Photovoltaic-Based Intelligent Search and Rescue Trolley

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Abstract. For the search and rescue work after the earthquake or the exploration of unknown areas, a photovoltaic-based intelligent search and rescue device was designed. A hardware platform for a car automatic driving system controlled by an STM32 single-chip microcomputer based on an ARM core is constructed, which consists of a photovoltaic auxiliary power generation module, a power supply module, a main controller module, obstacle detection, a motor drive module, a speed detection module, and a video transmission module. And constructed a software platform based on ARM core STM32F103 single-chip microcomputer controlled automatic control system. Finally, through the joint debugging of the hardware and software parts of the photovoltaic intelligent search and rescue equipment, the stability and feasibility of the system were verified, and the functions of photovoltaic-assisted power generation, manual control, autonomous obstacle avoidance, and video transmission of the car were realized.

1. System structure

When rescue technology is applied to local medical and disaster area search and rescue, it will be restricted by many factors, such as high energy consumption in transportation, high risk of rescue personnel and high manpower and time cost. To solve the problem of high energy consumption of search and rescue and high risk of search and rescue personnel, applying unmanned vehicle technology and photovoltaic power generation technology to the search and rescue industry, it is a feasible way to design a photovoltaic intelligent rescue car instead of the traditional car search and rescue to solve short-range search and rescue. The current smart cars are mainly manually operated by humans, but there are many disadvantages to manual operation. On the one hand, in some special environments, such as very low visibility, which may not be observed by human eyes, manual manipulation is inconvenient, but infrared sensors can detect obstacles and make them pass smoothly. On the other hand, when basic rough detection is needed, automatic obstacle avoidance instead of manual operation can save manpower and improve efficiency. Therefore, the automatic obstacle avoidance function is added on the basis of manual control, so that the car has higher adaptability [1][1].

In order to meet the functional requirements, the main components of the entire control system are: power supply module, photovoltaic auxiliary power supply module, main controller module, obstacle detection, motor drive module, speed detection module, video transmission module, positioning module, etc. The modular design is adopted, and the functions are independent of each other, which is convenient for subsequent improvement. The overall block diagram of the system is shown in Figure 1.
The functions of each module are as follows:

(1) Control center
   As the brain of the entire control system, it runs the solution and coordinates the information of each module, and uses a 32-bit single-chip microcomputer ST32F103ZET6 as the controller of the smart car.

(2) Power module:
   With two 18650 lithium batteries as the power supply, the output voltage in series is 7.4V, which is responsible for the power supply of the entire system.

(3) Photovoltaic auxiliary power generation module:
   Through the controller to extend the battery use time, it can achieve the effect of energy saving and emission reduction.

(4) Obstacle detection module:
   Infrared photoelectric sensor (Detect the target by judging whether the received light is strong or weak, and the power supply voltage is 5V) is used to detect obstacles and transmit data to the control center for processing.

(5) Speed detection module:
   The speed of the DC motor is measured in real time and uploaded to the control center, so that the motor control becomes a closed-loop control system. The speed sensor used is a Hall sensor, and the speed of the car can be obtained by counting the number of pulses in the sampling time.

(6) Motor drive module:
   The motor of the car drives independently to achieve differential steering. The integrated circuit L298N is used to control the motor, and the speed of the motor is adjusted by the pulse width modulation (PWM) method.

(7) Video transmission module:
   Connect the car via WIFI to transfer the video collected by the device to the mobile phone or PC.

(8) Positioning module:
   Based on Web services and GPS positioning, the position of the car can be obtained in real time.

2. Hardware design

2.1. Driving obstacle avoidance module
   The car driving module includes two parts, one is a motor-driven part to change the driving direction
of the car; the other is an infrared obstacle avoidance part to avoid obstacles for the car.

The motor driver uses the L298N driver chip. The L298N driver chip has a built-in 4-channel logic communication circuit. It has the characteristics of high working voltage, large range and large current. It can drive two DC motors or a two-phase stepper motor [3][4]. The car's motor uses a DC motor (The power supply voltage is 3V, the rated power is 3W, and the speed is 200 rpm), so two L298N are used to drive four motors. The complete driving circuit of an L298N chip is shown in Figure 2-1.

![Motor drive circuit](image)

Figure 2-1 Motor drive circuit

In the field of smart cars, obstacle avoidance sensors used are mainly divided into ultrasonic obstacle avoidance sensors, infrared obstacle avoidance sensors, and Lidar sensors. Obstacles detected by infrared obstacle avoidance sensors are not limited to metal objects. Any object that can reflect light can be detected, and has the characteristics of simple operation, mature technology, and low cost [5].

The HJ-IR2 photoelectric sensor was selected for this design, as shown in Figure 2-2 below. The sensor has a measurement range of 30-80cm, and uses a 5V DC power supply, which can be used directly with the 5V power supply provided by the system power supply for easy design. It is worth mentioning that the sensor outputs digital signals when it is working, that is, high level and low level. It can be used directly without digital-to-analog conversion, and the sensor is not sensitive to sunlight and can be used in daylight. In this design, the obstacle detection of the car is obtained by an infrared photoelectric sensor. The method uses a triangular ranging method. The sensor is set as shown in Figure 2-3 below.

![Infrared detection module](image)

Figure 2-2 HJ-IR2 infrared detection module

![Car sensor settings](image)

Figure 2-3 Car sensor settings

2.2. Photovoltaic auxiliary power supply module

The photovoltaic auxiliary power supply module is mainly composed of a solar photovoltaic panel, a controller, and a battery. The battery provides the main source of power for unmanned distribution equipment. When there is sunlight, the solar photovoltaic panel charges the battery through the controller to extend its use time and achieve the effect of energy saving and emission reduction. Because the output power of solar photovoltaic cells is affected by environmental factors such as light intensity and temperature, in order to ensure the normal and efficient operation of solar panels, maximum power point tracking (MPPT) is required in the control system[6][7].

The auxiliary power supply module selected in this paper is two solar photovoltaic panels connected in series, and each output power is 5V / 250mA. From the perspective of fully utilizing the conversion energy of solar energy, the SPV1040DC-DC conversion chip is selected to track the maximum power point to improve the conversion efficiency of solar energy. Taking into account the change range of the output voltage of solar cells, the charging safety of lithium batteries, and the working conditions of the charger itself, The L6924D power management chip is selected, and the
solar lithium battery charger with SPV1040 and L6924D as the main chip is designed. The solar charger design circuit for lithium batteries includes a solar panel boost circuit and a lithium battery charge management circuit. The boost circuit of the solar panel is shown in Figure 2-4. The lithium battery charge management circuit is shown in Figure 2-5.

2.3. Video transmission module

For mobile phones or computers commonly used in daily life, use WIFI for video transmission, and receive and display videos in the user interface. Use STM32 as the main controller to drive the camera to collect video information, send the video information captured by the camera to the wireless communication module to convert to the Wi-Fi communication protocol format, and send it to the wireless channel through the WIFI transmission module. And the computer receives the image information and displays it in real time [8]. The design of the video acquisition and transmission part is shown in Figure 2-6 below:

The WIFI module used in this design is to modify the router system and replace the original firmware with Open firmware. This router is equivalent to a small computer system installed in Linux system. It uses 8Mflash chip and 64M large memory. The resolution is 480 * 680, the input voltage is 5V and does not exceed 5.3V, and the current consumption is 1.2W. The signal indicates that the LED light is turned off for two seconds after turning on. This saves power. To send commands, the interface must be connected to the corresponding serial port on the main controller. As shown in Figure 2-7 above.

3. Software design

The main tasks of the system program of photovoltaic intelligent search and rescue equipment are to complete the system initialization, process the data uploaded by each sensor (infrared photoelectric sensor), and control the motor operation. When the car starts to move, it will feel the information from the sensor in real time. When it encounters an obstacle, it will control the motor to avoid obstacles. This design uses a digital photoelectric sensor, so you only need to connect the sensor to the I/O port of the processor to use the photoelectric sensor. The sensor will output a low level when there is an obstacle, so you only need to set the trigger mode of the interrupt to the falling edge interrupt. Then it
will trigger the interrupt when the input signal of the I/O port is low, and implement the obstacle avoidance program, control the DC. The operation of the motor to realizes the corresponding deceleration, backward, left-turn, right-turn and forward operations of the car [9]. The main program block diagram of the trolley is shown in Figure 3-1 below.

**Figure 3-1 Control program flowchart** [9]  **Figure 3-2 Wireless communication design flowchart** [10]

Wireless data transmission is the transmission of control signals and video information, which is based on the TCP/IP protocol. The sending end of the system sends the signal to the nested word structure, and the receiving end will read the data information in the nested word structure, which facilitates the communication between different hosts. The host computer sends the control command to the control terminal, receives the video signal transmitted by the WiFi signal through the Socket communication mechanism, and then displays it in real time on the host computer. The upper computer decodes the video signal transmitted by the lower computer into picture information, and then combines the corresponding video signal on the upper computer, and finally ends the data transmission by judging the monitoring status [10]. The flowchart is shown in Figure 3-2 above.

According to the functional requirements of the video transmission system collection terminal, the main tasks of the video acquisition terminal are to collect the video information of the environment in which the smart car is located, compress the video data, and send the compressed video stream [11]. When the camera starts to work, it compresses the collected signal, and then transmits the compressed video signal to the upper computer through a wireless router, where it can be monitored in real time. The specific principle is to store the collected signal into the buffer of the queue, and then the compression thread compresses the video signal in real time. The compression thread is to compress the collected video signal into a data stream according to the JEPG video compression standard, and then send it to the upper computer through wireless WiFi, and the upper computer then composes these signals into a frame signal to decode and display a frame of image [9][10]. The working...
flowchart of the collection thread is shown in Figure 3-3, and the receiving worker thread flow diagram is shown in Figure 3-4.

![Flowchart](image)

**Figure 3-3** Video sender flowchart [9][10].  **Figure 3-4** Video receiving end flowchart [9][10].

4. Test results and discussion
After doing the above work, the related functions of photovoltaic intelligent obstacle avoidance unmanned search and rescue equipment were tested, and some thoughts were made on the application prospect of the car.

4.1. Functional test
In order to realize the autonomous obstacle avoidance function of photovoltaic intelligent obstacle avoidance unmanned search and rescue equipment, a lot of work has been done in this design, and the obstacle avoidance function is now tested.

When the infrared sensor receives the infrared signal reflected by the obstacle, the indicator light of the sensor will light up, and enter the interrupt processing routine, perform the operation of backing and then turning. When the obstacle in front is greater than the infrared detection range, the lights on both sides light up, and then turn back to the right to a larger range, and then continue to detect; when an obstacle is detected on the left, the left light is on and then turn right; When an obstacle is detected on the right, the right light turns on and then turns left. The test is shown in Figures 4-1 (a), (b) and (c). The test was performed in the sun. And the infrared sensor was not disturbed and the working condition was normal.
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The car encounters an obstacle. (b) The car makes a right turn. (c) The car makes a left turn.

**Figure 4-1** Obstacle avoidance test chart.

The photovoltaic auxiliary power supply system of the car was tested outdoors, as shown in Figure 4-2(a) and (b). When the sunlight is blocked, the photovoltaic power supply system does not work, and the green indicator light is off; when there is sunlight on the car's photovoltaic panel, the green indicator light flashes, indicating that the battery is being charged.

(a) There is no light (b) Light to photovoltaic panels

**Figure 4-2** Photovoltaic power supply test

In order to realize the video transmission function of photovoltaic intelligent obstacle avoidance unmanned search and rescue equipment, the video transmission function is now tested. The device is connected to the mobile phone through the WIFI module to realize the video transmission function of the device. As shown in Figure 4-3, whether it is indoors or outdoors, the road is flat or rugged, the car can run well and transmit the surrounding conditions in real time.

**Figure 4-3** Real-time image transmitted by the device.

The photovoltaic intelligent search and rescue equipment designed in this article uses an infrared sensor control module for obstacle avoidance modules. The sensor measurement range is 30-80cm, the blind zone is 2cm, and the accuracy of the distance measurement is 0.3cm. However, during the test, the car occurs when it is 15cm from the obstacle. The deflection may be caused by the distance between the two HJ-IR2 infrared detection modules installed on the device being too close, which results in a steering command operation only when the distance between the device and the obstacle is closer.
4.2. Discussion
At the 2019 China Smart Car Conference and National Smart Car Development Forum, professors and experts from scientific research institutes, universities, academia, and industry applied the industrialization of smart car technology and promoted its in-depth application in energy, transportation and other fields discussed with industrial transformation and upgrading. Professor Chen Qijun of Tong ji University emphasized the problems of location identification combining ultrasonic and surround view, monocular visual positioning based on vehicle model, search-based complex path planning method, horizontal and vertical decoupling path planning method, etc. Huang Luoyi, senior manager of Bosch Automotive Components (Suzhou) Co., Ltd., focused on sharing the importance of safety for mass production of autonomous driving from the perspective of intelligent driving technology end users, involving perception, decision-making, control, map and positioning, regulations, etc. Great Wall Motor Co., Ltd. introduced how the new technology can truly achieve landing and large-scale application under the premise of safety [11]. In addition, how smart cars react to the environment through perception, transmission, analysis, decision-making, and control to complete autonomous driving requires further research and testing [11].

This design adds the function of autonomous obstacle avoidance on the basis of manual remote control. At the same time, the photovoltaic power generation system is used as auxiliary power supply. It is mainly used in the field of search and rescue in short distance. There is no competitive relationship with smart cars, but the development of smart cars thinking also applies to the field of search and rescue, and puts forward higher requirements for the development of the field of search and rescue. Of course, further research on photovoltaic intelligent search and rescue equipment can apply this technology to logistics transportation, combined with driverless and electric vehicle technology, and use photovoltaic power generation technology to solve the problem of long-distance driving vehicle energy power can effectively reduce the consumption of petroleum resources and control the emission of harmful gases which are truly green and environmentally friendly new renewable energy sources with higher commercial value.

5. Conclusion
The designed photovoltaic intelligent rescue car adds a little auxiliary automatic obstacle avoidance capability on the basis of the original manual remote control to increase operability. In addition, the car uses clean energy solar energy to provide power for the car's battery life, which has higher commercial value. When observing some rescue sites such as earthquakes or unknown areas of danger, the photovoltaic intelligent search and rescue trolleys of this design are sent to the site for surveying, first grasp the internal conditions of some sites, and then provide real-time timing and fixed-point feedback to the outside through video and positioning functions. Search and rescue personnel can provide them with many conveniences, which not only saves survey time, but also allows them to understand the situation on the scene more quickly, which indirectly reduces the casualties of search and rescue personnel. To a certain extent, it can also replace the function of search and rescue dogs, which can reduce the huge manpower and material consumption in the professional search and rescue dog training process, and use the least human, material and time to achieve the best rescue and material assistance.

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