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Tracking System on Solar Panels Using Microcontroller

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Abstract

Solar energy is a renewable energy that has not been widely implemented in a mass manner. To optimize the use of a solar panel, usually a control system that can adjust the position of the solar panel automatically is employed to get the optimal power value. This prototype tracking system of solar panels is dynamically following the direction of sunlight. The supporting devices used in this prototype are LDR sensor, Servo, Arduino Uno, Ina219, Bread Boot Power Supply and solar cell which must be activated first to work. The servo will drive a 3D printing device that is connected to an LDR sensor that is sensitive to sunlight. The Ina219 component serves to absorb the intensity of the sun and convert it in terms of voltage (volts) and electric current (amperes). The energy absorbed by the solar panels in the form of voltage and electric current will be stored in the battery so that it can turn on the lights. The solar panel prototype will be placed in an open area to get optimal solar energy compared to static solar panels.

Keywords: *prototype, tracking system, solar panels, microcontroller*

1. Introduction

Solar energy is one of the renewable energy and alternative energy that is clean, non-polluting, safe and with unlimited supplies (Environment Indonesia, 2021). Solar panels are materials made of semiconductors that can convert solar energy into electrical energy. The main problem with the use of solar panels is that the output power produced by solar panels depends on the intensity of radiation captured by the solar panels. The greater the absorbed solar radiation, the greater the output power that can be produced by solar panels (Sanspower, 2021). Improper installation of solar panels will result in a lack of radiation intensity, hence, that solar panels do not produce maximum output power.

The current problem is how to use solar cell panels to get optimal electricity output. The use of solar cell panels is generally placed in a certain position with no changes (Rif'an et al., 2012), for example, solar cell panels are faced up or perpendicular to the sun in order to get optimal energy, setting the direction of the solar cell panels less effective if done manually by humans. Thus, it is necessary to create a control system that can regulate the direction of the solar cell panels.

A control system requires an algorithm processing mechanism. Processing of control system algorithms can be completed with computers, microcontrollers, and other tools. Processing algorithms that are growing rapidly today are microcontrollers. Microcontroller is a technological breakthrough that only requires a small space and can be mass produced, so the price is cheaper than microprocessors (Maysha & Trisno, 2013).

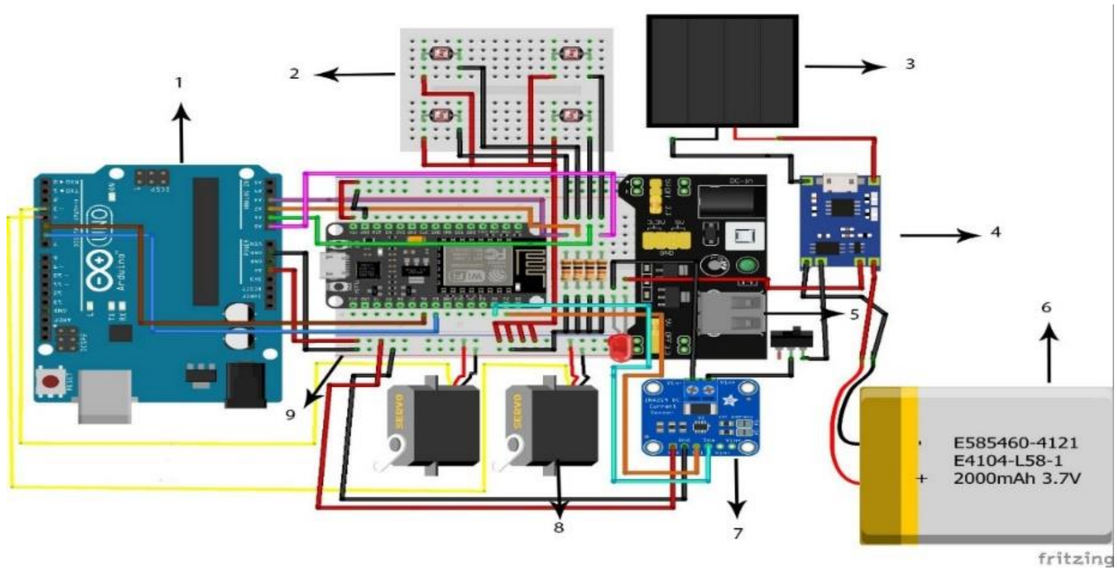
Solar panels will capture maximum solar radiation when perpendicular to the sun's rays. This can be achieved by adjusting the angle of inclination of the solar panels and the orientation of the solar panels. In setting the tilt angle and orientation of the solar panels, the sun's position is used as a reference to determine the optimal solar panel settings. To determine the optimal tilt angle and orientation direction of the solar panels, it can be done by measuring the maximum output power that can be generated by the solar panels for each setting. Another way that can be used is to calculate the position of the sun against the location of the solar panel installation to determine the angle of the sun's rays so that the angle of inclination of the solar panel and the orientation of the optimal solar panel can be determined. In this study, a dynamic (moving) solar panel device will be developed to follow the direction of the sun's rays to get maximum energy and determine the effect of the tilt angle of the solar panel on the output power generated.

Some of the studies that are used as references are research on the analysis of the design of a solar power plant system with a capacity of 50 Wp (Ramadhan et al., 2016). This solar panel is not directly connected to the battery but is connected to a regulator circuit, this is to regulate the output voltage of the solar panel and regulate the current entering the battery automatically. Because the regulator functions to connect and disconnect the current from the solar panel to protect the battery against overload. Furthermore, research by (Julisman et al., 2017) regarding the manufacture of prototypes of the use of solar panels as an energy source in the automatic system of the roof of the Football Stadium. The results of the design of this tool work by automatically moving the roof of the soccer stadium. This research uses Arduino, LDR sensor to detect. Then research on the use of solar power was carried out by (Maysha & Trisno, 2013) with a 2N3055 transistor-based solar panel design and a thermoelectric cooler. This solar panel utilizes used components that are no longer used but appropriate to produce solar energy in the form of sunlight and solar heat to produce electrical energy that has been stored in batteries.

2. Research Method

2.1. Circuit Prototype

This tracking system uses a P&O control algorithm and PID self-tuning control with ANN Perceptron embedded in the ATMega 8535 microcontroller. The control input comes from the results of voltage and current readings from the solar cell then processed using a microcontroller and the processing results in the form of a control signal that will adjust the position of the servo motor. In the hardware design process, each component in the circuit will be connected using a connector cable with other supporting components as input, process, and output to then perform certain actions according to the program embedded in it. Therefore, the supporting components can run well (Maulidin et al., 2021).



Source: Research Result

Figure 1. Arduino-based Circuit Prototype

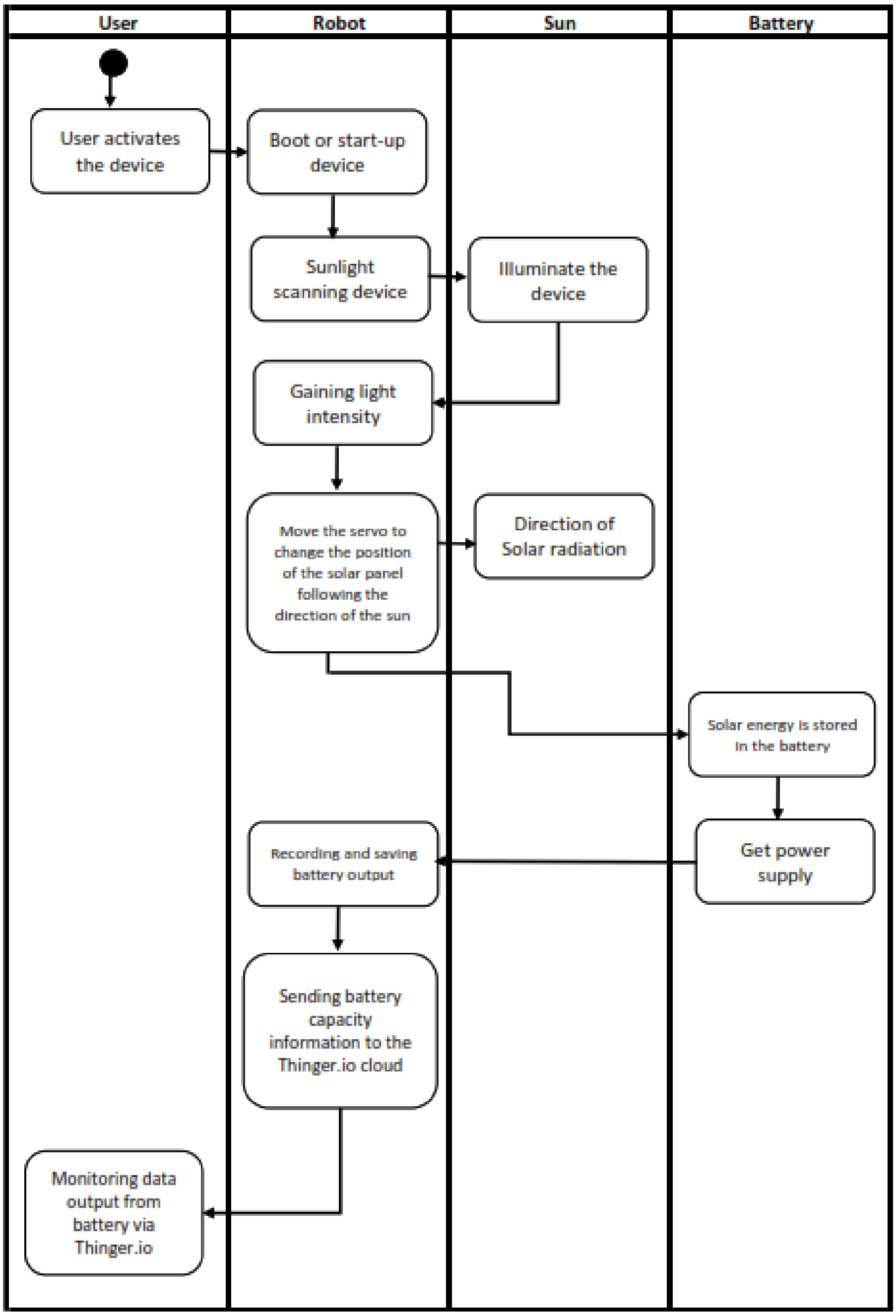
The process diagram (process diagram) serves to map the environmental model (depicting the relationship between external entities, system inputs and outputs), which is interpreted as a single circle representing a series as shown in Figure 1 (Sari et al., 2022). The details of the components listed in Figure 1 are described in table 1 below.

Table 1. List of Prototype Components

No	Component	Component Function
1`	Arduino Uno	As a device control center microcontroller or offline sensor
2	LDR Sensor	As a light intensity sensor
3	Solar cell	As an alternative to solar electric power absorbers
4	Modul charger	As a solar panel to battery power converter
5	Bread Board Power Supply	As a separate power device with solar panels
6	Baterai	As a reservoir of power that is supplied with electric current by solar panels
7	Ina219	As a sensor measuring the electrical unit of usage stored in the battery
8	Servo	As a driver of the position of the solar panel against the sun
9	Node NCU Amica	As a central microcontroller that focuses on sending data to the Thinger.io cloud about solar panel power management

Source: Research Result

Figure 2 is the flow of the solar panel tracking system mechanism in this study, where the user will activate the device and monitor it. In addition, the user has the task of monitoring software applications that have been programmed on the Thinger.io platform so that the prototype can carry out its functions to be able to move 3D printing properly. Users can also analyze if an error occurs so that it can be controlled. Start-up devices can scan solar cells for absorption. The intensity of sunlight shining on the device will be recorded by the robot/prototype system. The servo component on the robot is the driving medium for solar panels. The servo moves the device with the help of the LDR sensor to follow the light so that it gets optimal light. Microcontroller as a medium for sending data to the Thinger.io platform which is software that provides output power output from solar panel installations. The solar energy that has been absorbed will be stored in the battery so that the lamp can be turned on (output).



Source: Research Result

Figure 2. Diagram Activity of Prototype System

2.2. Software Programming

The software requirements in this prototype are related to several software platforms to meet the needs of the running of the solar panel prototype as follows.

a. *P&O algorithm*

P&O is an algorithm commonly used for MPPT solar cells. This system also uses the P&O algorithm. θis the angle of the servo motor which has a value between -90^0 to 90^0. This value of θ will direct the solar cell to get the maximum light intensity, so that it will get the maximum power (Azmy et al., 2015).

b. *Arduino*

Arduino is an open-source single-board micro controller, derived from the Wiring platform, designed to facilitate the use of electronics in various fields. The hardware has an Atmel AVR processor, and the software has its own programming language. Arduino uses a modified C programming language, commonly called the C programming language for Arduino. Arduino IDE is software for programming Arduino. In this software, Arduino is programmed to perform functions embedded through programming syntax. In designing the prototype, Arduino is used as a solar panel monitoring tool by driving 3D printing from a servo that has been installed in such a way (Arduino IDE, 2021).

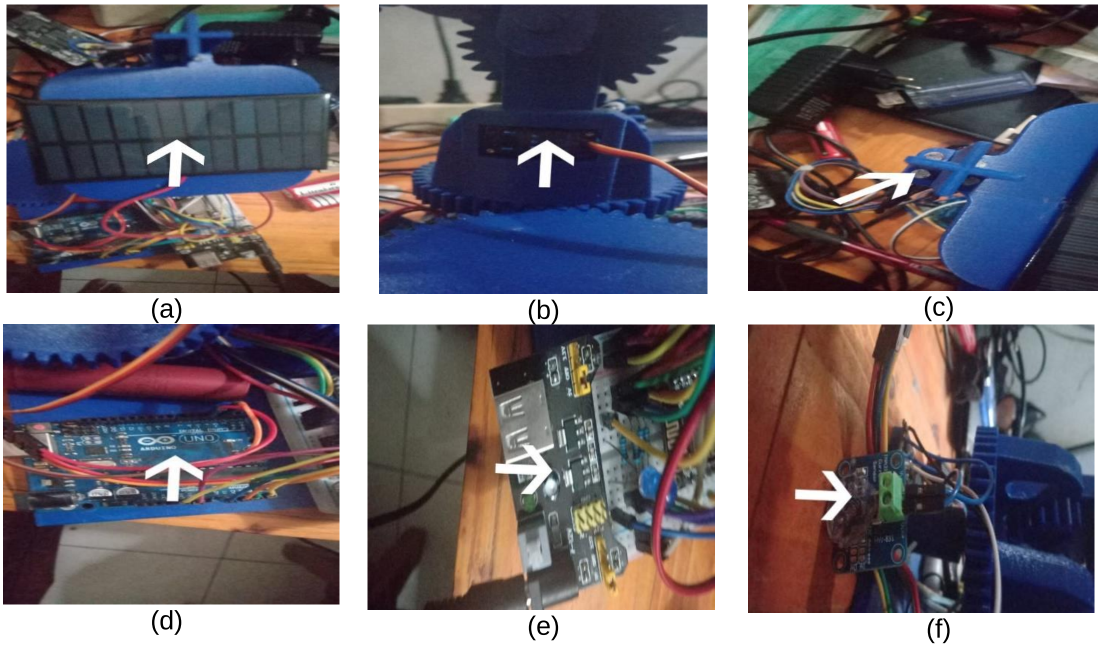
c. *Thinger.io*

To monitor the work of the light sensor in detecting the amount of electrical energy generated in volts and the amount of electric current generated in amperes. Both quantities will be known through the output data from the Thinger.io. To manage application connectivity on the prototype system, the SSID and Password connections are used. If connected to WiFi, there will be an on notification to connect to the prototype device of the solar panel tracking system. If it is not connected, the graph of the light absorbed in the solar cell on the Thinger.io platform will not appear (Thinger.io, 2021).

3. Results and Analysis

3.1. Prototype of Solar Cell Tracking System

The prototype of a solar panel tracking system using a microcontroller has been successfully carried out. The installation process of each component that has an effect on driving the solar panels is shown in Figure 3.



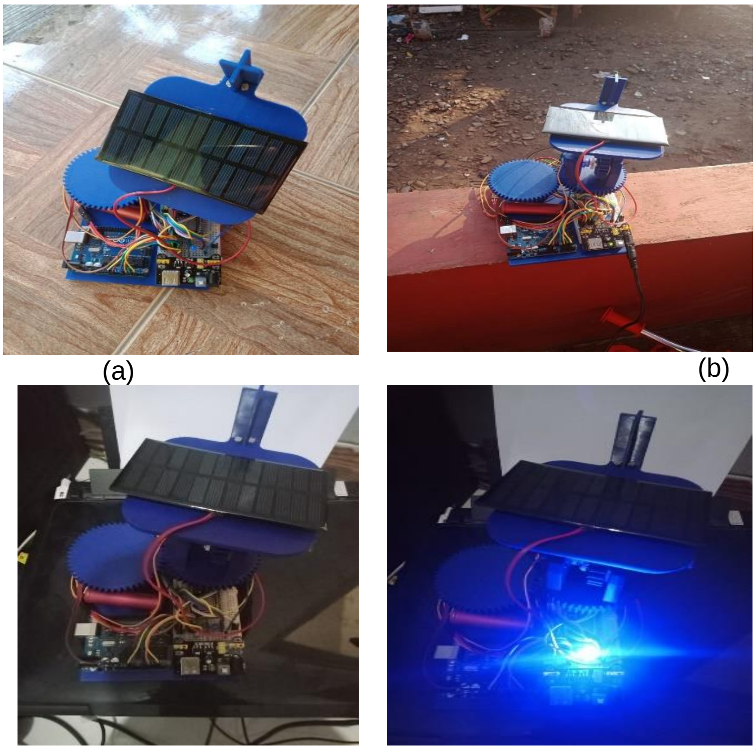
Source: Research Result

Figure 3. Prototype Component and Installation Process

Figure 3(a) is a display of the Solar Cell device to absorb solar energy to produce electrical energy in the form of voltage and electric current. Figure 3(b) is a display of the Servo device that functions to drive 3D printing and devices related to controls that have been programmed on the Arduino IDE platform, this servo is very influential in the motion of the solar panel if the servo does not run properly then 3D printing cannot generate data optimally. Figure 3(c) is a display of the LDR Sensor device which has sensitivity to light, this type of resistor can move the 3D printing device in following the sunlight. 3D printing has 4 parts, each of which has a task, namely moving up, down, left, or right with the help of an LDR sensor to follow the motion of sunlight. Figure 3(d) is a display of the Arduino Uno device, an ATmega328-based microcontroller board used as an output. In use it requires a USB connector, power jack, ICSP header, and a reset button. Figure 3(e) is a display of the Bread Boot Power Supply device which functions to provide a supply voltage so that the components in this device can live and the sensor components can work. Finally, Figure 3(f) is a display of the Ina219 electronic sensor device to measure two parameters at once such as voltage (in volts) and current (in amperes) of electricity in the solar panel device, these components are needed to support the voltage current.

3.2. Device Trial

The test results of the prototype tracking system solar panel are shown in Figure 4. It is a view of the solar panel device when in a cool place you can see the tilted position of the solar cell. Figure 4(b) is a display of the solar panel set in an open space and the components have been activated, the position of the panel has changed from the previous one. This shows that the prototype has worked dynamically by moving in the direction of sunlight. Figure 4(c) is a display of the device when it gets energy from sunlight and is absorbed into the solar cell then the energy is stored into the battery and then turned into electrical energy. The captured and stored energy in the battery can turn on the light when the ON switch is turned on. Figure 4(d) is a display of a solar panel device that already contains electrical energy that is accommodated in a battery that has been assembled on a hardware device. The energy output can be applied to turn on the light (output) by setting the scalar button to ON and to turn it off by pressing the OFF button (Solar Cell Surya, 2021).



(a) (b) (c) (d)

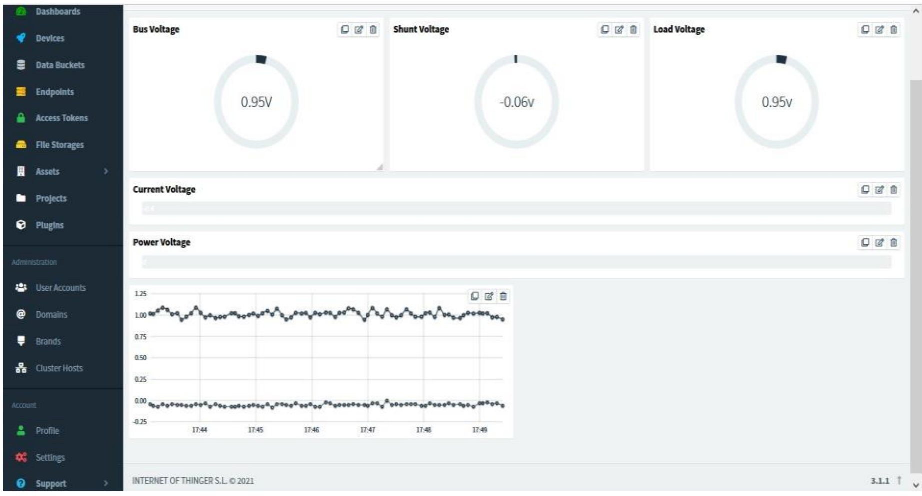
Source: Research Result

Figure 4. The test results of a prototype solar panel tracking system using a microcontroller

This prototype system will continue to move if there are still errors obtained from changes in the power obtained by the system. The motion of the system still depends on the value of the change in the angle $\Delta\theta$ which is the rotation angle of the servo movement to detect the intensity of the sun's rays. The larger $\Delta\theta$, then the system response will be fast, but the movement is very rough and conversely the smaller the value of $\Delta\theta$, the system response will be very slow, but the movement is smooth. For this reason, this algorithm needs to be added with PID control to get a fast transient response, with smoother movements.

3.3. Output Data System

Thinger.io is a website-based software application that is very helpful for collecting prototype output data in the form of current and voltage graphs obtained from the absorption of solar cells contained in solar panel devices. To enter the Thinger.io application, user must register with the Arduino IDE library and select Programming language. Furthermore, in the Arduino program, enter the Thinger.io account using the registered email or password. If you have logged in, the dashboard display will appear, and the solar panel device must be ON when it is illuminated or in the sun. From the Thinger.io application, data will appear in the form of a graph which is the amount of voltage and electric current which is the output of solar energy that has been absorbed by the solar cell. The output data display of the Thinger.io application is shown in Figure 5.



Source: Thinger.io

Figure 5. The Graph of The Output of Thinger.Io in the Form of Electric Voltage and Electric Current

The graph in Figure 5 is solar cell data that shows the current and voltage units obtained from light, hence, we can see how much intensity it is. If the solar panel device is running well, the graph will change according to what the solar cell gets. If the solar cell has a problem with the internet connection, there is no connection here, there will be a notification, so all the data is clear.

System testing was carried out from 08.00 am to 06.00 pm in July in Bekasi, Indonesia with a sampling time of one minute. In Figure 5, the maximum voltage that can be generated by the controlled system is 1.18V with an average value of 0.95V. Comparison of the performance response of solar panels is influenced by several factors, including solar cell temperature, solar radiation, and orientation to get the maximum value. Systems with tracking have better results than static ones. For further development, improvements can be made to the mechanical circuit, as well as the actuator so that it is able to work more optimally, and to be tested with different conditions such as altitude, temperature and humidity models, as well as other influencing parameters.

4. Conclusion

A tracking system protorype for solar panels using Arduino through the Thinger.io application has been successfully created and can implement solar panel monitoring. With the help of the Arduino IDE software through the source code commands that have been formulated, the solar panel monitoring tool can run all the commands that have been programmed. The prototype of the solar panel tracking system can move automatically following the light or manually based on the source code embedded into the microcontroller. The output of this prototype is obtained from the Thinger.io platform which is connected to the system device, so that the voltage (in volt) and current (in ampere) values are obtained by the solar cell per unit time. The current generated will be delivered to the battery so that it can turn on the light. Comparison of the performance response of solar panels is influenced by several factors, including solar cell temperature, solar radiation and orientation to get the maximum value.

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Author Contributions

Rafika proposed the topic; Rafika and Bagaskara conceived models and designed the experiments; Bagaskara conceived the optimisation algorithms; Rafika and Sugiyatno analysed the result.

Conflicts of Interest

The author declare no conflict of interest.

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