Design and Implementation of Intelligent Car for Light Environment Detection Based on Data Analysis

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Abstract. With the wide application of LED lighting products in road lighting, there are more and more requirements for illumination measurement. Traditional road illumination measurement uses full manual method, which takes a long time, but the amount of data collected is small, which easily leads to inadequate measurement accuracy, and the full manual measurement method cannot guarantee the personal safety of the surveyors. Therefore, the development and design of an intelligent car can accurately and quickly detect the illumination of street lamp and road surface. The design of this intelligent car is based on cloud server. The hardware core is composed of Raspberry pie and Arduino. Through Arduino management and scheduling illuminance measurement module, GPS positioning module and wireless remote control module, the measured data are packaged and sent to the cloud server through Raspberry pie for data storage and analysis in real time. Finally, the data are stored and analyzed through the visual window. The test results were displayed. Compared with the traditional road lighting detection method, the illumination detection method based on intelligent car can improve the detection efficiency, increase the data accuracy and ensure the safety of the inspectors.

Keywords: Intelligent car · Illumination measurement · Wireless remote control · Cloud server

1 Introduction

Road lighting detection technology is an important means to evaluate and test the lighting quality of road lighting products. It is of great significance for accurate and fast detection of illumination parameters of street lamps and pavement. The North American Institute of Lighting Engineering has made a thorough study on road lighting

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standards [1]. Illumination and brightness are the main test parameters required by the National Lighting Standards of the United States for road lighting. The measurement methods, operating instruments and the distribution of monitoring points are standardized, and began to try to use cars for mobile testing. In our country, the light environment detection only stipulates the lighting detection indicators or design requirements, and most of them directly apply the relevant foreign standards. At present, the basis of detecting and evaluating road illumination quality is mainly composed of two evaluation indexes: road illumination parameters (road illumination, average illumination, illumination uniformity) and power consumption. For the measurement method of illumination, the center distribution method and the four corners distribution method are mainly adopted [2]. The on-site detection steps of road illumination parameters are as follows:

(1) Enclosing the detection lane before detection, measuring the distance between the two street lights and determining the spacing of the distribution points;
(2) After locating the points according to the standard method, the inspectors use the illuminometer to test and record points by points.
(3) Using the same steps to measure the adjacent lanes.

The whole process of this testing method is manual testing (30–40 min per test) low detection efficiency, low level of automation, difficult to guarantee the accuracy and consistency of measurement results, personnel working in semi-closed traffic, which is easy to cause greater security risks. It fails to meet the requirement of shortening test period and reducing test times. Therefore, the detection method of road illumination is in urgent need of improvement. Currently, vehicle-based detection equipment has appeared in China [3, 4]. But this kind of car is not very perfect in function, neither can realize intelligent remote control, nor can the data collected for storage and analysis. The intelligent light environment detection car based on data analysis designed in this paper has the function of automatic detection of road illumination. It can continuously pick up points in the test range and form large data storage. It is helpful to shorten the detection period and ensure the safety of the inspectors.

2 System Overall Design

This design is based on cloud server. The hardware core is composed of Raspberry pie and Arduino. The overall design, hardware selection and software compilation of illumination measurement system are carried out. Intelligent car drives DC motor by double H bridge chip to control the car's driving; GY-616 axis gyroscope attitude sensor is used to measure the car's motion state, adjust the car's driving direction and speed; GPS module is used to locate the car's longitude and latitude in real time; BH1750FVI illumination module is used to measure illumination and pass through. Through I2C protocol, the data will be transferred to Arduino, and then through serial communication, the data measured by the module will be transmitted to Raspberry pie. The Raspberry pie will pack the data and send it to the cloud server. After receiving the data packet, the cloud server will analyses and store the data in real time. Finally, the collected data will be presented through the visual window. The system block diagram is shown in Fig. 1:

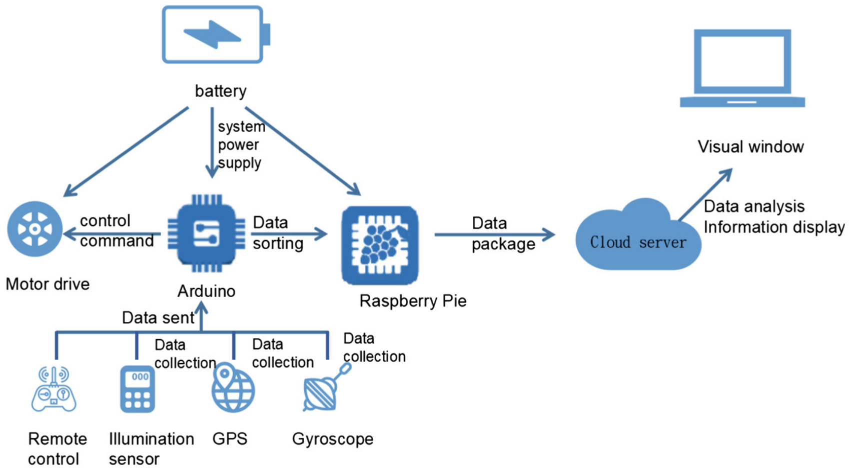

Fig. 1. System block diagram

3 Hardware Design

The intelligent light environment detection vehicle based on large data analysis includes GY-30 digital light sensor BH1750FVI module, 2.4G remote controller, DC motor drive, ATMEGA328P, 12 V lithium battery, Raspberry Pie 3 generation B+type, GY-616 axis gyroscope attitude sensor, GPS module, flash memory card, metal frame and other components.

3.1 Main Control System

The main control system includes body, extended version, Arduino board and Raspberry pie. Arduino controls the motor's forward and backward rotation and speed by controlling the dual H bridge L298 driver chip, thus realizing the control of the car's Omni-directional driving; adding GY-616 axis gyroscope attitude sensor to detect the car's motion information can realize the functions of automatic speed regulation and direction adjustment; in addition, Arduino receives the pulse width modulation from the remote controller. Signal, remote control can be realized (Fig. 2).

3.2 Sensor System

The sensor system consists of three parts: GY-30 digital light intensity illumination sensor, GY-616 axis gyroscope attitude sensor and GPS module. Among them, GY-30 digital light intensity illumination sensor collects illumination information, GY-616

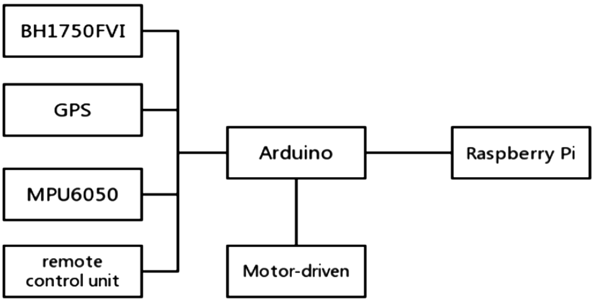

Fig. 2. Hardware block diagram

axis gyroscope attitude sensor detects the motion state of the car, and GPS module is used for positioning. All sensors and Arduino communicate with each other through I2C mode to transmit data. The measured data are analyzed and real-time adjusted to the direction and speed of the car, illumination and other information.

1: GY-30 Digital Light Intensity Sensor
BH1750FVI, a digital ambient light intensity sensor without distinguishing light sources, is an integrated circuit with two-wire serial bus interface [5]. It has the advantages of high measurement accuracy and convenient data acquisition. BH1750FVI can monitor the environment according to the collected light intensity data. Its high resolution can detect a wide range of light intensity changes. It has a high resolution of 0-65535Lx and can support a wide range of light intensity changes. Among them, ADDR is the port to control the address of BH1750; DVI is the reference voltage port of I2C bus and the asynchronous reset port of chip; SCL is the clock signal terminal of I2C bus to produce high and low level changes and control data transmission; SDA is the data terminal of I2C bus for data transmission.

2: GY-616 Axis Gyroscope Attitude Sensor
Y-616 Axis Gyroscope Attitude Sensor is a high precision, high stability, small volume attitude measurement module. It integrates three-axis acceleration, three-axis gyroscope output, and combines Kalman filter technology; the measurement results are more accurate. In addition, it has an automatic zero offset detection and calibration algorithm, which can automatically identify the motion state of the module and automatically calibrate the gyro's zero offset when the module is still. The power input is 5 V/3.3 V. XDA/XCL is used to connect other IIC interface sensors. SCL and SDA are used as clock signal ports and data terminals of I2C bus. INT generates interrupt signals and connects them to Arduino.

3: GPS module
GPS module is an integrated circuit which integrates RF chip, baseband chip and core CPU, together with related peripheral circuits. With up to 50 parallel channels, fast start searching ability, accurate positioning effect, compact size and excellent performance, it is very suitable for applications with high performance and low power consumption. The module has amplifier circuit, which is helpful for passive

ceramic antenna to search satellites quickly. It can set various parameters through serial port, and can be saved in EEEPROM. It is also very convenient to use. In addition, the module also has SMA interface, which can connect all kinds of active antennas. It has strong adaptability and is compatible with 3.3/5 V level. It is convenient to connect all kinds of MCU systems. At the same time, it has its own rechargeable backup battery, which has the function of keeping ephemeris data when power is off. GPS module communicates with Arduino through I2C bus.

3.3 Power Supply System

The power supply system consists of rechargeable 12 V lithium batteries and LM2596S DC-DC DC adjustable step-down regulated power supply module. The 12 V lithium battery not only provides driving voltage for JGA25-371 deceleration motor, but also provides 5 V DC regulated power supply for the whole system through LM2596S power supply module [6] (Fig. 3).

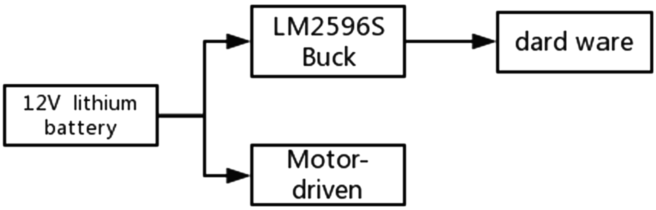

Fig. 3. Power supply system diagram

4 Software Design

4.1 Illuminance Measurement Function

The photometric data measured by photosensitive diode (PD) is amplified by integrated operational amplifier (AMP) and then transferred to analog-to-digital converter (ADC), converted into digital signal, and then into illumination calculator for calculation. The illumination data is transmitted back to Arduino through IC communication. Arduino sends the data to Raspberry pie after sorting, and then uses the principle of message-driven mechanism to pack and upload the data to the cloud server according to the message format. The local visual window obtains the data from the message queue of the cloud server and displays it. Figure 4 shows the data processing flow of illumination measurement.

On the Arduino to Raspberry pie in the process of data processing [7], SendMsg function is responsible for data processing according to the planned format, including the related parameters of software version number, message serial number, UTC time for data collection, the precision of the collected data, collected data of GPS data, temperature, humidity, the current device's MAC address, data specification and checking information and intensity of illumination, which also have reserved fields, convenient later to expand the content of the message data. When the collected data are

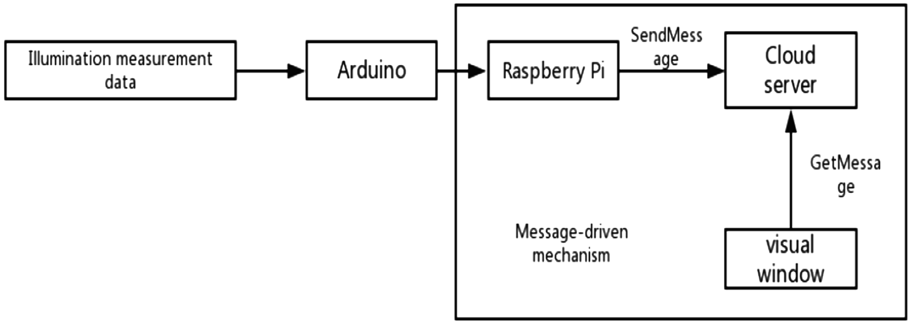

Fig. 4. Illuminance measurement data processing

sorted out, the socket is used to communicate with the cloud server and the data is uploaded to the cloud server for storage and analysis.

4.2 Intelligent Car Attitude Detection Function

GY-61 6 Axis Gyroscope Attitude Sensor module measures the attitude of the car, calculates the motion information of the car, converts the measured analog quantity into the output digital quantity through three 16-bit ADCs on the module, and finally transmits the measured data back to the Arduino board through SDA interface. After receiving the data, the Arduino board runs the algorithm stored in the Arduino board to control the running of the car, thus changing the driving state of the car [8] (Fig. 5).

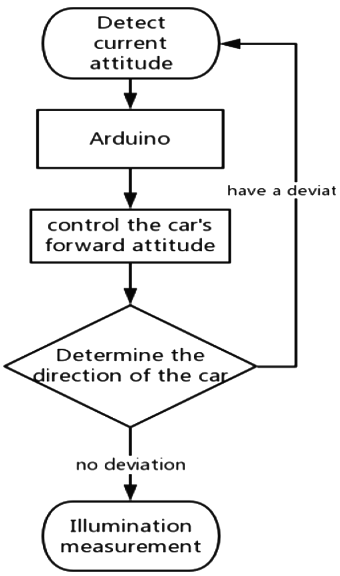

Fig. 5. Flow chart of intelligent car attitude detection

4.3 Network Data Transmission and Data Visualization

The intelligent car server designed in this paper selects the DataV data visualization service of Aliyun [9]. Compared with the traditional chart and data dashboard, this service can provide a more friendly and vivid form. The system collates the data collected from the Raspberry pie according to time periods and packages them into packets. When the network communication is good, the packet will be sent directly to the cloud server. If the signal is not good, the packet will be delayed to prevent data loss. After receiving the data packet, the cloud server will dismantle the data and store the data in the cloud MySQL database. Finally, the data required by the user is displayed in real time on a visual screen created with DataV. The interaction process between Raspberry pie and Cloud server is shown in Fig. 6:

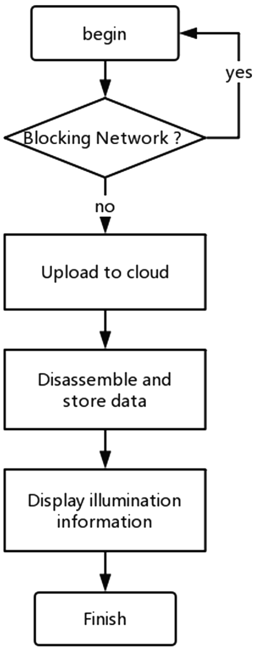

Fig. 6. Raspberry pie and Cloud server processes

The data visualization window is shown in Fig. 7. In the visualization window, the map information, current running speed and illumination curve of the smart car can be displayed in real time.

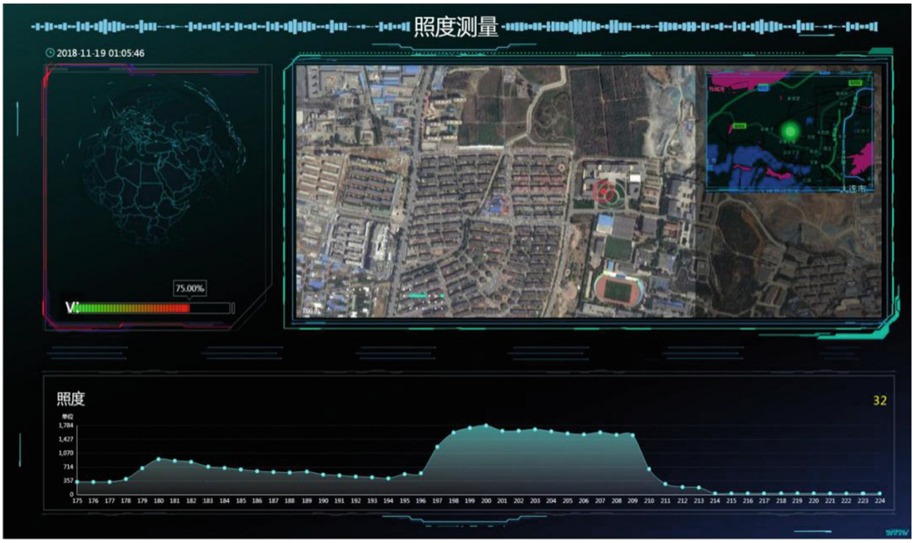

Fig. 7. Visualization window

5 Concluding Remarks

This paper designs an intelligent car for light environment detection based on data analysis, which has the functions of road illumination automatic measurement, GPS positioning and wireless remote control. At the same time, the data storage and analysis function can be realized by connecting the cloud server with the wireless network. This design not only has the advantages of fast measurement speed, low labor intensity, convenient data processing and more intuitive display results, but also greatly reduces the danger of manual measurement and guarantees the safety of the surveyors. The use of car measurement also eliminates the difference of light shielding, reflection and height of the measuring points caused by the surveyors in the field. Due to the interference of other factors, more measurement data and less calculation error are obtained, which effectively improves the accuracy of measurement and data acquisition.

With the increasing application of domestic LED lighting products in the field of public lighting and lighting energy-saving transformation, the intelligent car will realize the level of information and automation of detection technology, further optimize the standard system, and promote the healthy development of the lighting industry, which has important research and development value and practical significance.

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