lighting installations were provided under a national program ;just over 1.4 million solar cookers were distributed in India. In January 2019, Indian Railways announced the plan to install 4 GW capacity along its tracks.

Solar panels typically consist of photo voltaic (PV) cells covered with a protective glass coating[1]. Subject to sufficient amount of solar radiations falling over them, they absorb the energy from the radiations and subsequently convert this energy into electricity[1]. Solar cells form 'green energy' resources since they reduce carbon dioxide emissions and hence protect the surrounding environment.[1]Solar energy completely depends on the light and radiations coming from the sun. If the light and radiations are greater, then energy produced by PV modules is also greater [2]. So developing a solar power plant requires large area so as to give maximum exposure to the light and radiations. Weather also plays a critical role to generate energy from solar cells [3].

There are many factors that affects a PV power efficiency ,such as birds excreta , dust and dirt. The main factor that affects the panels efficiency is dust, which can reduce its efficiency by upto 25 to 30% depending on the environment. Though the bird dropping and dirt is not making a big issue , it can be seen that the efficiency of solar panel decreases by 15 to 20%. So cleaning the solar panel in frequent period is necessary for getting same output for longer time. Cleaning the solar panels is normally done by manual washing which is tedious and also expensive in terms of the labor involved and time.

In this paper, the problem is reviewed and methods for dust removal are discussed. A portable robotic cleaning device is developed and features a versatile platform which travels the entire length of a panel[4]. Robot system is controlled by Raspberry pi and the cart is controlled by Arduino micro controller.

PROPOSED SYSTEM

The proposed system have the ability to clean multiple panels in solar plants using a single robot instead of having multiple robots in the same farm working simultaneously. It can also detect the cracks in panels. The system consists of two main parts; the first is the cleaning robot and the second is an automated carrier cart (see figure 1) to facilitate the robot transfer from one panel to another. The carrier part is a cart that moves on a rail platform. The cart transfers the robot from one panel to the next. The operation sequence of the system is shown in Figure 1. That is, the carrier cart aligns itself with the solar panel at which point the robot leaves the cart to clean and detecting crack in the panel through forward and backward sweeps (Figure 1-1) and returns to the cart which transports the robot to the next panel (Figure 1-2). Then, the robot performs the cleaning sweeps as before (Figure 1-3).

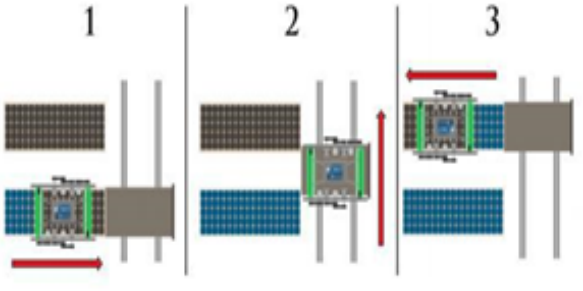


Figure 1: The proposed system operation sequence

The cleaning robot, as shown in figure 2, travels the entire length of a solar panel while cleaning and crack detecting in the panel.

The robot mainly consists of: two brushes on the extreme ends, four wheels, six motors, sensors and controller subsystem.

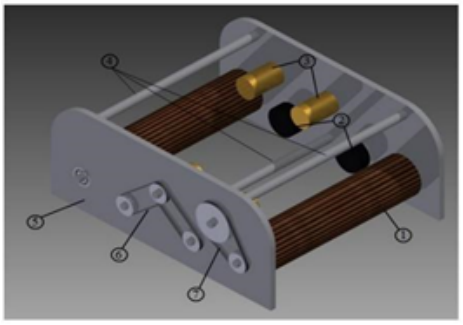


Figure2:Thecleaningrobotsystem(1.brush, 2.wheels, 3. motors, 4. connecting rods, 5.side panels, 6. wheel driving system, 7. brush driving system)

Two motors are installed on each side of the robot frame. Two motors are used to drive a pair of two wheels and the other motors is used to drive the brushes, pump and fans. The robot is symmetrical so the weight distribution is uniform and this increases the stability of the robot on top of a tilted solar panel. The design of the robot side panels insures the robot guided movement along the panels while cleaning and crack detection.

ARCHITECTURE OF THE PROPOSED SYSTEM

The proposed system consists of several modules that implement various operations like locomotion, sensing, data processing and cleaning. Figure.3 shows the block diagram of the robotic cleaner.

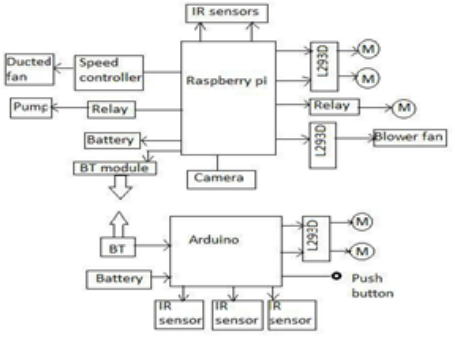


Figure 3: Basic block diagram of the robotic system.

CIRCUIT DIAGRAM

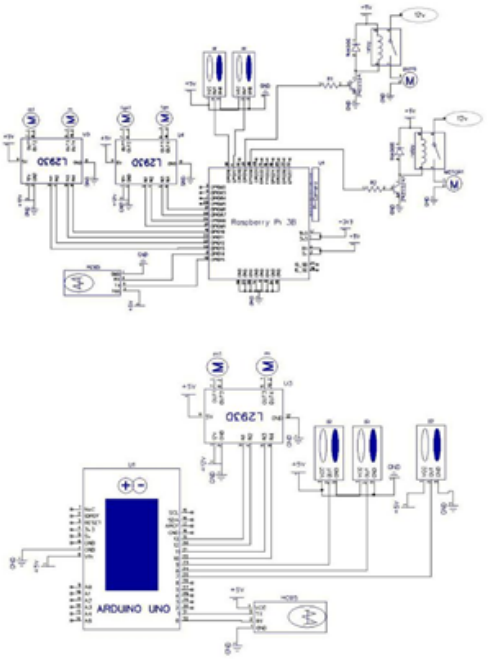


Figure 3.a: Circuit diagram of robotic system

COMPONENTS DESCRIPTION:

A. Microcontroller

The main part of the proposed system is microcontroller. There are two sections in the proposed system; vehicle and cart. Vehicle section is controlled by Raspberry pi (version 0).It implements the functions like crack detection and control of the motor drivers. The cart section is controlled by Arduino UNO ,which controls it's starting and stopping .



Figure 3.1: Raspberry Pi Zero

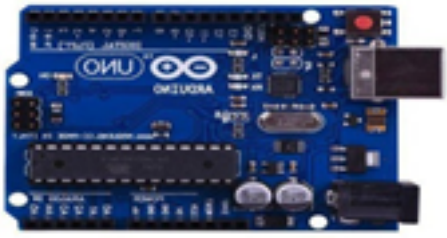


Figure 3.2:Arduino UNO

B. Ducted Fan

Locomotion constraints arising from slippage due to traversal on smooth surface and inclination of PV modules are handled by use of ducted fan and runner wheels. Ducted fan creates adhesion, which lets the robotic cleaner stuck to PV module thus mitigating the effect of slippage. Ducted fan moves in counterclockwise direction and creates a negative air pressure. This pressure compresses the air so as to flow it out at a high speed ultimately resulting into thrust and thus creating adhesion towards PV module.

C. Roller Brush and Blower Fan

Roller brush performs the key operation in the robotic cleaner. With the passage of time, dust starts to stick on PV modules ultimately resulting into formation of a thick layer of dust on the modules. Roller brush in the proposed system scratches dust from PV modules and allows blower fan to remove this dust by providing a strong thrust of blowing air. The strong thrust of blowing air takes away the dust and other particles from PV

D. Wheels and Motors

Eight motors are used in the cart and vehicle. One motor for each pair of front and back wheels in vehicle and cart section. The other motors are used in cleaning brushes and other controller systems.

E. Motor Driver

An L293D driver is used to drive six motors, that controls the wheels and fans of the vehicle and cart. The control signals are provided by Raspberry pi and Arduino UNO. L293D contains two in build H bridge driver circuits.

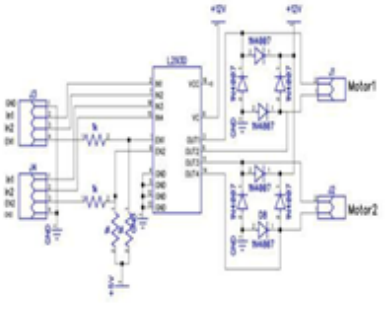


Figure3.3: L293D driver interfacing with controller

F. Relay

A Relay driver IC is used in the proposed system to drive a brush motor and a pump in the vehicle section.

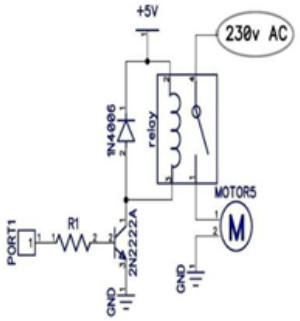


Figure 3.4:Internal Circuit Of Relay

G. Bluetooth Module

Two Bluetooth modules are there for maintaining the wireless operation of the system. HC-06 Bluetooth module is used for the smooth movement of vehicle on cart.



Figure 3.5:Bluetooth module

H. Sensors

The IR Sensor-Single is a general purpose proximity sensor. Here we use it for edge detection. The module consist of a IR emitter and IR receiver pair. Also IR sensors are used for sensing operation in the system. There are five IR sensors. The function of IR sensor to provide the system with the feedback about the PV panel boundaries. This makes the system to stop before reaching the edge of the panel.

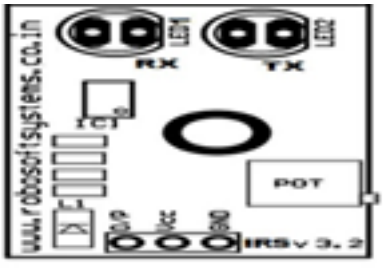


Figure 3.6 :IR MODULE

I. Power Supply

Two batteries of 12V, 1.2AH and12V 4.2AH are used in the system to provide the essential power.

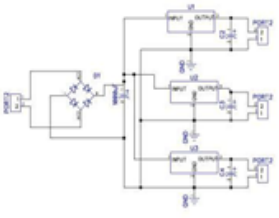


Figure 3.7: Power Supply

SOFTWARE ARCHITECTURE

Robotic cleaner vehicle is controlled by Raspberry pi micro controller. Initially, it receives the signal from the wireless module. This signal is then feed to one of the two processes depending upon the type of the signal received. The first process controls brush movements of the robot. It takes decision based on the received signal and resultantly moves the robot in the commanded direction. The second process is giving command to the camera to detect the cracks in the panel.

Figure 4 illustrates complete description of software architecture for the robotic cleaner in a systematic manner.

Carrier cart is controlled by arduino micro controller. Based on the signals from the IR sensors, movement of carrier cart is controlled.

Figure 5 illustrates software architecture for the carrier cart operation

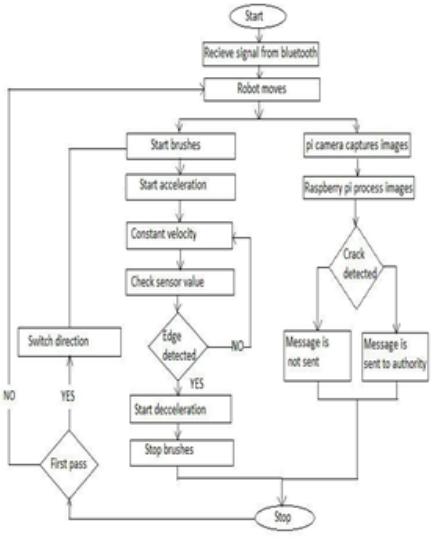


Figure 4 : Robot operation flowchart.

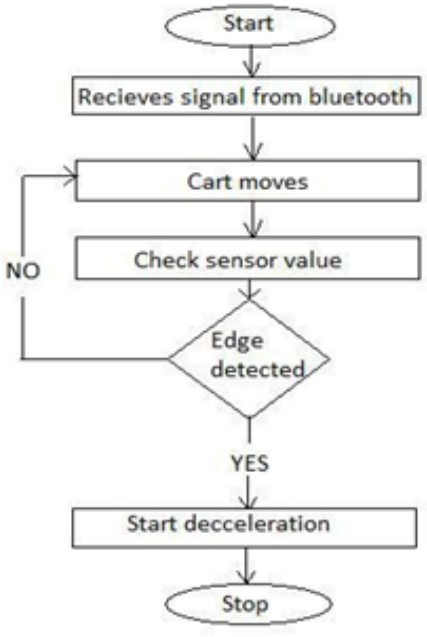


Figure 5 : Carrier cart operation flow chart.

CONCLUSION

A Robotic system is developed which automatically cleans and detects the cracks on PV panels . The environmental factors like dust and dirt accumulation can reduce the solar panel efficiency. The robot system proposed in this paper is a best solution for these problems. It ultimately reduces total time required for cleaning panels and also efficiently reduces the man power required for the cleaning process. On cleaned surface sunrays impartation increases and hence the efficiency of panels increases by 10-20%.

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