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Enhancing Oman Renewable Energy Sources Using Smart Robot For PV Panel Cleaning

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Abstract

Globally it can be understood a fast change in technology and everything modified quite faster with billions of inventions and especially in the field of Electrical & Electronics. In this paper we focus on fast changing renewable energy sources through automation. A new technique is proposed based on signaling pathway unmanned vehicles (UV) to clean the PV panels (solar) when a dust is formed. The proposed paper details about the different operating modes of the robot used for cleaning. The two different operating modes are manual mode and auto mode. In the manual mode the entire PV panel will be cleansed by the robot through the defined path. The auto mode is the calculative mode where the amount of dust is calculated. To read the dust value the robot is encompassed with dust sensors which detect the amount of dust and provide the input to the system. If the dust sensor value is higher than the threshold value set then the robot will move to that exact location by following the shortest path and clean the PV panel. The robot is moved to the dust formed location through shortest path which is identified by the aid of Dijkstra's shortest path algorithm. During the mid-day while the intensity of sunlight is high the robot moves automatically on the panels and sprinkle water on the panels to avoid the voltage drop. Also the voltage output of the panel is calculated and compared. When there is a dip in voltage and the sunlight intensity is normal then the robot starts cleaning the panel.

Keywords: *unmanned vehicles, PV panel, shortest path, Dijkstra's algorithm*

1. Introduction

Globally it is pronounced the earth's natural resources are damaged due to the economic growth and technology development which leads to global warming. It is also noticeable that renewable energy provides significant welfares for the environment, human health and the economy. The major advantage focused by Nathan et al., and Carasco et al., is applying renewable energy is that it is renewable and sustainable and can be reused [1],[2]. As Martin et al., quotes that renewable energy infrastructure need minimal maintenance than the usual generators as their fuel is absorbed from the natural resources which in turn reduces the operation cost [3]. The significant advantage of using the renewable energy resources is that the waste products produced by the renewable energy sources such as carbon dioxide and other chemical pollutants are less. It leads to the less impact on the environment.

Most of the literatures identifies that the solar energy has a vital role in the field of renewable energy. Based on the studies the solar energy is been widely used globally. But still there are factors involved which affects the energy provided by the photovoltaic (PV) panels [1]. As indicated by Wai et al., that the energy supply and its use is not only leads to global warming but other environmental alarms such as radioactive substance emissions, ozone depletion and air pollution. New possible findings progressed to prevent the environment through energy conversation like reduction in fossil fuels to produce an environmentally approachable energy production. Out of all such techniques the energy produced with solar cells has pulled a greater consideration in research as it seems to be the best solution for the environmental problem [4]. One important reason which affects the accumulated energy provided by the PV panels is dust formation on the PV panels. When the solar panels are kept in the remote places more likely to be in deserts due to heavy wind the dust can be easily formed on the PV panels which in turn affects the productivity. So it's required to keep a dedicated person to clean the PV panels manually.

In this paper we focus on a technique based on signaling pathway unmanned vehicles (UV) to clean the PV panels when a dust is formed. The unmanned vehicles or the robots can be used especially when you're dealing with situations that undergo constant change, or embody continual uncertainty, and difficult for a human to do the repeated jobs. Autonomous vehicles do it in a lot of ways with high degree of precision and accuracy. The dust formed in different locations are identified by a dust sensor and the amount of dust formed is calculated by the control system. The control system enables the robot to move to the exact location by determining the shortest path. The detailed algorithm and the working methodology is illustrated in the following sections.

2. Literature Review

The photoelectric effect which was initially renowned by a French physicist in 1839, Edmund Bequerel, resulted when certain materials exposed to sunlight will produce a remarkable amount of electric power [5,6]. In such a way the solar panels are capable of producing electricity when it is exposed to sunlight. While comparing with the price of different fossil fuels and crude oil resources the main advantages of the solar cells energy is it is free reachable to the common man and it is obtainable hugely [7, 8]. In case of the solar cells the accumulation of dust over the solar panels makes the larger domestic markets unattractive when it is kept in urban areas. Literatures proved the dust accumulation will leads to decrease in the efficiency of the PV systems [9]. The impact of dust formation on the PV panels were addressed by Hottel and Woertz. They logged a maximum degradation in collector performance of 4.7%, with an average loss in incident solar radiation being less than 1% [10]. Catelani et al. noted in his literature that the formation of dust over the PV panels leads to a reduction in the transmittance of solar cell glazing and in turn leads to a weighty degradation in the efficiency of solar conversion [11].

It is well noted that any common Solar user should aware the importance how frequently the panels should be cleaned. They should have a clear picture about the performance loss due to dust accumulation if in case frequent cleaning is not possible. A detailed study about the effect of dust formation on the PV panels will help the common man to choose the panel technology which will suits the application and where it can be fixed. Zohu et al. focused the influence of dust deposits on the power efficiency and performance on the PV panels in the long term [12]. Current-Voltage (I-V) and Power-Voltage (P-V) curves, open-circuit voltage

(Voc), short-circuit current (Isc), fill factor (FF) and maximum power (Pmax). The solar panel assembly at Nizwa College of Technology, Oman is shown in Figure 1 and Figure 2 illustrates the control system architecture and the basic power output from the solar panel.

Figure 1. PV Modules Assembly at Nizwa College of Technology

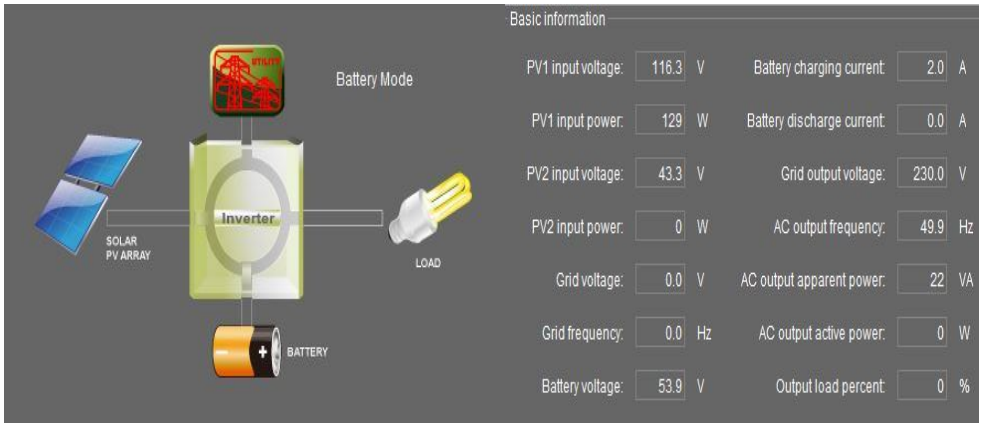

Figure 2. PV Control System and Input Power Information

3. Proposed Methodology

This paper focus on a novel technology to clean the PV panels using a robot. The designed robot follows the Dijkstra's shortest path algorithm to reach the dust formed location in the PV panels. The intensity of the dust is the driving input to the robot and the amount of dust formed is identified by the dust sensor. The Sharp Optical Dust Sensor) GP2Y1010AU0F is used for reading the dust formation in the solar panels. This robot is aimed to work in two different modes, the auto mode and the manual mode. A 4X4 keypad is used to select the operating mode of the robot. In manual mode the robot travels to all parts of the solar panel and clean it with water. A water pump is fixed with the robot to provide water supply whenever it requires cleaning. When the robot starts cleaning the panel the cleaning brush which is fixed at the

bottom will rotate in order to clean the panels. The rotation of the brush and the sprinkling of water by the water pump is aimed to ensue in the same time.

The foremost mode of the robot is the auto mode. In auto mode the robot is aimed to perform two different options of cleaning. The first option is focused when the intensity of sunlight is high and there is a drop in power than the set threshold value, the robot move to the entire panel and sprinkle the water on the panel. Many studies proved that when the intensity if sunlight is more and due to overheating of panels the generated power will be reduced by the PV modules. In order to overcome this issue the robot will sprinkle the water on the panels. The second option focus on the dust formation. The dust sensor will be the driving input to the robot. When the robot is in auto mode, the robot will continuously sense the output of the dust sensor. When the dust formation indicated by the dust sensor is higher than the set threshold value the robot moves to the exact location through the shortest path and performs the cleaning of the panels. The principle working of the robot is illustrated in Figure 3.

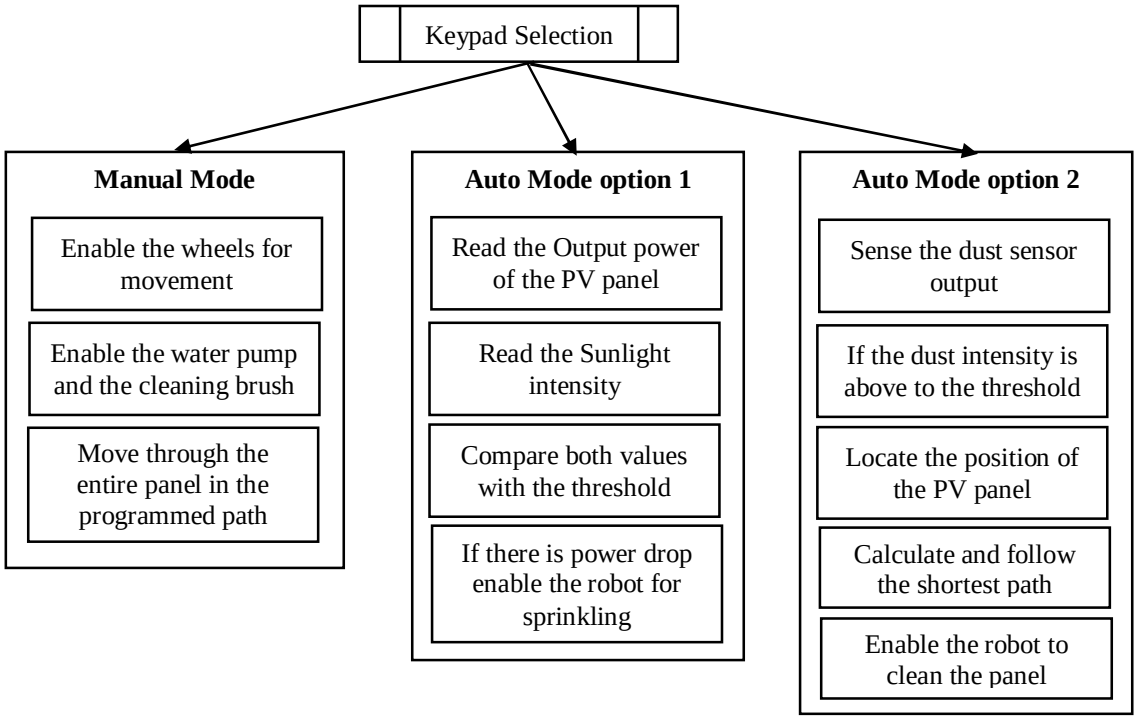

Figure 3. Work Flow of the Proposed Model

The movement of the robot in auto mode option 2 is done on the shortest path. The current location of the robot is stored in the memory and the dust formed location will be acquired from the dust sensor location. Based on these inputs the robot calculate the shortest path using the Dijkstra's shortest path algorithm. The movement through the shortest path without changing the robot direction is achieved by the mecanum wheels. The following section details the shortest path algorithm and the functions of mecanum wheels.

3.1 Dijkstra's Shortest Path Algorithm

The Dijkstra's shortest path algorithm is used to find the shortest path by forming a graph like structure starting from a single source node. From the single source node it will build the

nearest neighboring nodes by calculating the distance from the source node. The vertices or the nodes contained in the graph is denoted by *v* or *u* and *(u,v)* denotes and edge and *w(u,v)* indicates its weight. The Dijkstra's shortest path algorithm intents to calculate the shortest distance continuously from the starting point and to eliminate the longer distances.

The pseudo code of the Dijkstra's algorithm is illustrated below.

1. INITIALIZE : Start Node as 0 and other nodes as Infinite
2. DEFINE : Start Node distance as fixed and other nodes temporary.
3. SET : Start Node as active.
4. CALCULATE : Temporary distances of neighbor nodes. Add the weights of the edges to identify the temporary distance.
5. UPDATE: If the calculated distance is lesser than the present, update the distance and set the current node as antecessor.
6. SET: minimal temporary distance node as ACTIVE and Mark the distance as permanent.
7. Repeat steps 4 to 7 until there is no node with permanent distance, which neighbors still have temporary distances.

3.2 Robot Movement using Mecanum Wheels

The Mecanum wheel is a contemporary wheel design for a wheel which has the ability to move vehicle in any direction. The mecanum wheel is fabricated with a series of rollers which are attached to its circumference as illustrated in Figure 4. The rollers on the wheels are fabricated in such a way that its axis of rotation is at 45° to the plane of the wheel and at 45° to a line through the center of the roller parallel to the axis of rotation of the wheel. If all wheels are moved in the same direction the vehicle cam be moved in forward or backward direction and when the wheels are rotated in opposite directions the vehicle can be moved in different direction. In order to achieve the vehicle motion in any direction with any vehicle rotation the rotation of the wheels are modified and controlled. Figure 4 illustrates the construction of the Mecanum wheel shaft and the Mecanum wheel.

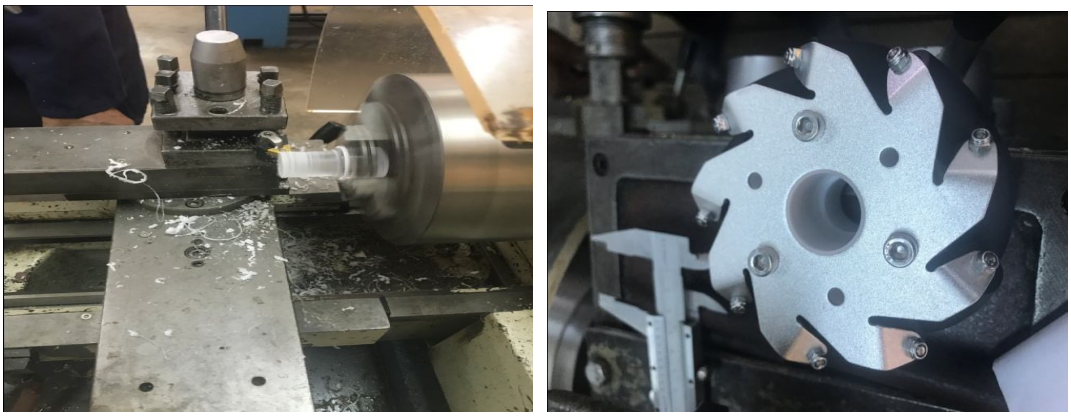

Figure 4. Construction of the Mecanum Wheel Shaft and the Mecanum Wheel

Figure 5 depicts the prototype of the robot which is implement and used for the testing purposes.

Figure 5. Prototype of the Robot

4. Results and Discussion

The following section details the results retrieved from the solar panel in real time. Table 1 indicates the output voltage and power from the solar panel before cleaning. Table 2. Illustrates the voltage and power after cleaning.

Table 1. Solar panel output before cleaning

Device mode	Time	PV1 input voltage	PV1 input power
Battery Mode	2010-09-14 09:10:58	116.4	134
Battery Mode	2010-09-14 09:09:52	116.4	134
Battery Mode	2010-09-14 09:08:44	116.4	140
Battery Mode	2010-09-14 09:07:41	116.4	134
Battery Mode	2010-09-14 09:07:36	116.3	129
Battery Mode	2010-09-14 09:06:29	116.4	134
Battery Mode	2010-09-14 09:05:21	116.4	134
Battery Mode	2010-09-14 09:04:20	116.4	134
Battery Mode	2010-09-14 09:03:18	116.3	129
Battery Mode	2010-09-14 09:02:13	116.4	129

Table 2. Solar panel output after cleaning

Device mode	Time	PV1 input voltage	PV1 input power
Battery Mode	2010-09-14 10:20:28	146.4	164
Battery Mode	2010-09-14 10:19:12	146.2	161
Battery Mode	2010-09-14 10:18:18	146.4	164
Battery Mode	2010-09-14 10:17:52	146.4	164
Battery Mode	2010-09-14 10:16:20	146.3	163

Battery Mode	2010-09-14 10:15:14	146.4	164
Battery Mode	2010-09-14 10:14:45	146.4	164

5. Conclusion

To conclude, the proposed work is implemented and tested in the real time scenario. It is noted that the system can be used in all solar power plants to enhance the power generation. Few limitations also understood from the proposed model which are planned to overcome in the future research.

6. References

[1] Nathan S.Lewis and Daniel G. Nocera, " powering the planet : Chemical challenges in solar en-ergy utilization", Proceedings of the national academy of science of the USA, Vol.103, No.443.

[2] Carrasco, Franquelo and Bialasiewicz, "Power-Electronics systems for the grid integration of renewable energy sources: A Survey", IEEE transactions on industrial electronics, Vol 53, issue.4.

[3] Martin Pehnt, "Dynamic life cycle assessment of renewable energy technologies", Elsevier re-newable energy, Vol.31, Issue.1.

[4] R.-J. Wai, W.-H. Wang and C.-Y. Lin, "High-Performance Stand-Alone Photovoltaic Generation System," Proceedings of IEEE Transactions on Industrial Electronics, Vol. 55, No. 1, January 2008.

[5] February 2010. http://www.rise.org.au/info/Education/ SAPS/sps003.html

[6] February 2010. http://science.nasa.gov/headlines/y2002/solarcells.html

[7] Grisham, L.R. (2008) "Nuclear Fusion in: Future Energy, Improved, Sustainable and Clean Options for our Planet", Edited by Trevor M. Letcher, 2nd Edition, Elsevier Ltd., Amsterdam, 291-301.

[8] Rana, S. (2013) "A Study on Automatic Dual Axis Solar Tracker System using 555 Timer". International Journal of Scientific & Technology Research, 1, 77-85.

[9] Monto Mani, Rohit Pillai "Impact of dust on solar photovoltaic (PV) performance: Research status, Challenges and recommendations", Elsevier Renewable and Sustainable Energy Reviews 14 (2010) 3124–3131.

[10] Hottel HC, Woertz BB. The performance of flat plate solar heat collectors. ASME Trans 1942; 64:91–104.

[11] Catelani M, Ciani L, Cristaldi L, Faifer M, Lazzaroni M, Rossi M (2012) "Characterization of photovoltaic panels: The effects of dust", Instrumentation and Measurement Technology Conference (I2MTC), 2012 IEEE International. May 2012.

[12] Zhou W, Yang H, Fang Z (2007) "A novel model for photovoltaic array performance prediction", Appl. Energy 84:1187-1198.