Design and Implementation of an Indoor light supplement control system based on STM32 microcontroller

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Abstract. At present, most traditional lighting methods use energy conversion methods, which not only causes great harm to the environment, but also has great functional limitations and low solar energy utilization. This paper proposes an indoor adaptive precise light supplement system that can be applied to multiple scenes. This system introduces the hardware and software components of the adaptive and accurate light supplement system from three aspects: the light follow-up system, the light supplement system, and remote monitoring. It realizes the information interaction between users and the system, which significantly improves the accuracy and efficiency of indoor lighting, and has great strategic significance for the full development and utilization of solar energy.

1. Introduction
At present, the application of solar lighting in the market is mainly a sunlight introducer, which locates, tracks, and separates sunlight through optical sensors, mechanical devices, and light-concentrating components, and then sends the sunlight into the room through optical cables to provide the room with light. It is to provide a new energy-saving way to reduce environmental pollution [1]. However, the solar light importer has the problem of being very expensive. Although it can provide lighting, it has a high dependence on the external sunlight and cannot adequately provide a stable and constant light source. It cannot meet the requirements for monitoring and adjusting indoor light intensity. Therefore, we have designed a system that can be applied to multiple scenes, can adapt to the environment, and achieve perfect fill light. It can not only meet the use of sunlight but also solve the problems of high cost and environmental adaptation.

2. The overall structure of the system
The system is mainly composed of three parts: data acquisition layer, data transmission layer and computer control management layer. It mainly implements automatic chasing light when the external light is sufficient. When the external light is insufficient, the indoor light sensor detects it and then turns on the corresponding LED light to keep the indoor light intensity constant. The data acquisition layer is designed by integrating multiple sensors and signal transceiver units. Form a wireless sensor for sensing outdoor light intensity. Data collection The day lighter composed of Fresnel lens and ellipsoidal casing gathers the orthographic light in a large radius into a light spot. The Fresnel lens has the unique advantages of small size, lightweight, and low cost. [2] Through total reflection The optical fibre guides light into the room. The daylighting device is mounted on a 3D printed tracking head that automatically tracks and locates the position of the light source. The head determines the position of the light source through multiple sets of lighting sensors in the data acquisition layer and calculates and outputs the...
control signal to the servo through the main control MCU. The rotation of the steering gear makes the gimbal point vertically to the light source, and the dual-axis tracking, that is, the full tracking [3] is used to improve its utilization of light. At the same time, an indoor light sensor is arranged to detect the indoor light intensity. When the outside is in a dark or no-light environment such as cloudy or night, the indoor sensor detects that the current light intensity is below a set threshold. Constant, the main control MCU issues a command to turn on the LED lights in the room to achieve normal life intensity.

![System flowchart](image)

**Figure 1. System flowchart**

3. hardware design

3.1. Two-axis motor controller

Using high-quality engineering plastic as the shell material, built-in analogue-to-digital, digital-to-analogue conversion circuit, STM32 main control chip, motor drive circuit, etc. The shell reserves the waterproof interface and mounting holes of other modules, and uses multi-core wires to link with other modules. To solve the problem that the existing solution is too cluttered due to too many connection lines, the anti-interference ability of the system is improved, and the overall industrial-grade three defences are achieved.

3.2. Solar positioning module

It adopts integrated design, pre-commissioning, and only uses a single-line link with the control module. This connection line integrates power and signals. XH2.54 is used, and the 5P end is only used as an interface to the controller. Commissioning steps.

3.3. Photosensitive module

According to the tracking method, the tracking of the sun is roughly divided into active tracking and passive tracking. Passive tracking generally installs multiple photosensors on the sun receiving board [4]. The photosensitive module is implemented with a BH1750 sensor, which has high efficiency and small size. Low power consumption and long life [5]. BH1750 sensor is a digital light intensity sensor integrated circuit for two-wire serial bus interface, this integrated circuit can adjust the liquid crystal according to the collected light intensity data or the brightness of the keyboard's backlight, and its high resolution can detect a wide range of light intensity changes.
Two-dimensional tracking is also called full tracking [6]. Two mutually opaque flat plates are fixed on the bottom plate as shown, and a photoresistor is placed near the centre of the cross. When the light comes in from different angles, four each photoresistor has different resistance values due to different light intensity. The light source position can be calculated by comparing the resistance values of the four photoresistors. The principle of comparing and calculating the position of the light source is: the photoresistors P1 and P3 are irradiated in the horizontal direction. If the light collector is not vertically aligned with the light source, the two photoresistors will have different resistance values. The photoresistor is a junctionless device. It is made by using the photoconductive properties of semiconductors. The stronger the light intensity, the smaller the resistance [7]. When the voltage changes, the control circuit drives the horizontal steering gear to rotate through the change of voltage so that the light collector can vertically align the light source. The principle of controlling the light collector to align the light source in the vertical direction is the same as that in the horizontal direction. Through the single-chip microcomputer control system and the light source position tracking system, the requirements of automatic tracking of the light source position are achieved.

3.4. Light collection module
Reduce the existing solution Fresnel lens focal length, further compress the equipment volume, reduce the weight of the module, and facilitate transportation and installation. The design scheme is: the collector housing is made of ABS engineering plastic, and ABS engineering plastic has wide application [11], anti-ageing, long service life, reduce the cost per unit time. The shape is a hemispherical autumn shell with an open bottom, and the shell is injection-moulded. The sensor mounting hole is reserved at the top, and the mounting hole is preset at the bottom for quick installation on the motor bracket. The schematic diagram of the light collection module is as follows:

![Figure 2. Light collection module](image)

3.5. Two-axle bogie integrated block
The design uses an aerospace-grade aluminium tube as the skeleton structure, which reduces the weight while increasing the structural strength. Its structure is: the top flat plate structure is connected to the light collector casing, the flat plate structure uses a single aluminium tube as a support, is connected to the flat plate center through a universal joint, and uses a soft transmission structure composed of steel cables, pulleys and motors to adjust the lighting direction of the device. The schematic diagram of the two-axle bogie integrated block is as follows:
4. Hardware control system
The control system is mainly composed of control of the light tracking system and control of the fill light system.

The STM32 series is based on the ARM Cortex-M3 core specially designed for embedded applications that require high performance, low cost, and low power consumption [9]. Connect the VCC of the horizontal and vertical servos to +5V of the STM2 board, connect GND to the GND of the STM32 board, and connect the PWM control signal lines of the horizontal and vertical servos to the two PWM leads of the STM32 board. Feet, by adjusting the PWM duty cycle to control the rotation angle of the horizontal servo and vertical servo, in order to achieve the purpose of making the collector face the light source [10,11].

In this design, two channels of PWM are used to control the rotation angle of the horizontal and vertical servos, and the four channels of the STM32 integrated AD converter are used to collect the voltage of the photoresistor to obtain the data to control the rotational orientation of the servo. When the light collector (four photoresistors) is illuminated by light at the same time, the data of the light intensity sensor BH1750FVI is read through the IIC bus to obtain the light intensity.

Press the power key to initialize the timer, set the timer to PWM mode, and initialize the PWM duty cycle, initialize the AD converter, and set the channel required to collect the photoresistor voltage for analogue-to-digital conversion. The iic bus initializes the light intensity sensor BH1750FVI. Adjust the rotation angles of the horizontal and vertical servos so that the light collector is in the best position to detect light. Start the AD converter and use the four channels of the AD converter to collect the voltage value of the photoresistor to determine whether there is light shining on the collector. If no light is detected, it indicates that it is still at night at this time and the sun has not risen to keep the light collector in the best position for detecting light; if it detects that light is shining on the light collector, determine whether the light collector is facing the light source (whether the four photoresistors are illuminated by light at the same time). The light collector is not directly facing the light source. Adjust the PWM duty cycle to adjust the position of the light collector so that it meets the light source. After the light collector is facing the light source, read the light intensity sensor BH1750FVI data through the iic bus, obtain the light intensity, and display it on the PC through USART. Because the sun moves slowly, you can sleep the MPU for one minute at this time to reduce power consumption. Repeat the above operation after one minute. The flowchart is as follows.
5. Software system design

5.1. Background program design
The background service program of this system adopts C language as the programming language to realize the data transmission and feedback control of the system.

The data communication is used for data collection through serial communication between BH1750 and STM32. The data is pre-processed in STM32, and the error data and incomplete data are corrected. The information is transmitted through the wireless sensor network module and transmitted through WIFI on STM32. Module, which sends the light intensity, deflection angle, and LED lights to the database on the computer side, and displays it on the web page; on the web page, you can see the real-time indoor light intensity, the real-time deflection angle of the light collector, and the indoor LED. The number of lights can be set through the Web at the same time, the threshold value can be set through the two-way communication between the host computer and STM32 to fill the light equipment, to achieve the effect of controlling the steering gear to adjust the indoor light intensity.

5.2. Database Design
With the precious resources of the open-source community, MySQL's performance has been favoured by developers and various enterprises [12]. As a relational database, MySQL uses SQL language for database management. Compared with large databases such as SQL Server, MySQL can work on different platforms. It has the advantages of high portability, compact and straightforward installation, and high operating efficiency. It can effectively reduce the working load of the server and has multiple storage types to meet Storage of data from different sensors.

This system uses a MySQL database and deploys the database using a docker container. Build a storage table corresponding to the collected data. When constructing the light intensity data table, three fields of timestamp (DHT-TIME), light intensity, and preset light intensity are used. The timestamp is
obtained by the strftime function and converted into a format. Floating-point decimal to mark. Modify the /etc/mysql/my.cnf file and open the remote port of the database for connection and data retrieval. Navicat Premium, as a database management tool, is suitable for data management of small databases.

5.3. Server setup
The entire system is implemented using docker container technology, and the tomcat container is used to implement the web server construction. As a lightweight web application server, the Tomcat server is suitable for small and medium-sized systems and occasions with fewer concurrent users. Tomcat binds IP address and listens to TCP port, supports running Servlet/JSP applications, can dynamically generate resources and return to the client; docker technology can achieve more lightweight development and deployment, making the entire server deployment process easier Efficient.

5.4. web client design
The system’s Web client uses a B / S structure and provides 1. the current light intensity display function; 2. the current light collector deflection angle display; 3. the indoor LED light to open the number display; 4. the light intensity preset function. The Spring Boot and Mybatis frameworks are used. Spring Boot is a new framework provided by the Pivotal team. It is designed to simplify the initial construction and development of new Spring applications. The framework uses a specific way to configure, eliminating the need for developers to define boilerplate configurations. In this way, rapid deployment and release can be achieved. Combine with the above-mentioned MySQL database to realize application service support.

The implementation of the Web client can be divided into two parts: the front-end display page and the back-end data processing. The front-end display page uses E-charts charts, handles ajax requests to dynamically obtain and load the encapsulated JSON data, and finally displays the indoor light intensity on the page in the form of charts; the back-end data processing is based on java development and uses the Spring microservices architecture to implement restful API and databases Access and format JSON data to better implement service deployment and iterative updates.

In the web client, send a request for the current light intensity display service, and convert related data information such as light intensity obtained from the database into a data curve and display it in the form of a graph; the deflection angle of the light collector and the number of indoor LED lights turned on are digital In the form of display, at the same time when sending a request for the light intensity preset service, enter the preset value through the front-end page, and send the data to the hardware device through the back end to realize the indoor light intensity preset.

6. Summary
The system combines software and hardware. Through continuous implementation and improvement, the functions in all aspects can reach the original design goals. It can remotely monitor the indoor light intensity and adjust the indoor light brightness in real-time. Compared with the traditional sunlight introducer, this system has a lower cost, and can continuously maintain the stability of indoor light intensity, and is not affected by the unstable outdoor light intensity. Making full use of solar energy and reducing environmental pollution caused by lighting is of considerable significance in scientific life, energy conservation and environmental protection.

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