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Automatic Solar Panel Cleaning Robot

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Abstract—

The dust particles accumulating on the solar panels will decrease the solar energy reaching the solar cells, thereby reducing the overall power output. In this paper, the problem is reviewed and methods for dust removal and reduction of heat are discussed. A robot cleaning device is developed and features a versatile platform which travels the entire length of a panel. An Arduino microcontroller is used to implement robots control system. The robot will provide a favorable result and shows that such a system is viable. In conclusion, it is found that robotic cleaning and heat reduction is practical and can help in maintain the solar panel efficiency.

Keywords— Solar panel, Arduino, motor

I. INTRODUCTION

With about 300 clear, sunny days in a year, the theoretically calculated solar energy incidence on India's land area is about 5000 trillion kilowatt-hours(kWh) per year. The solar energy available in a year exceeds the possible energy output of all fossil fuel energy reserves in India. The daily average solar power plant generation capacity over India is 0.20 kWh per m^2 of used land area, which is equivalent to about 1400-1800 peak (rated) capacity operating hours in a year with the available commercially-proven technologies. The accumulation of dust on the surface of the photovoltaic modules decreases the incoming irradiance to the cell and produces power losses[1]. Previous studies[2] show that in dry areas, these losses could reach 15%.

In these cases the only solution is to clean the mod In large-scale photovoltaic plants this task is often expensive, especially in those areas with water storage. To make the solar panel much effective, the solar panel should always receive the maximum intensity of light. For that the panel should always face perpendicular to the sun and there should not be any dust particles on the panel and there should not be any dust particles on the panel. But in some heavy pollution areas the dust particles are directly deposited on the solar panel, so that most of the light coming from the sun is reflected rather than refracting because of the dust deposited on the panel by making the front portion of the panel shaded, the dust deposited panel can be shown in Figure.1.

The efficiencies of the panels descend because of the dust depositing even though the panel is tracking the sun. This paper explains the efficient self-cleaning and obtain the results of the panel for the condition of the panel.

II. LITERATURE SURVEY

Solar industry has shown an accelerated growth over the last decades, however solar panel cleaning and contingency planning has attracted very least amount of centre of attentions. Arrays with less number of panels are cleaned with the help of mop and soap water solution which has less speed. A solar farm (Charanka solar park) in Gujarat, India spread across 2000 hectare site for example uses over 220litres of water to clean a 10 square meter array. Present technologies include hand cleaning device for maintenance of solar panels is the tucker pole which has brittle hand nylon brush attached with pole and in some cases provided with water spray system and allows two people to clean a array of 48 solar cells of 4 x 4 size in less than 3 hours.

The problem occurs when the smut inclusive of bird droppings has settled on the surface of the panel and is at a particular height which is difficult for mop to rub it off and there's no one over there to have a better clarity of cleaning. And hired labour is not aware of the amount of water they should direct without harming the solar panel as well as without wastage. For the past ten years the industries main focus has been on reducing the physical barriers by the inventing an automated system which will timely and efficiently clean the solar panel with minimal manual intervention as well as light weighted and sophisticated. The testing environments have made it possible to improve the capacity factor from 35% to 45%. A major portion of this improvement goes to increasing the size of the mop, improvement in the rotor mechanics and also the material of the mop which affects the dynamics associated with the operation of these cleaning systems.

NASA has researched the decreased efficiency due to dust and buildup in relation to number of days on Mars[6]. For a 30 day mission they suffered more than 52.2% power loss, and accounted for 89% power loss over the next two years. However, due to some fateMars rover went through an unexpected wind (Martian Wind) which cleared all the dust settled on the panels partially helping NASA to in their accelerating their electrical output. Glass cleaning methods are also quite prevalent since cleaning of a glass panel is somewhat equivalent to cleaning of solar panel array. A large number of such glass panes cleaning robots exist, the most famous being the Robuglass robot designed to clean the Louvre glass pyramid in Paris, France.

III. METHODS

A number of methods for dust removal from solar panels are developed and tested.

A. PROTOTYPE

The prototype for the automated solar panel cleaning robot, the model of the robot is shown in the Fig 2.

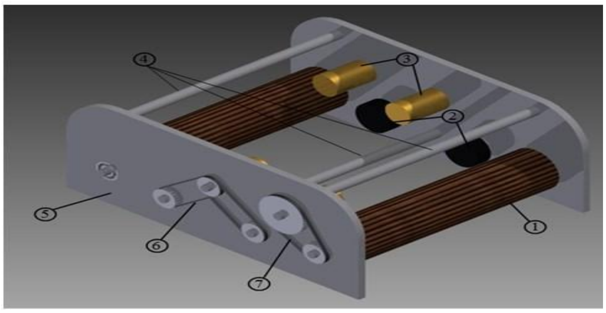


Figure1: The cleaning robot system (1. brush, 2. wheels, 3.motors, 4. connecting rods, 5.side panels, 6.wheel driving system, 7. brush driving system)

1. BRUSHES

Rotary and coil brushes are mounted on automated cleaning equipment. Regardless of brush size or speed, brush balance is implemented to ensure complete surface contact.

2. WHEELS

Wheels here are required for the movement of the motor over the complete panel. Through this wheels the robot will be able to move all throughout the panel.

3. MOTORS

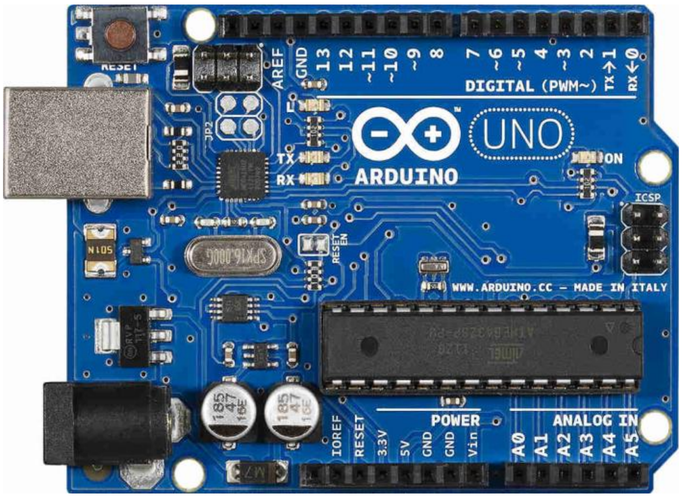
Motors are used for the rotational purpose of the robot. The other types of motor is been used to rotate the cleaning brushes which helps in the cleaning purpose.

4. SIDE PANELS

Side panels of the robot is to fit the components towards it. Due to this side panels the robot will be robust from the environmental effects.

B. ARDUINO UNO

Arduino Uno is a microcontroller board based on theATmega328P. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack,etc., It contains everything needed to support the microcontroller. The role of the Arduino here is that it is been made to control the robot and working of the robot by simple programming.

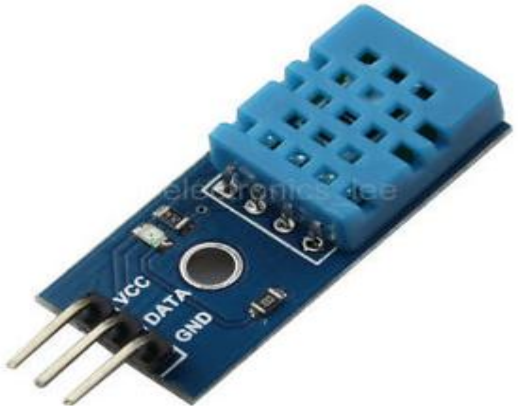


C. LIGHT DEPENDENT RESISTOR

A Light Dependent Resistor is a resistor that changes in value according to the light falling on it. LDR is very high resistance, sometimes as high as 10MΩ when they are illuminated with light resistance drops dramatically. It has a high resistance in the dark and a low resistance in the light. Here LDR is been used to detect the light from the sun. If there is any interruption then the cleaning process will be started.

D.TEMPERATURE SENSOR

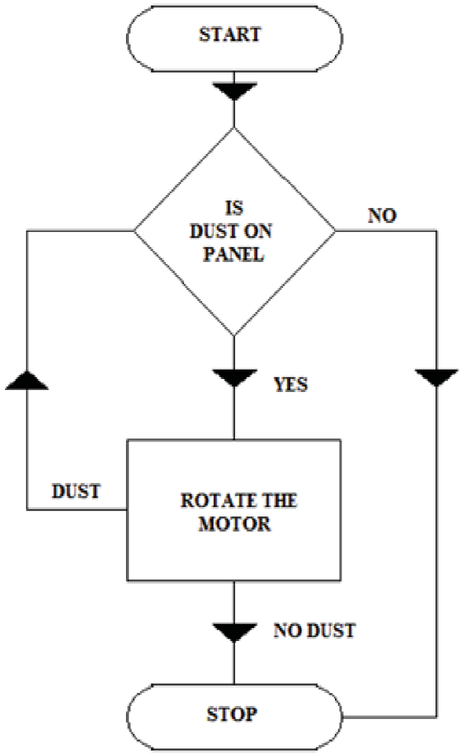
The DHT11 is a basic, ultra low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). Its fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is you can only get new data from it once every 2 seconds.



IV. IMPLEMENTED ALGORITHM

The algorithm for implementation of cleaning arrangement and robot mechanism has been explained by the following flow charts.

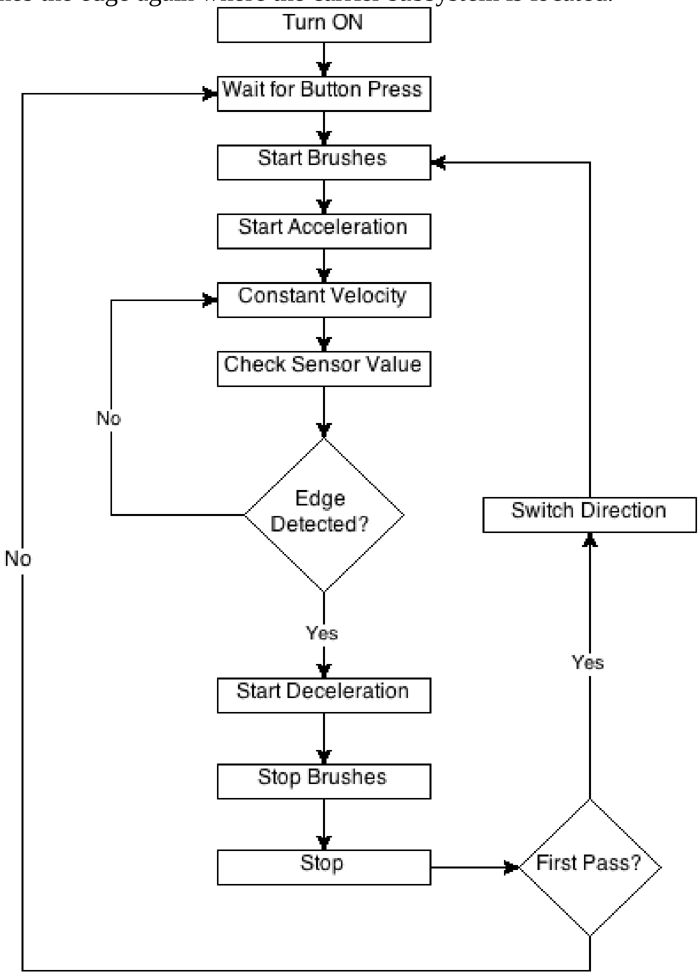
At first using the LDR the light intensity through the panel will be monitored. If there is any deviation of intensity on the panel the motor tends to rotate to clean the dust accumulated on panel.



After the dust is cleared the rotation of the motor will be stopped. Hence the cleaning operation will be completed.

The next algorithm is the robot mechanism, Initially, the robot stationed at the panel end waits the user start command. Once the command is received, the brushes start working and then the robot starts moving in one direction while cleaning the panel.

During the operation, the robot keeps moving at constant speed until the sensors signal reaching the panel edge at which point the robot slows down and stops. If this is the robots first pass on the panel, it will switch direction and move backward until it reaches the edge again where the carrier subsystem is located.



V. RECOMMENDATIONS FOR FUTURE WORK

Although the test results show the robot PV panel cleaning, it is believed that there are a few ways in which the design can be improved to achieve its autonomous state. It is proposed that future work should concentrate on replacing the automated cart system by a flying mechanism such as quadrotor. A quadrotor can be mounted onto the robot cleaning subsystem so that it can fly from one solar panel to another. This system can then be controlled remotely or fully programmed for outdoor environment, as illustrated in figure 14. The rotors may be arranged such that their downwash will enhance the system cleaning operations.

VI. CONCLUSION

Dust accumulation on PV panels can significantly reduce their power output. The robotic system proposed in this paper is a simple way to tackle this challenge effectively. Although promising results were obtained from the prototype, further improvements and testing are required in order to create a more robust and autonomous cleaning solution.

REFERENCES

[1] Dunlop, J. P., "Batteries and Charge Control in Stand-alone Photovoltaic Systems. Fundamentals and Application", *Working Paper*, Sandia National Laboratories, Photovoltaic Systems Applications Dept., Florida Solar Energy Center, Cocoa/Florida -. USA, 1997

[2] Ross, J., Markvart, T., and He, W.: „Modelling Battery Charge Regulation for a Stand-alone Photovoltaic System", Sol. Energy, 2000, 69, (3), pp. 181 190

[3] M. H. Rashid, Power Electronics Handbook, Academic Press, 2001.

[4] Frede Blaabjerg, Florin Iov, Remus Teodorescue, Zhe Chen, „"Power Electronics in Renewable Energy Systems""", Aalborg University, Institute of Energy, IEEE transaction, 2006.

[5] Harprit Sandhu, "Making PIC Microcontroller Instruments and Controllers ",2008.

[6] John Peatman ,"Embedded Design with the PIC18F452 Microcontroller" ,Prentice Hall, 2003.

[7] http://www.seia.org/policy/solar- technology/photovoltaic-solar-electric

[8] A. Ibrahim, A., Effect of Shadow and Dust on the Performance of Silicon Solar Cell, *J. Basic. Appl. Sci. Res.*, 1 (3), 222-230, 2011.

[9] O. Seely, Some Observations on Photovoltaic Cell Panels, http://www.csudh.edu/oliver/smt310-handouts/solarpan/ solarpan.htm, 2011

[10] S.A.M. Said, Effects of Dust Accumulation on Performances of Thermal and Photovoltaic Flat-Plate Collectors, *Applied Energy*, 37, 73-84, 1990.

[11] M.S. El-Shobokshy and F.M. Hussein, Effect of dust with different physical properties on the performance of photovoltaic cells, *Solar Energy*, 51, 505, 1993.

[12] H. Haeberlin and J.D. Graf, Gradual reduction of PV generator yield due to pollution. In: Second World Conference on Photovoltaic Solar Energy Conversion, Vienna, Austria, 1998.

[13] H. Jiang, L. Lu, and K. Sun, Experimental investigation of the impact of airborne dust deposition on the performance of solar photovoltaic (PV) modules, *Atmospheric Environment*, 45, 4299-4304, 2011.

[14] S.A. Sulaiman, H.H. Hussain, N.S.H. Leh, and M.S.I. Razali, Effects of Dust on the Performance of PV Panels, World Academy of Science, Engineering and Technology, 58, 588-593, 2011.

[15] M. Mani, and R. Pillai, Impact of dust on solar photovoltaic (PV) performance: Research status, challenges and recommendations, *Renewable and Sustainable Energy Reviews*, 14, 3124–3131, 2010.

[16] H.K. Elminir, A.E. Ghitas, R.H. Hamid, F. El-Hussainy, M.M. Beheary, and K.M. Abdel-Moneim, Effect of dust on the transparent cover of solar collectors, *Energy Conversion and Management*, 47, 3192–3203, 2006.

[17] J.K. Kaldellis, A. Kokala, Quantifying the decrease of the photovoltaic panels' energy yield due to phenomena of natural air pollution disposal, *Energy*, 35, 4862-4869, 2010.

[18] A.M. Pavan, A. Mellit and D. De Pieri, The effect of soiling on energy production for large-scale photovoltaic plants, *Solar Energy*, 85, 128–1136, 2011.

[19] M. Vivar, R. Herrero, I. Anton, F. Martınez-Moreno, R. Moreton, G. Sala, A.W. Blakers and J. Smeltink, Effect of soiling in CPV systems, Solar Energy, 84, 1327–1335, 2010.

[20] G. He, C. Zhou and Z. Li, Z. Review of Self-Cleaning Method for Solar Cell Array, in International Workshop on Automobile, Power and Energy Engineering, *Procedia Engineering*, 16, 640 – 645, 2011.

[21] M. Anderson, A. Grandy, J. Hastie, A. Sweezey, R. Ranky, C. Mavroidis, and Y.P. Markopoulos, Robotic device for cleaning photovoltaic panel arrays, http://www.coe.neu.edu/Research/robots/papers/CLAWAR09.pdf, 2011

[22] J. Son, S. Kundu, L.K. Verma, M. Sakhuja, A.J. Danner, S. Charanjit, C.S. Bhatia, and H. Yang, A practical superhydrophilic self-cleaning and antireflective surface for outdoor photovoltaic applications, *Solar Energy Materials & Solar Cells*, 98, 46–51, 2012.

[23] K. Lee, S. Lyu, S. Lee, Y.S. Kim and W. Hwang, Characteristics and self-cleaning effect of the transparent super-hydrophobic film having nanofibers array structures, *Applied Surface Science*, 256, 6729–6735, 2010.

[24] J.P. Bock, J.R. Robison, R. Sharma, J. Zhang and M.K. Mazumder, An Efficient Power Management Approach for Self-Cleaning Solar Panels with Integrated Electrodynamic Screens, *Proc. ESA Annual Meeting on Electrostatics 2008*, Paper O2.

[25] C.I. Calle, C.R. Buhler, J.L. McFall and S.J. Snyder, "Particle removal by electrostatic and dielectrophoretic forces for dust control during lunar exploration missions, " *Journal of Electrostatics*, 67, 89–92, 2009.

[26] C.I. Calle, C.R. Buhler, M.R. Johansen, M.D. Hogue and S.J. Snyder, " Active dust control and mitigation technology for lunar and Martian exploration, " *Acta Astronautica*, 69, 1082–1088, 2011.

[27] R.A. Sims, A.S. Biris, J.D. Wilson, C.U. Yurteri1, M.K. Mazumder, C.I. Calle and C.R. Buhler, Development of a Transparent Self-Cleaning Dust Shield for Solar Panels, Report, Department of Applied Science, University of Arkansas at Little Rock, USA.

