Gamification in Education and its Role in Shaping a Sustainable Future

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Abstract- This paper presents research of design and manufacturing a prototype of solar panel cleaning system in Vietnam. The 2D and 3D design of this prototype is also shown in this study. The device is used to clean dust accumulated in the face of solar panels so that it can help for enhancing power efficiency of solar panels. The prototype can be controlled manually or automatically via WiFi based on options of control system. An ESP8266 NODEMCU board is used in the hardware of the controller so that it can connect to WiFi, control motors and traveling of the device. An app is set based on Blynk app to control the system via WiFi. Operators can control the system everywhere with WiFi or 5G connection. The device can help to remove dust on solar panels and enhance the power generation efficiency, reduce time, labor, keep safety for cleaning solar panels compared with manual cleaning method.

1 Introduction

Vietnam is a country in Southeast Asia and has a huge potential of solar power. Vietnam is also in the high long-term average irradiance region of the world [1]. The average number of sunshine hours is from 1600 h to 2600 h in a year and the average solar energy is between 4 and 5 kWh/m^2 in a day [2]. Currently, there are many houses installed grid-connected solar power systems to use and sell to the government [3]. However, a challenge is that solar power systems in Vietnam currently lack of automatic photovoltaic (PV) panels cleaning systems, leading to a lot of dust accumulated on the panels, reducing the performance of the whole system [4]. And PV panels are often installed in high places, so they are difficult to be cleaned. So there are a lot of dust accumulates after a long time, sometime reducing generation efficiency by 50% [5].

Now there are some research about optimization method for enhancing power generation efficiency of solar panels. Bipasa Patra et al. [6] studied optimization of solar energy using MPPT techniques. Harvin Krishnan et al. [7] identified parameters of solar cell using improved Archimedes optimization algorithm. Asif Afzal et al. [8] gave a review about optimizing the thermal performance of solar energy devices. However, the research in this paper focuses on enhancing power generation efficiency of solar panels by cleaning dust accumulated on PV panel face.

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There are some research about solar panel cleaning device in the world. Hou Zhen-Ye et al. [9] published a paper about mechanism for cleaning solar panel. Manju [10] also give a design for an automatic system for solar panel cleaning. Shahzada presented a dry cleaner for PV systems [11]. This paper shows a prototype for cleaning solar panels using WiFi to control the system based on ESP8266 NodeMCU module. The system can be controlled in manual mode or automatic mode using Blynk app. Blynk is an internet of things platform that allows controlling electronic devices using iOS and android apps. Blynk gives dashboard by which users can create their own graphic interface using different widgets. Blynk also has libraries for most of the popular hardware platforms such as Arduino, ESP8266 [12].

2 Mechanism design and mechanical design

Figure 1 shows principle of solar panel cleaning system. It includes solar panels which is arranged to be series array and two limit switches which is installed in two ends of solar panel array. The cleaning device will be placed on the surface of series of solar panels. It has two motors; one motor is connected to the main wheel to move the system; the other motor is used to rotate the cleaning shaft to clean dust on the glass surface of PV modules. Two limit switches are installed at both ends of the model to limit the system's traveling and help the system move back and forth automatically. The device is not only controlled automatically but also can be controlled manually with an app designed in Blynk. When pressing start button on app, the moving motor assembled in moving frame will move the whole moving frame to travel along the solar panel array and the cleaning motor will rotate a brush shaft (cleaning shaft) to clean dust on the surface of solar panels. When the moving frame reach to the second limit switch, the moving motor stops and reverses to move the moving frame back until it touches the first limit switch and stops. Because of cleaning shaft rotation and traveling of moving frame, dust accumulated on the solar panel surface will be removed. This process is controlled manually or automatically via smartphone using app Blynk based on WiFi.

The flowchart in the figure 2 presents more specifically the operating principle. In this chart, the solar panels supply energy to a battery. The energy in the battery is used for both cleaning motor and moving frame motor. The cleaning motor rotates a cleaning shaft to cleaning the face of solar panels. And the moving frame motor will move cleaning motor to many panels in the array. This means that the moving frame motor and cleaning motor operates simultaneously. The moving frame motor moves the whole system including cleaning motor travel to each solar panels in the array. This principle is shown clearly in 3D design of the prototype (Fig. 5).

Based on mechanism design, mechanical structure is also designed based on AutoCAD and SolidWorks software. Figure 3 shows 2D design of the moving frame of solar cleaning system using Autocad software. It shows the front view, left view and dimensions of the moving frame. The length, width and height of model is 720 mm, 100 mm and 125 mm, respectively. By the 2D design, a 3D design of moving frame is built as figure 4. The frame is made of steel bars, welded together. Then a 3D design of the system is shown as in figure 5. In this design, there is a frame to keep solar panels which is shown in blue color. Limit switches are assembled at two ends of solar panel frame. The moving frame motor with cleaning shaft and wheels is also presented in this figure. This model is designed to clean array of solar panels which is arranged in one row. If there are two rows or more solar panel arrays, operators move the moving frame to the second row so that it can clean dust on the second row solar panels.

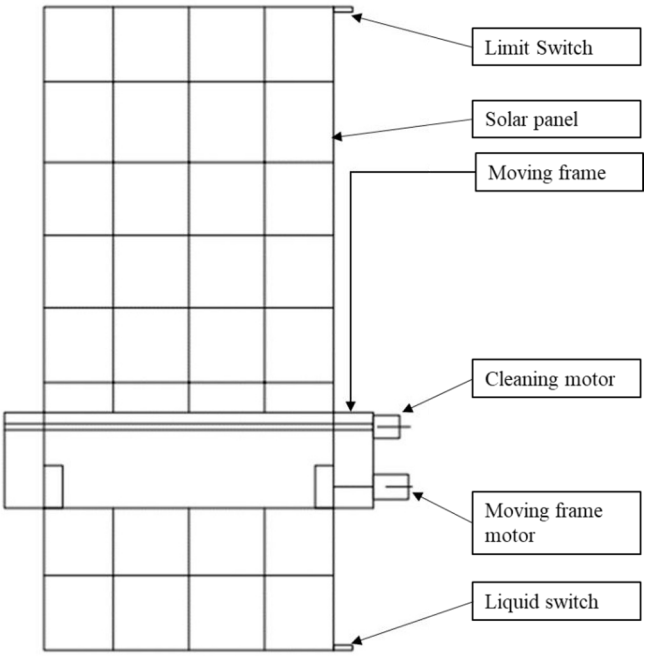

Fig. 1. Mechanism design of solar panel cleaning system.

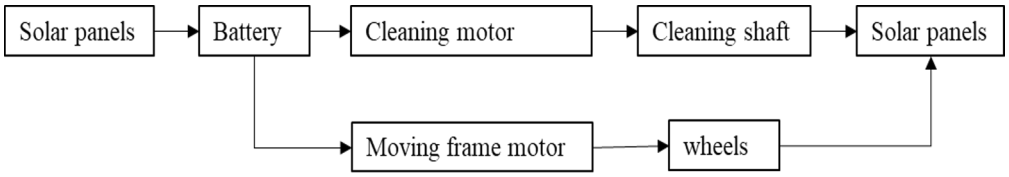

Fig. 2. The flowchart of solar panel cleaner principle.

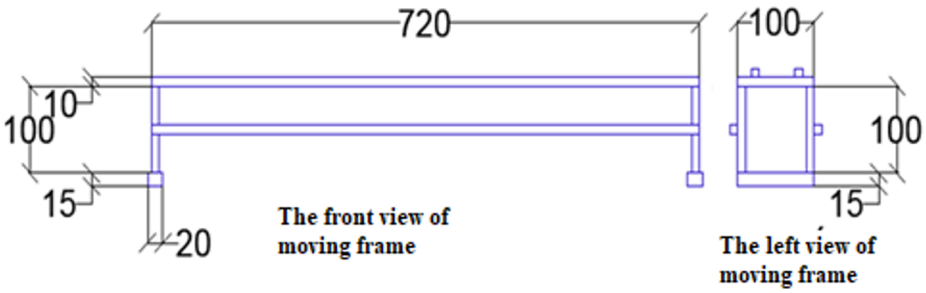

Fig. 3. The front view and left view of 2D design of moving frame with dimensions.

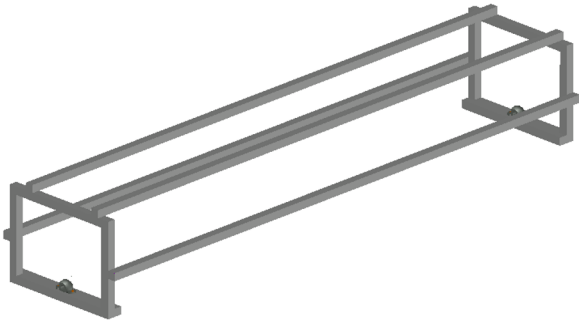

Fig. 4. The 3D design of moving frame based on SolidWorks software.

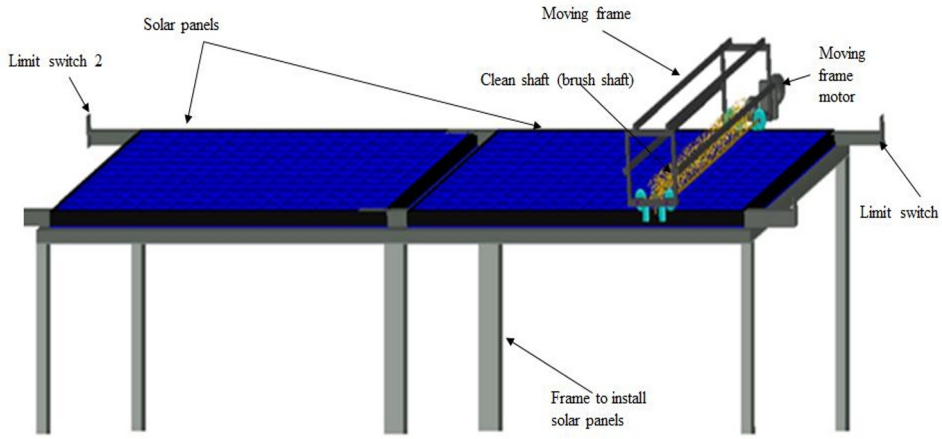

Fig. 5. The 3D design of whole solar panel cleaning system

3 Design control system

After design the device mechanism and 3D model, the controller of the system is also studied. First, the flowchart of controlling is designed and presented as in figure 6. The controller using an 12V DC battery to supply power, then users choose modes for operation. There are two modes which are automatic and manual. If the manual mode is chosen, the user will control manually the device by pressing virtual button on the screen of control. If the automatic mode is chosen, the device will automatically move and rotate the cleaning shaft to clean dust on solar panels until touching the second limit switch. Then the device automatic reserve the moving and go back so that the device touch to the first limit switch and stops. The system will be installed to clean once a day.

By the flowchart of controller, the schematic of the prototype is also designed. Figure 7 and figure 8 are the schematic diagram and printed circuit board (PCB) of controller of the prototype. It includes one ESP8266 NodeMCU module, L298N driver and a 12V power source. From on this design, the final circuit has been carried out.

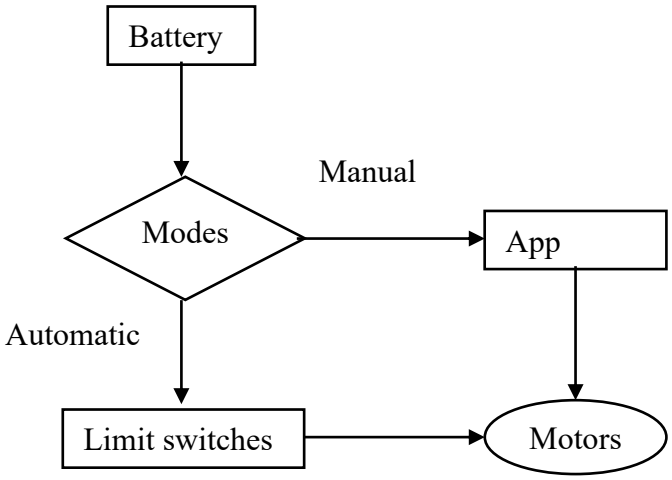

Fig. 6. The flowchart of controller.

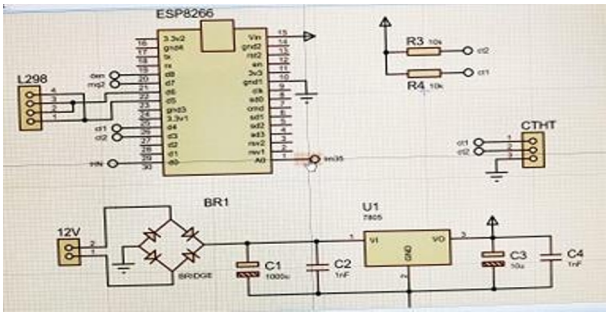

Fig. 7. The schematic of controller.

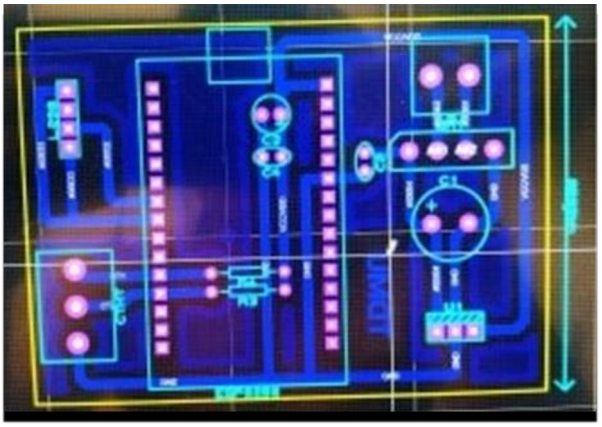

Fig. 8. The PCB design of the controller.

4 Calculation for the prototype

The prototype is calculated for a system of 10 solar panel modules. Each module has power capacity 100W and dimension 1030 mm x 670 mm x 35 mm. The parameters of the prototype are shown as in table 1. The capacity of moving motor is calculated as following:

Table 1. The parameters of the prototype

Parameter	Value
Mass of prototype (m)	68.67 N
Velocity of the moving frame (v)	4 m/minute
Distance the frame move (D)	10,3 m

Based on designed distance and velocity, the time for the prototype moving is calculated as following:

$$t = D/v = 10.3/4 = 2.6 \text{ minutes} = 156 \text{ second.} \quad (1)$$

The work done when pulling the model to move a distance of 10.3 m:

$$W = F*s = 70*10,3 = 707.301 \text{ (J)} \quad (2)$$

Power required to pull the model:

$$P = A/t = 707.301/156 = 4.53 \text{ (W).} \quad (3)$$

Based on required power, a gear motor 20 W is chosen for the model so that it can pull the whole frame better.

5 Manufacturing the prototype

Based on research, calculation and design, a prototype of solar panel cleaning is manufactured as figure 9 and figure 10. Figure 9 shows the moving frame that includes cleaning shaft, moving motor, moving motor, frame bars, the controller of the system via WiFi using NodeMCU. Figure 10 presents the controller of device which has L298N driver, ESP8266 NodeMCU, moving motor and cleaning motor. Figure 11 illustrates the solar panel cleaning device tested in one PV modules. Figure 12 presents the control screen which is designed on Blynk app to control the whole system via WiFi.

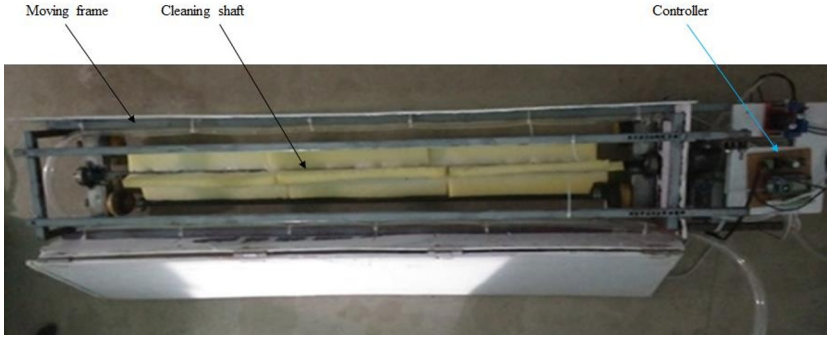

Fig. 9. The moving frame after manufacturing.

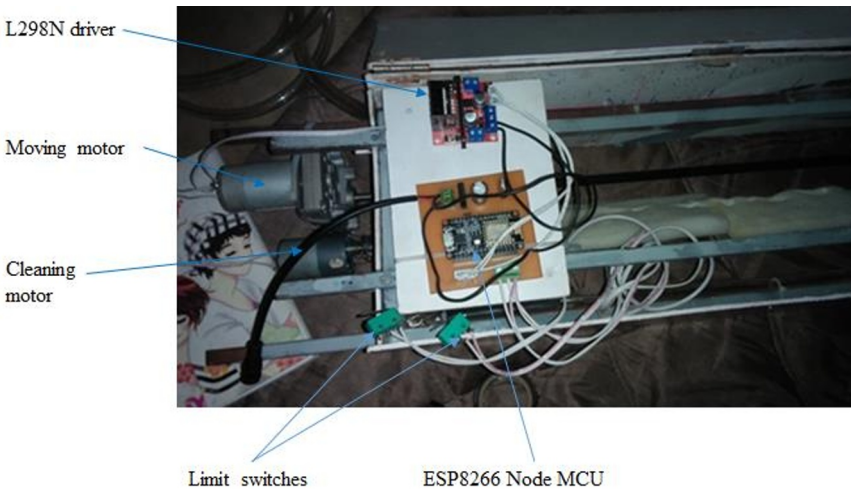

Fig. 10. The controller of the system.

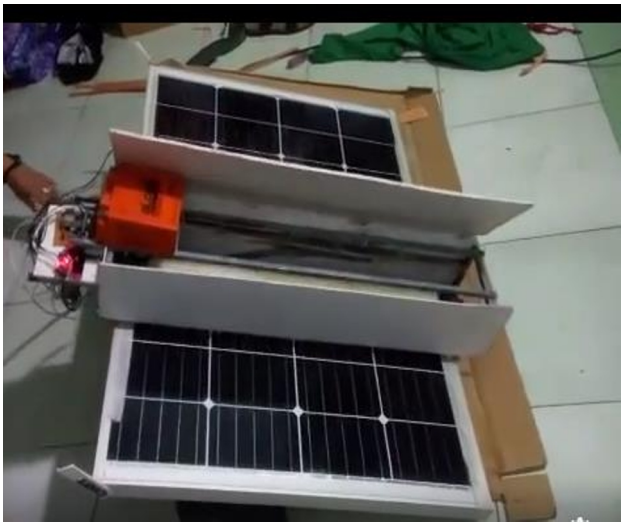

Fig. 11. The prototype tested on one solar panel module.

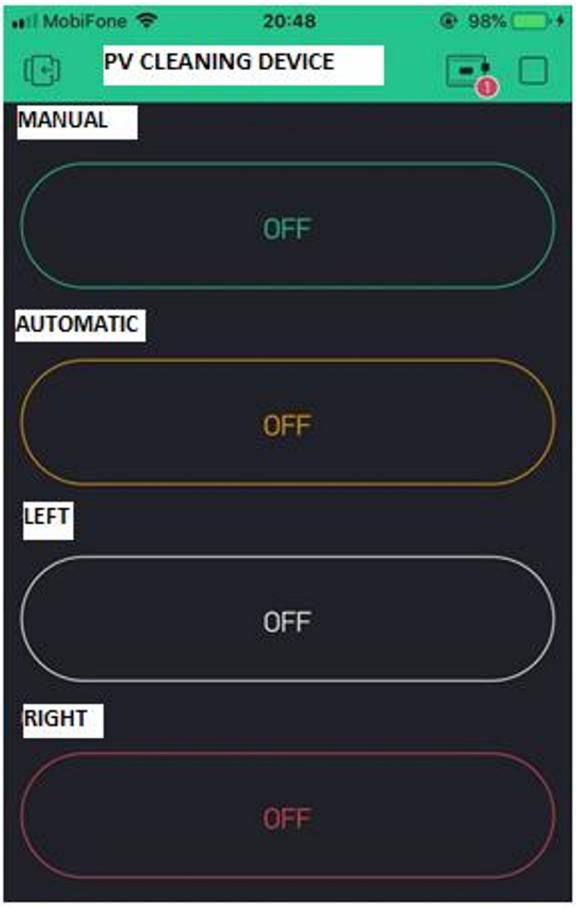

Fig. 12. The screen of controller designed on the app Blynk.

6 Conclusion

Based on the study, a prototype of solar panel cleaning device is calculated, design and manufacturing. The prototype can clean dust accumulated on PV modules to enhance the best power generation ability of the solar panels. The device has automatic mode and manual mode based on WiFi control and app Blynk so that it can adapt to user's requirement. This device can be developed in the future for application into practice.

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