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Design of automatic light tracing system for solar panels

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Abstract: This paper designs an automatic light tracing system for solar power generation. Arduino UNO was used as the development board, and 3D printing technology was used to create a device construction bearing connection mold. Adjust the angle using horizontal and vertical motors, receive light signals through photosensitive resistors, judge the brightest spot of light, and track and capture light. This design can make the solar panel receive sunlight to the maximum extent, improving the efficiency of power generation.

Keywords: Light tracing system; Arduino UNO; Solar cell.

1. Introduction

The solar automatic light tracing system is a system that keeps the solar cell perpendicular to the sun's rays at all times. Solar power generation is an important way to improve the utilization rate of solar energy. Research shows that using solar automatic light tracing devices for the same solar cells under the same environmental conditions can increase the daily power generation by about 35% compared to fixed installations [1,2]. Most of the research on solar automatic light tracing systems is aimed at small household systems or photovoltaic power stations, and multi-axis automatic light tracing systems combined with sensors are mostly used, with a high degree of technical maturity; There is relatively little research on solar automatic light tracing systems applied to vehicles, but relevant light tracing technologies can be used for reference.

The research on solar automatic light tracing systems at home and abroad mainly includes the following content: Sungur designed a multi axis electromechanical system that uses programmable logic control to track the sun's position, and calculates the sun's azimuth and altitude angles per hour during the year. Using these data, a programmable logic controller (PLC) program was written, The purpose is to minimize the errors caused by the use of photoreceptors in cloudy conditions in the tracking system [3]. Zhang et al. proposed a solar tracking system that combines photoelectric tracking and time tracking, using four photoelectric sensors to estimate weather conditions. If it is sunny, the system selects photoelectric tracking, otherwise it selects time tracking. The tracking system uses a stepper motor to rotate at a certain angle after a set time interval. When the sun sets, the solar panel will touch the limit switch, indicating that the tracking is complete, and then the system will be reset for use the next day. Chern Sheng Lin et al. proposed a light source tracking system, in which four photoelectric sensors with different tilt angles are arranged on the four sides of the tracking board and adjusted according to the movement range of the light source to achieve the goal of tracking light. In order to improve the sensitivity of the sensor, a four-sided sensor algorithm with servo motors is used at various locations. The measured values of the photoelectric sensor can be fed back to the programmable logic controller through the wireless transceiver module. After the proportional integral differential operation, the system can obtain the light irradiation situation [5]. Gregor et al. developed a dual axis sun tracking system that obtains the geographic coordinates of the sun in real-time based on information and communication technology and GPS to improve the efficiency of solar systems [6]. Yao et al. applied a system with fine control capabilities, known as the declination clock rack system, which uses two automatic tracking strategies, one is a conventional tracking strategy, and the other is a daily adjustment strategy. The goal of conventional tracking strategies is to keep the tracking error less than a predetermined value to improve the performance of photovoltaic systems. The daily adjustment strategy is to make the photovoltaic panel reach the calculated position based on local time, and then the solar position sensor provides feedback to correct the tracking error [7].

Rahimi et al. designed and tested a new type of hybrid solar wind tracking system, which combines a dual axis solar tracking system and a wind tracking system. The wind tracking system serves as an auxiliary system to supplement the dual axis tracking when there is wind, and to cool the photovoltaic cells. The experiment shows that the power generation of the hybrid tracking system is 10.4% higher than that of the ordinary dual axis tracking system [8]. Zhang et al. designed a dual axis hybrid tracking system using GPS/Beidou for positioning, photodiodes for closed-loop tracking, and orientation algorithms for open-loop tracking. The difference between the calculated solar time angle, altitude angle, and azimuth angle and SOLPOS (Solar Position and Solar Radiation Intensity Calculator) results is less than 1. An initialization calibration method is proposed to correct errors caused by photodiode mismatch. The installation error, positioning error, and true north meridian deviation of the positioning algorithm are analyzed and corrected. Field tests show that after the second dynamic compensation, the overall tracking accuracy of the system has been improved [9].

2. Overall design

This design achieves efficient utilization of solar energy by designing a light tracing device. This design improves the efficiency of solar energy conversion by increasing the angle and flexibility of small power generation devices.

(1) Lighting is multi angular. In the perception of light, it is difficult to achieve accurate capture without sensitivity to individual senses. In the design, we must add four dimensions in the southeast, northwest, and the average value of the four dimensions as a criterion. Therefore, four photoresistors are added to the design, and a baffle is used to simulate the illumination at four angles, making the illumination at four angles different, so as to obtain the parameters of the four dimensions of the light. Here, I have selected four photoresist sensing modules. The photoresist sensing module is equipped with adjustable potentiometers to adjust and detect the brightness of the light. The comparator outputs a clean output signal with a good waveform. It also features strong driving ability, current carrying capacity that can exceed 15mA, low power consumption, and fixed bolt holes at the four corners of the module, facilitating installation.

(2) Regarding motherboard selection: fully consider several mainstream control schemes currently available on the market. The selected microprocessor is the Arduino UNO of ATmega328 Because of its wide range of use, supporting development environments, and many open resource libraries that can be easily invoked. Therefore, the Arduino UNO board is the most suitable choice.

(3) After obtaining the corresponding parameters, in order to take into account, the complexity of the implementation, combined with the long-term changes in the Earth's temperature and the periodic motion of solar energy in meteorology, by controlling the angle of the solar panel, it is only necessary to achieve a 180-degree rotation of the solar panel. Within this rotational range, the maximum solar energy efficiency can be captured. To achieve 180 degrees, it is necessary to adopt a dual motor mode, which covers most of the angles horizontally and vertically, and also reduces the cost of product production. Connect the two steering gears to the pins of the Arduino UNO. When the parameters obtained are less than the average of the four constant lights, they are shifted to an equal orientation to the average value where the parameters are less than the constant light, thereby providing stability and continuous output for the rotation of the solar panel.

3. Hardware design

The small system hardware of Arduino system for light capture and power generation consists of UON core control system board, horizontal steering gear, vertical steering gear, photosensitive sensor module, solar panel, and expansion module (shield). The UON core control system board uses a microprocessor: ATmega328. The voltage during operation is 5V, and the voltage during device input is 7V to 12V. During transmission, there are 14 digital bidirectional IO ports (6 of which provide PWM output) and 6 analog input pins. The maximum output current of each IO pin is 40mA and the provided 3V3. The maximum current is 50mA. Storage: Flash size is 32K bytes, static random-access memory (SRAM) size is 2K bytes, EEPROM size is 1K bytes, and equipped with a clock frequency of 16Mhz per second.

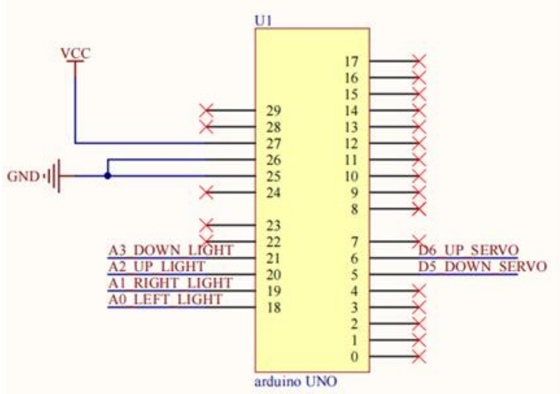

Figure 1. Partial schematic diagram of UON's circuit composition and preset ports

The photoresist sensor module can use a conventional version that can be collected on the market, as the photoresist is the core component of data collection in this design, and its sensitivity to light is very sensitive as a data calculation parameter for the design swing. The working voltage of the module is DC3.3V-5V, the photosensitive resistor model is 5516, and the module pin is 3 pins. These are the VCC power ports connected for 5V, S is the signal line, and GND is the ground wire.

The internal components of the horizontal steering gear and the vertical steering gear include signal lines that receive microcontroller control signals; A potentiometer for measuring the position of an output shaft, which is a part of the feedback element of a servo mechanism; An internal controller that processes external control signals, drives a motor, and processes position signals from feedback signals. It is the core component of a servo mechanism; A motor serving as an actuator for outputting rotational speed, torque, and torque position; And a transmission/steering gear system that reduces motor travel based on a certain transmission ratio coefficient.

The expansion module uses the expansion board and Arduino to bundle together to increase Arduino pins and expand the implementation of functions. Then connect the steering gear and the photoresist module to complete the hardware connection.

4. Design of system software

After the system is powered on, the software performs initialization default value assignment. Every time you start, the steering gear will return to its default angle. At the same time, the four sensors re acquire data. The baud rate of the serial port is set to 9600, which is consistent with the baud rate of the photosensitive sensor to facilitate signal transmission, with a delay of 100ms. The main core part of the program is to use photosensitive sensors to calculate the average value of the up and down and left and right row averages. By checking whether the difference is within the tolerance range, otherwise, the vertical and horizontal angles will be changed. However, if the average value is very close to the values of these two sensors, then the steering gear will not have much movement.

5. Commissioning results and analysis

Figure 2 is a physical diagram of the design. The system operates well. When the illumination angle changes, the system can change the direction according to the illumination angle, so that the illumination can be vertically irradiated on the solar panel.

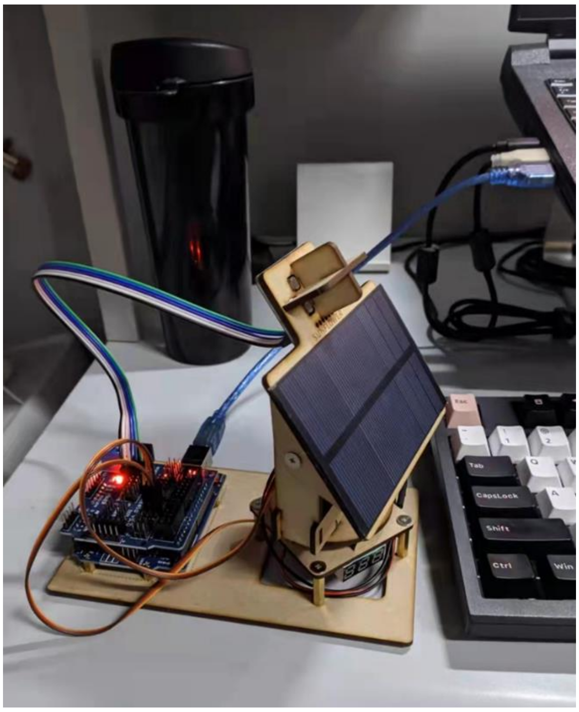

Figure 2. Physical diagram of the system

6. Conclusion

This article has conducted research on the energy management system of solar panels with automatic light tracing function, designed the mechanical structure and control scheme of the automatic light tracing system, completed the parameter matching of key assemblies, built a solar energy generation system with automatic light tracing function, and completed the hardware and software design.

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