Design of solar light tracking system
Research on energy autonomy system design of outdoor patrol car based on solar energy

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Abstract. The Inner Mongolia has abundant solar energy and electricity resources. Because of the long distance between cities, transmission lines are too long, making it difficult to check lines. In order to solve the problems existing in the inspection work, this paper studies a kind of outdoor inspection vehicle using solar energy, the energy system of the inspection vehicle can independently complete the charge and discharge, so as to realize the inspection task. This paper focuses on the energy autonomy of the on-site inspection vehicle for solar energy. According to the design requirements of the inspection vehicle, appropriate parts are selected to build an energy autonomy inspection system for the inspection vehicle. Then the solar tracking algorithm and maximum power tracking control algorithm are used to improve the conversion rate of solar panels and achieve fast charging. Finally, the hardware and software of the solar controller are designed, and the corresponding functions are debugged.

1. Introduction
With the rapid development of science and technology today, the continuous consumption of fossil energy and the enhancement of environmental awareness, the use of renewable energy has been paid more and more attention. Solar energy as a pollution-free renewable energy, the utilization rate is higher and higher. The solar tracking algorithm structure can realize the real-time tracking of the sun, but its tracking structure is mostly fixed single-axis and double-axis system, which is not applicable to the outdoor patrol car. Therefore, A new kind of solar tracking system is studied in this paper.

2. Energy autonomous system
The energy autonomous system of solar outdoor testing vehicle mainly includes three parts: first, motors, batteries and photovoltaic modules; The second is the sun tracking system; The third is the solar charge and discharge controller [1]. The system principle block diagram is shown in Figure 1.
Figure 1. Outdoor patrol car energy autonomous system.

According to the system principle block diagram 1, the functions of each part of the system are described as follows:

(a) Photovoltaic module: it is the power supply unit of the whole system. It converts light energy into electric energy through energy conversion, so as to charge the lithium battery.

(b) DC/DC circuit: it is part of the hardware circuit of solar charge and discharge controller. Its working principle is to adjust the output voltage by changing the duty ratio, and control the output power.

(c) Solar charge and discharge controller: the main function is to achieve energy autonomy by controlling a controllable switch. When charging, connect the control DC/DC circuit, and the controllable switch is closed.

(d) Solar tracking: a control system consisting of a four-quadrant photoelectric sensor, a sun tracking algorithm and a gyroscope is adopted to make the solar panel perpendicular to the sunlight to maximize the collection of energy and improve the output efficiency [2].

3. Formatting the title, authors and affiliations

3.1 Tracking algorithm

The solar tracking algorithm adopted in this project belongs to a hybrid algorithm combining photoelectric tracking and apparent solar tracking [3], and the algorithm schematic diagram is shown in Figure 2. Firstly, by setting the local geographical latitude (the latitude of Hohhot, Inner Mongolia) and SCM RTC function real-time acquisition of the required date and time, rough adjustment, the azimuth can be calculated by using the visual day tracking algorithm. Then, By calculating the deviation of yaw Angle picked up by gyroscope (magnetic field detection sensor), it is determined that the deviation value is less than the set \( \varepsilon_1 \). If the deviation is greater than the set value \( \varepsilon_1 \), then through the proportional control of the azimuth motor, drive the motor rotation, until the deviation is less than the set value \( \varepsilon_1 \). When the deviation is less than the set value of \( \varepsilon_1 \), the tracking system will skip roughing directly into fine tuning [4].

Enter the fine tuning section, and adjust the azimuth Angle and height Angle at the same time. By comparing the current position information with the data collected by the four-quadrant sensor, the error value is determined to be less than the given adjustment dead zone \( \varepsilon_2 \). If it is greater than \( \varepsilon_2 \), the azimuth and height Angle of the motor are controlled by PID control PWM output, so that the car rotates smoothly until the deviation is less than \( \varepsilon_2 \). When the deviation value is within the given dead zone (i.e., less than \( \varepsilon_2 \)), it means that the solar panel is in a vertical state with the sunlight at this time, and the solar tracking is over [5].
3.2 Hardware design of solar tracking system
According to the schematic diagram of solar tracking algorithm, the system structure block diagram 3 is obtained. The output unit includes four drive motors for controlling the azimuth Angle, two telescopic rod motors for controlling the height Angle and two motors for controlling the expansion and closure of the solar panel [6].

3.3 Program design of solar tracking control system
The program flow chart of the solar tracking control system is shown in Fig. 4. First, set the local latitude $\phi$ and read the lithium battery voltage $U_1$ ($U_1$ and $I_1$ read the data of the collection circuit that the solar energy acts as a point controller through the serial port, as described in Chapter 4) and the four-quadrant sensor acquisition voltage $U_3$ ($U_3$ is the sum of the four quadrants data). Then judge whether the battery needs to be charged, that is, whether the battery voltage $U_1$ is less than the set discharge cutoff voltage $U_2$, 10V. Then judge whether the current weather allows charging, that is, whether the four-quadrant voltage $U_3$ is greater than the set voltage $U_4$ ($U_4$ is the sum of the four-quadrant voltage under weak light condition, $0.08 \times 4 = 0.32V$). Finally, only when the above two conditions are met, can the solar tracking function be carried out. In addition, before tracking, the top solar panel and the second solar panel should be opened by the chip control motor, and then the rough tuning link can be entered [7].

4. Experimental data analysis
The tracking structure of on-site inspection vehicle is single axis tracking structure. The structure uses the expansion function of the telescopic rod motor to make the solar panel rise and fall, so as to realize the tracking of the height Angle. When the sun height Angle is too large and the telescopic rod can not be tracked, the screw motor will push the rod back to drive the slider on the slide rail, and then drive the telescopic rod motor to move backward, so that the height Angle reaches 90°. The experiment began at 10.55am with a temperature of 18 °C and a cloudless sky. The measurement voltage of the lithium battery was 11.5V. The lithium battery selected for this test has a capacity of 12V and 60Ah. This battery is chosen because it has a display circuit to display the remaining power.
Figure 3. Block diagram of the control system.

As can be seen from Figure 5, the voltage of the lithium battery increases slowly to 12.6V from the initial 11.5V after 2 hours and 30 minutes of charging, indicating that the power inside the battery is slowly increasing. The constant current charging current is relatively stable. By calculating the average output current per hour is 5.2A, and calculating the output power and input power, the efficiency of the solar charge and discharge controller can be obtained, and its efficiency is more than 72%.

5. conclusion
In this paper, a solar tracking system is designed for outdoor patrol cars. The control algorithm is composed of photoelectric tracking method and apparent solar orbit tracking method. The solar
Figure 4. Flow chart of the double loop tracking system.
azimuth is found by using the gyroscope and the apparent solar orbit tracking, and using four quadrant photoelectric sensor combined with PID control accurate positioning the solar azimuth. Through the hardware and software design, the automatic light tracking function of the detection vehicle in the field environment is realized. According to the experimental data, it is proved that the optical tracking system can improve the output power of solar panels.

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