Research Article

An Intelligent Lighting Control System for Urban Street Lamps Using Internet of Things

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With the rapid development of the city, the city's intelligent lighting control system has gradually replaced the traditional lighting control system. But at present, there are still some problems in urban street lamp lighting control, such as a low level of intelligence, a huge waste of electric energy, improper maintenance, and so on. Firstly, aiming at the problem of untimely detection of street lamp faults, this paper adds GIS technology to the intelligent lighting system and uses GIS to locate the faulty street lamp. To improve the accuracy of intelligent dimming, an improved intelligent dimming algorithm based on a support vector machine is proposed. To verify the effectiveness of the proposed algorithm, an intelligent lighting control system based on an improved algorithm and GIS technology is designed in this paper. It can control the street light switch in real-time and monitor the working condition of the street light in real-time. The performance of the improved system is verified by experiments. The experimental results show that the system achieves automatic dimming function through an improved dimming algorithm; the system can alarm and locate the fault lamp position quickly; the system can achieve a greater energy-saving effect.

1. Introduction

With the rapid development of urban construction, the street lighting system of each city has also developed rapidly. It not only improves people's night environment but also sets up a modern image for the development of the city. Recently, more and more people focus on the concept of environmental protection and low carbon. Energy-saving and environmental protection lighting has become an important issue facing today's society [1]. In cities, street lights usually stay on from late evening until morning, which can easily result in a huge waste of electricity. In addition, with the development of the city, more street lights are placed in each section according to the city planning. According to statistics, in our country's lighting power consumption, urban road lamp consumption accounts for 31% of the proportion. Therefore, energy-saving street lamps can bring greater economic benefits to society. Designing a lighting monitoring system with a high degree of automation, reliable operation, high efficiency and energy saving, convenient use and maintenance, and can beautify the city's appearance is an inevitable requirement for the modernization of lighting control and management.

Recently, IoT technology has become more and more popular. It has been widely used in many fields, such as intelligent transportation, smart home, intelligent lighting, and so on. In intelligent lighting, in order to save energy, many kinds of sensors are installed on the street lamp pole to collect data on the environment around the street lamp. These data are uploaded to the human-computer interaction center through wireless communication technology, and the remote automatic control of the street lamp switch and dimming is realized. Intelligent lighting systems have been used in many cities throughout the country. For example, Hangzhou city street lamp realizes intelligent control of city street lamp through an intelligent lighting system. Sanya realizes intelligent lighting management of street lamps and other lighting night scenery projects in scenic areas through intelligent lighting construction. Managers are free to manually adjust the brightness of street lamps and lighting of scenic areas [2]. The application of intelligent lighting systems in cities of China has achieved good results.
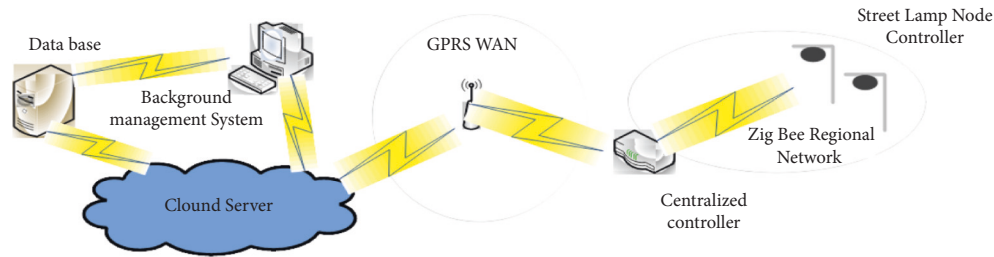
FIGURE 1: Framework of intelligent lighting control system for urban street lamps based on IoT.

Of course, in the intelligent urban lighting system, how to rationally plan the layout of street lamps, select the source of street lamps, intelligent dimming, prolong the service life of street lamps, timely troubleshooting and reduce management costs are all issues that need to be studied. Because of the large number of street lamps and the longtime of turning on the lights, there are many problems with urban street lamps, such as large power consumption and difficult management. Hangzhou Time Domain Electronic Technology Company has proposed a solution for intelligent street lamps. In the solution, the street lamp controller is connected to the communication network through RS485 bus, and then connected to the detection computer through the communication network. To address the issue with intelligent lamp sources, Millet introduced intelligent LED ceiling lamps and Yeelight intelligent lamps [3]. But at present, the phenomenon that the brightness of street lamps is not timely adjusted intelligently according to the environment of street lamps exists in many intelligent lighting systems. In addition, the failure of street lamp detection in time is also a problem in the current intelligent lighting system. Therefore, to address the issue of the untimely detection of street lamp faults, this paper firstly adds GIS technology to the intelligent lighting system and uses GIS to search for the location of the fault street lamp. It is convenient for managers to observe the state of street lights directly in the process of work, and to deal with them in time once the street lights fail. To improve the accuracy of intelligent dimming, an improved intelligent dimming algorithm based on a support vector machine is proposed. To verify the effectiveness of the proposed algorithm, an intelligent lighting control system with five parts is designed in this paper. It includes five parts: background management system, centralized controller, street lamp node controller, cloud server, and database. The background management system provides automatic dimming and fault alarm functions; central controller is responsible for data forwarding and remote wireless communication functions; street lamp node controller is responsible for data acquisition and ZigBee networking functions; and cloud server is responsible for backing up street lamp information collected by street lamp node controller. The database is mainly responsible for the storage of data, and to a certain extent guarantees the security, integrity, and reliability of the data.

The rest of the paper is sequenced as follows: An intelligent lighting control system for urban street lamps using IoT is discussed in Section 2, which is followed by experimental results in Section 3. These results are discussed thoroughly in Section 4. The paper is concluded with future research directions in Section 5.

2. Intelligent Lighting Control System of Urban Street Lamp Based on IoT

2.1. Framework of Intelligent Lighting Control System for Urban Street Lamp Based on IoT. Intelligent lighting system is mainly composed of signal acquisition, data communication, network transmission, analysis, calculation, and decision support. Therefore, the general framework of intelligent lighting control systems for urban street lamps based on IoT is shown in Figure 1.

As shown in Figure 1, the system mainly includes five parts: background management system, centralized controller, street lamp node controller, cloud server, and database. In this system, the street lamp node controller is installed on the lamp pole. On the one hand, it is responsible for the switch and dimming operation of the street lamp. On the other hand, it is also used for collecting information on the current, the intensity of sunlight, the traffic flow around the street lamp, and so on. The collected information is sent wirelessly through ZigBee network. Delivery to the central controller; the centralized controller is responsible for transferring the uploaded data to the cloud server through the GPRS network for backup. The background management system obtains data from the cloud server and displays it on the display screen for staff to see. On the other hand, the data is analyzed and processed to make decisions, and then gives instructions to the street lamp node controller according to the processing results. If it is fault information, the system will issue a fault alarm.

2.2. Key Technologies

2.2.1. IoT Technology. The Internet of Things (IoT) [4] is a type of physical Internet that makes it possible to share information about global commodities in real-time on top of the Internet. It is based on technologies like sensor technology, radio frequency identification technology, and more. To actualize the link between things, it depends on fixed and mobile networks. It is capable of achieving intelligent management and recognition. Without human intervention, it can function intelligently. The IoT is, therefore, a crucial component of the Internet of the future. It is a flexible,

adaptable global network architecture built on open, standardized, and interoperable communication protocols. In the Internet of Things, everything has a unique identity, set of physical characteristics, and fundamental individuality. Utilizing an intelligent interface, it integrates with the information network. The IoT is separated into three layers from the perspective of technological architecture, the first of which is the data perception layer. The foundation and core layer of the Internet of Things is the perception layer, which is the lowest layer of the three-layer architecture. Its major job is to finish collecting, converting, and collecting information. A network of short-distance transmitters and a variety of sensors make up the sensing layer. The sensor is used for data acquisition and control, and the short-distance transmission network is utilized to either convey the data the sensor has collected to the gateway or to the controller with instructions from the application platform. The network layer, which is the second layer, is primarily in charge of processing and transmitting information. Access unit and access network make up this system.

The access unit serves as a bridge between the perception layer and the access network, collecting and transmitting data from the perception layer. Mobile communication networks, cable telephone networks, cable broadband networks, and other networks are all included in the access network. Data finally enters the Internet via network access. The application layer is the third layer. It primarily completes data management and processing, combining this data with numerous industrial applications. IoT middleware and IoT apps are included in the application layer. IoT middleware is one of them. It is an independent system software or service program. It offers a variety of non-networking applications and encapsulates many common capabilities. All types of applications directly used by users fall under the umbrella of the Internet of Things (IoT, or Internet of Things), including telemedicine, onboard applications, intelligent control of home appliances, and home security. The IoT has three characteristics [5] as:

(1) The Internet of Things uses a variety of sensing technologies. Each sensor on the Internet of Things is a source of information as a result of the widespread deployment of numerous different types of sensors. Different sensor types can record information in a variety of formats and contents. The sensor continuously refreshes the data while occasionally gathering environmental data at a specific frequency. As a result, the data the sensor collects is current.

(2) The Internet of Things is ubiquitous network. The Internet continues to be the crucial cornerstone and heart of IoT technology. To precisely and in real-time send object information, it links a variety of wireless and restricted networks with the Internet.

(3) The IoT not only enables sensor connectivity but also has the capacity for intelligent processing, enabling the implementation of intelligent object control. The Internet of Things (IoT) is widely used in a variety of industries, including smart transportation, environmental protection, public safety, safe homes, industrial testing, urban management, smart buildings,

cultural relics protection, digital museums, real-time monitoring of historic sites, and more. The ten most popular applications of them are smart grid, intelligent transportation, intelligent logistics, smart homes, and others. The IoT is the primary technology that will underpin the future smart city according to a recently suggested smart city idea.

2.2.2. ZigBee Technology. Zig Bee technology is a low-cost and low-power short-range wireless communication technology. The name Zigbee is inspired by the way the bee colony communicates: the bees fly in a zig-zag to notify the location, distance, and direction of the food they find. Its main characteristics are short distance, low complexity, self-organization, low power consumption, low data rate, and low cost. It is mainly used in the field of automatic control and remote control and can be embedded in various devices. Zig Bee can realize network communication through network, star, and tree network topology. It can form a wireless data transmission network platform consisting of up to 65535 wireless data transmission modules. Within the whole network scope, each data transmission module can communicate with the other. The distance between each network node can be several kilometers from the standard 75 m, and it can be extended infinitely. The structure of each Zig Bee network is shown in Figure 2.

As shown in Figure 2, the Zig Bee network [6] consists of a coordinator, multiple routers, and multiple terminals. The coordinator is responsible for establishing the network and assigning the network address; the router is responsible for expanding the interface and increasing the number of network terminal nodes; and the terminal is used for collecting data and information, but cannot forward messages from other nodes. The communication distance of ZigBee is generally about 100–120 meters. If we want to achieve long-distance communication, Zig Bee network can extend the communication distance by adding multiple routes to achieve long-distance data transmission. ZigBee has a low communication delay of about 15 milliseconds. Because Zig Bee has a large network capacity, low power consumption, low communication delay, and short wake-up response time, people usually choose ZigBee as the street lamp node networking technology. Generally, ZigBee can communicate data through three different bands: 868 MHz, 915 MHz, and 2.4 GHz. The transmission rates of each band are different, which are 20 k bit/s, 40 k bit/s, and 250 k bit/s, and the number of channels is different, which are 11, 11, and 16, respectively.

The network structure of ZigBee network is adopted in this paper. The terminal and routing of ZigBee are street lamp node controllers, and the coordinator of ZigBee is centralized controller. The network structure diagram is shown in Figure 3.

The networking process of forming a networking structure is as follows:

(i) A new LAN is constructed by coordinator

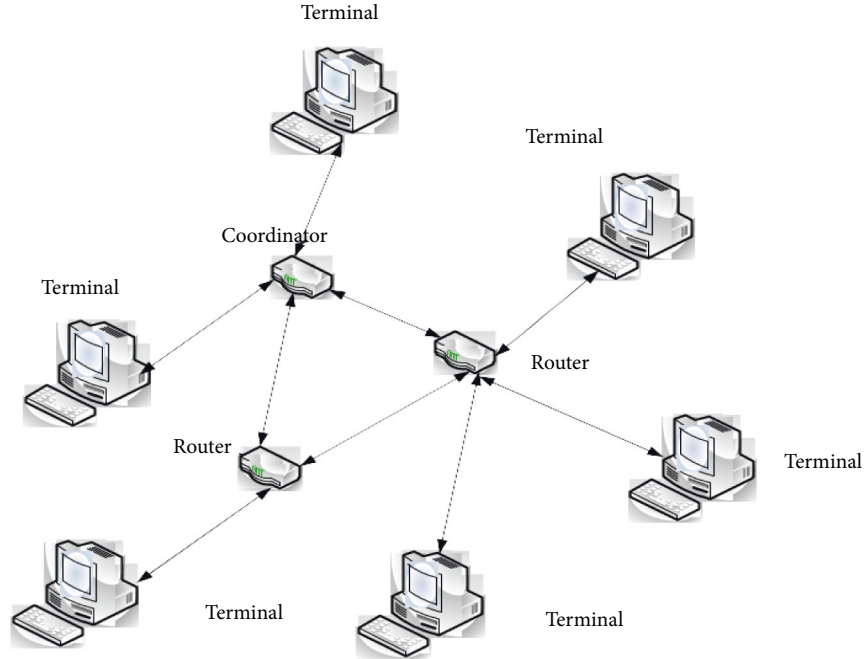Firstly, the coordinator detects the channel in each frequency band and calculates the channel energy.

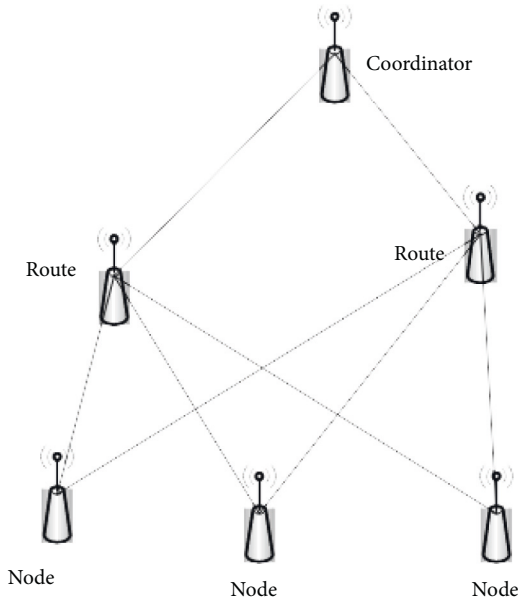FIGURE 2: Network structure of zig bee network.

FIGURE 3: The zig bee network structure of this article.

Then, all channels are searched actively to determine whether the searched channels are used or not. Then, according to the search results, unused channels are selected as the only LAN identifier. The initial value and the length of the network address in the network topology are set, and the values are 0×0000 and 32 bits, respectively.

(ii) Add terminals and routing nodes to Zig Bee network

The terminal or node scans the channel first, and then sends the associated request message to the

appropriate network. When the coordinator receives the associated request message, it checks whether it has sufficient resources. If sufficient, the coordinator allows terminals or nodes to join the LAN and assigns them 32-bit short addresses. Generally, there are two ways to allocate addresses to newly joined network nodes: distributed allocation and random allocation. In this paper, distributed allocation is used to allocate addresses. The distribution of keys among hosts in the network based on this approach is not restricted in any other respect. When the node and the coordinator establish a connection, the coordinator checks whether its address is sufficient and if sufficient, assigns the remaining address segment to the node. The address segment consists of three parameters, as shown in Table 1:

Calculate the address offset assigned to the node according to formulas (1) and C_m, R_m, L_m and d.

$$C_d = \begin{cases} 1 + C_m \times (L_m - d - 1) & R_m = 1 \\ \\ \dfrac{1 + C_m - R_m - C_m \times R_m^{L_{m-d-1}}}{1 - R_m} & R_m > 1 \end{cases} . \quad (1)$$

Then, according to coordinator address A and address offset C_d, the address A_i of the first routing node is calculated by formula (2), and the address A_j of the jth terminal node is calculated by formula (3).

$$A_i = A + 1 + (i - 1) \times C(d) \quad (1 \le i \le R_m), \quad (2)$$

$$A_j = A + j + C(d) \times R_m (1 \le j \le C_m - R_m). \quad (3)$$

TABLE 1: Address segment parameters.

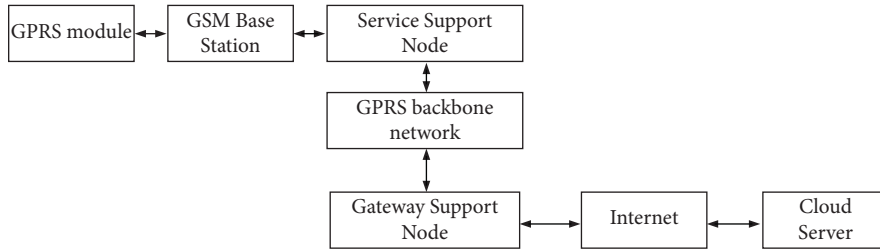| Maximum number of terminal nodes C_m allowed by the device	Maximum number of routing nodes R_m allowed by devices	Maximum network depth L_m of network topology	Current Node Network Depth d

FIGURE 4: Connection diagram between GPRS and cloud server.

In this paper, the classical on-demand distance vector routing algorithm (AODV) is adopted in ZigBee networking communication. It is mainly used as a routing protocol in wireless random networks and can implement unicast and multicast routing. The steps of the routing algorithm are as follows [7, 8]:

(iii) Search path process

The source node first checks its own routing table to see if there is a path from the source node to the destination node in the table, and if not, broadcasts the routing request to the neighboring nodes. When each node receives a message, it inquires whether there is a requested path in its routing table and sends the path information to the source node if it exists; if it does not exist, it continues to broadcast to other neighboring nodes. After receiving the routing request, the destination node chooses an optimal path to send the reply message to the source node. In the process of sending a reply message, each passing node creates or updates its own routing table to store the new path.

(iv) Routing maintenance process

In order to ensure their connectivity with neighboring nodes, each node sends a HELLO packet message periodically to neighboring nodes. This message is used for supply and demand, HSRP protocol data units of HSRP information like virtual IP address, HELLO time, and hold time. Therefore, if the neighboring node does not receive the HELLO packet message for a long time, it can determine that the network link is wrong. Then the node will send routing errors to the surrounding nodes in the form of broadcast, requiring reconnection with its adjacent nodes.

2.2.3. GPRS Technology. Since Zig Bee is only suitable for short-distance data transmission, it is impossible to access the Internet directly. Therefore, this paper introduces the general packet radio system (GPRS) communication technology to make up for its shortcomings. The specific method is: firstly, the data of Zig Bee LAN is transmitted to the GPRS module, and then uploaded to the cloud server using the remote communication function of GPRS. The principle of GPRS connecting to cloud servers is shown in Figure 4.

As shown in Figure 4, the GPRS module acquires data from the central controller and sends it to the GSM base station after encapsulation according to the GPRS communication protocol. Base station receives data and transmits it to GPRS service support node to package and send it to GPRS backbone network for communication with GPRS gateway support node. The gateway supports the nodes to process the data and send it to the cloud server through the Internet.

2.2.4. GIS Technology. Geographic information system (GIS) can analyze and process spatial information, map and geography, and gather them together. In order to repair the lamp in time, it is necessary to know the location of the lamp in time and accurately. Therefore, the application of GIS technology in intelligent lighting control systems makes the system be able to alarm and provide an accurate location in the first time when the street lamp fails. The engineering design, emergency repair, and daily maintenance of lighting infrastructure can be completed with the help of GIS. Its spatial distribution visualization and massive information storage and management capabilities provide effective tools for lighting systems.

2.3. Hardware Design of the System. The intelligent lighting control system designed in this paper has several functions, such as signal acquisition, data communication, network transmission, analysis, calculation, and decision support. To realize these functions, the hardware circuit of this paper includes several hardware modules, such as street lamp node controller, coordinator, centralized controller, and GPRS module. The hardware circuit framework of the system is shown in Figure 5. On the one hand, the street lamp node controller is responsible for the switch and dimming operation of the street lamp, on the other hand, it is also used for collecting information on the current, the intensity of sunlight, the traffic flow around the street lamp, and wireless transmission of the collected information to the ZigBee
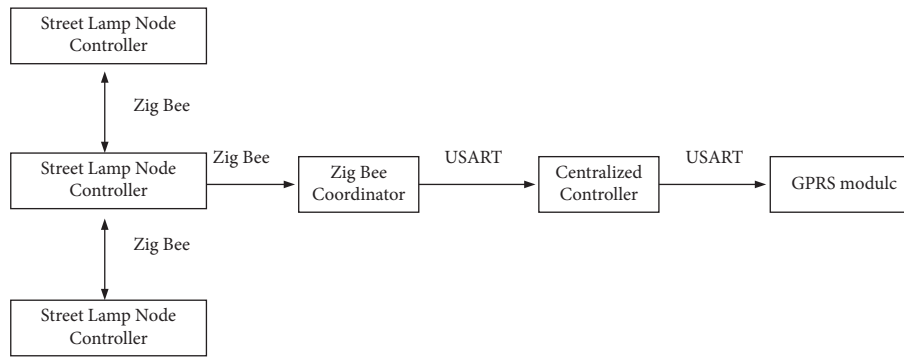
FIGURE 5: Hardware circuit framework of the system.

coordinator through the ZigBee network. ZigBee coordination is transmitted to the central controller through universal synchronous/asynchronous receiver/transmitter (USART) serial port.

2.4. Automatic Adjustment and Control of Solar Street Lights.

The role of the controller in the whole system is: turn off the load during the day, control the solar panel to charge the battery when the battery capacity is insufficient, and charge the battery with different currents and voltages when the battery capacity is in different stages; When the capacity is sufficient, it is charged in the form of small current or microcurrent to make up for the loss of natural discharge.

2.4.1. Dimming Control

Dimming control measures mainly include two types:

> All-night lights: The so-called all-night lights refer to the whole night, the street lights are on and the brightness remains unchanged. There are still quite a few areas in this way. This method is suitable for places with large traffic flow, many people, and frequent activities, and the lighting conditions are good.

> Half-lit: The so-called half-lit refers to the use of street lights every other night in the middle of the night. Most of the country take this approach. Although this method saves electricity, it will cause uneven illumination of road lights and affect people's vision. At the same time, the up-front work of the half-light mode is great. It needs to be grouped when installing street lamps, which increases the difficulty and cost of installation. Based on various current dimming control technologies.

This paper proposes a new energy-saving control strategy, that is, multistage timing dimming. That is, in the second half of the night, the brightness of the street lights will be reduced in turn. This not only saves electricity to the greatest extent but also does not affect the vision of pedestrians and driving because of uneven illumination. Multiperiod timing dimming is to change the voltage across the LED lamp and the current through it by sequentially reducing the duty cycle of the pulse signal.

The main work of the solar LED street lighting system is completed by the controller. The functions of the controller are: automatically turn off the lights during the day and automatically turn on the lights at night. In the process of battery charging, three-stage charging methods of maximum power, constant voltage and constant current are adopted, and different charging methods are adopted according to the different battery power to improve the charging efficiency. The first stage precharges the battery and activates the internal battery at the same time; the second stage charging voltage remains constant, the current drops, and the power continues to increase; the third stage current gradually increases and remains constant, the power increases rapidly, and the voltage rises.

2.4.2. Discharge Energy Saving Control.

When the controller is in the discharge mode, the control of the street light includes two points: the first is the switch control when the day turns to night. The second is the dimming control after the lights are turned on at night.

Timing control: This control method is completely based on the time to switch street lights, and the operation is very simple. However, due to the different dark times in different seasons in the same area, the time required for street lighting will change. This not only complicated the operation but also increased the workload invisibly. This method is not very flexible. In addition, the controller needs to time accurately for a long time, which is very demanding on the hardware. This also increases the production cost.

Timing + delay control: For the shortcomings of the above timing switch control methods. Another way is timing + delay switch control. The method is to first set a timed value. But this method also takes a long time. In this way, the problem of inaccurate timing of long-term working hours may occur. It is very convenient to operate, highly flexible, and can be adjusted in time according to the actual situation.

Illumination control: This paper presents a control method with high flexibility and less workload, that is, illumination control. Regardless of the season or the weather, the switch can be turned on as long as the actual environmental conditions require street lighting. This method not only meets the actual needs but also does not require frequent modification of the switching time, as shown in Figure 6.
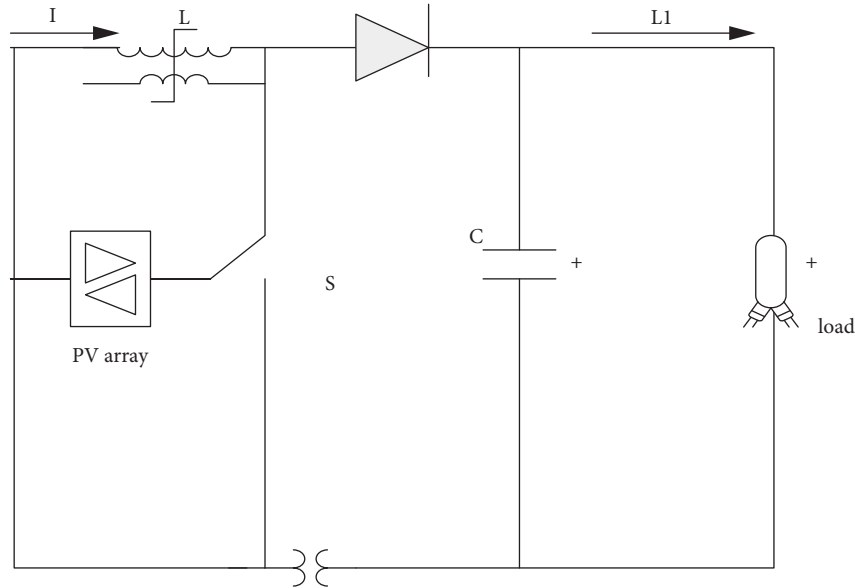
FIGURE 6: Principle of illumination control.

As shown in Figure 6: In this system, the output voltage of the solar cell is measured to judge whether it is disconnected or not. Also, to avoid unexpected situations. Such as plastic bags and misjudgment caused by shade. In the design, a certain delay can be added on the basis of the control of the illuminance. That is, to say, when it is judged that it is night, it will be delayed for a certain period of time. If the judgment result does not change during this time, then turn on the switch. Do not open it if the result changes.

2.4.3. Day and Night Recognition Procedures. As mentioned above, the function of the controller is to control the charging of the battery during the day. Control battery discharge at night. Therefore, the controller needs to determine whether the current environment is day or night. The identification of the environment is mainly based on the obvious difference between the light intensity during the day and night. From the hardware composition and design of the whole system, it is known that the output voltage of the solar panel is obviously different when the light intensity is different. After measurement, the solar cell of this system is relatively weak in light intensity, that is, the moment when ambient light needs to be illuminated. Its output voltage is about 8 V. So, when the output voltage of the solar panel is less than 8 V, the controller works in night mode. When the output voltage of the solar cell is greater than 8 V, the controller works in the daytime mode.

2.5. Software Design of the System. There are three main functions of a background management system: Firstly, by analyzing the light intensity and traffic flow data around the street lamp, the decision is made, and the corresponding dimming instructions are sent to the street lamp node controller to realize three intelligent controls: Firstly, turning on the street lamp, adjusting the brightness of the street lamp and turning off the lamp; secondly, when the

FIGURE 7: Street lamp data receiving and displaying interface.

TABLE 2: Corresponding states of different street lamp current values.

Current value (mA)	Street lamp condition	State
>50	On	Normal lighting
25–50	On	Dimming
<25	Off	Fault

FIGURE 8: Street lamp information interface.

street lamp fails, the background management system displays the street lamp signs in different colors. And timely inform the staff through bullet windows; and thirdly, check the status and location of street lights and other information.
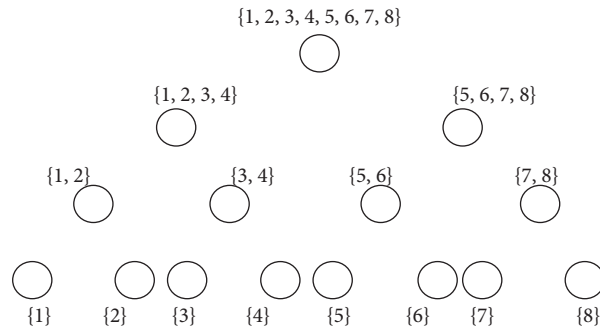
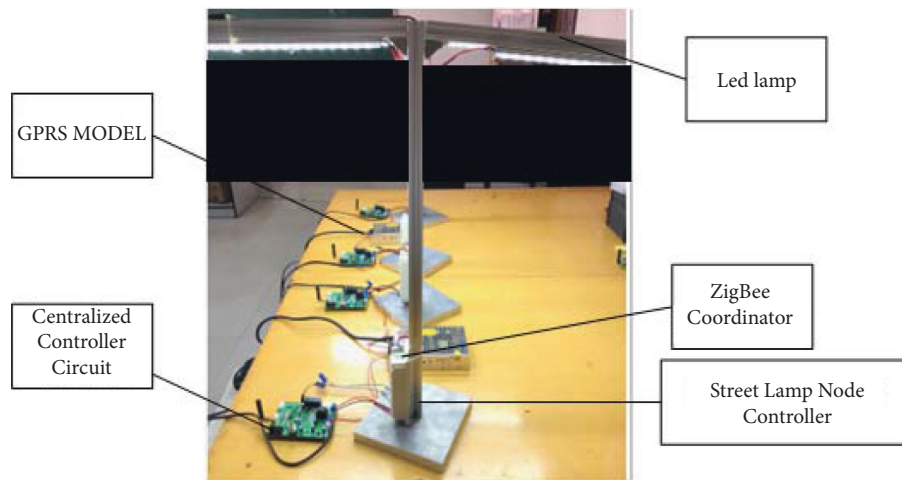FIGURE 9: Multiclass sample decision-making process.

FIGURE 10: Street lamp model.

The background management system has four main functional interfaces:

2.5.1. Street Lamp Data Receiving and Displaying Interface.
The background management system can log in to the cloud server by inputting the IP and port number of the cloud server. Receive data from the street light controller from a cloud server. The system displays the process of receiving these data in the interface shown in Figure 7. Street lamp data received by display includes data upload time, lamp, light intensity and current, etc.

2.5.2. Street Lamp Information Interface.
The interface intuitively displays the status of the current street lamp, the current value of the street lamp, the dimming level, the light intensity of the current sun and the data upload time in the form of a two-dimensional table. The system judges the state of street lamps by the current value of street lamp. In this paper, the critical values of street lamp current are set at 50 mA and 25 mA, as shown in Table 2 below. When the street lamp is in failure state, the font of all information of the street lamp is in red bold state. The street lamp information interface is shown in Figure 8.

2.5.3. Map Location Interface.
The location interface of street lamp map shows the location of all street lamps. This can be achieved by calling the API interface of Baidu Map and inputting the location of street lights in advance. The main function of this interface is to locate the location of the street lamp according to the map when it is found that the street lamp is out of order so that the staff can rush to the scene immediately to solve the problem.

2.5.4. Switch Dimming Control Interface.
Clicking on the street lamp number in the street lamp information interface will bring up a drop-down menu under the number. They can control the street lamp remotely by clicking on them with the mouse. Of course, the background management system can also realize the automatic switch dimming function. Considering that the environmental data collected by street lamp energy-saving controllers cannot be accurately classified according to the dimming level in the dimming design commonly used, this paper proposes an improved intelligent dimming algorithm based on SVM. Since dimming levels are generally classified into many categories, and SVM is often used for binary classification problems, this paper proposes a combination of directed acyclic graphs and SVM. Its basic principle is shown in Figure 9.
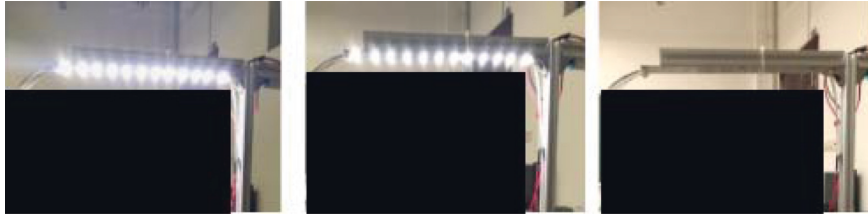
Figure 11: Test results of turning on, dimming, and turning off lights in the system.

Table 3: System test results.

Time	Light intensity (lx)	Vehicle flow (vehicle)	Dimming grade
1	1	8	2
2	2	2	2
3	3	3	2
4	50	3	1
5	20	2	2
6	40	0	1
7	3800	20	3
8	2100	13	1
9	1333	13	1
10	1200	12	3
11	1400	8	2
12	1300	10	1

The algorithm first classifies the samples from the top root node, then decides whether the direction of classification is left or right according to the output of the classification until the samples are divided into multiple categories.

3. Experimental Results

The model of cloud server used in this paper is: 2-core CPU 3.2 GHz, memory 2 GB, 1 M bandwidth, public image is Windows 2008 R2 64 enterprise version. The street lamp model includes 12 LED lights, 12 street lamp node controllers, a ZigBee coordinator, a central controller circuit, and a GPRS module. As shown in Figure 10.

4. Discussion of the Results

4.1. System Dimming Test. The dimming test of the system is to test whether the background management system can realize the functions of turning on, turning off, and dimming street lights. This experiment clicks on the no. 3 street lamp and clicks on the three items of turning on, dimming, and turning off, respectively, to check whether the lamp source has reached the three effects. The test results are shown in Figure 11.

4.2. Street Lamp Fault Alarm Test. In order to test the function of the street lamp fault alarm module, the power line of no. 5 street lamp was cut off in this experiment. The background management system was tested to whether it would receive information about the street lamp fault and whether it would alarm the street lamp fault information.

After the no. 5 lamp is off, the no. 5 fault information appears in the background management system, and the alarm interface appears in the system.

4.3. Performance of Improved SVM Dimming Algorithm and Energy Saving Test of the System as a Whole. To test the performance of the dimming algorithm of the system, in this paper, two kinds of lighting systems with different configurations are set up to test and compare. The first kind of lighting system is the intelligent lighting system which adopts the improved SVM algorithm. The second kind of lighting system is a traditional lighting system with a simple timing switch control function. The two types of lighting systems use the same lighting hardware configuration, and the street lamp layout is the same, respectively:

A 60 W LED lamp is placed every 30 m. A total of 12 were placed. Each lamp is equipped with street lamp node controllers, which are controlled by a centralized controller and connected to the background management system through a cloud server. All street lights were on from 7 p.m. until 7 a.m. and were not turned off until 7 a.m. for a total of 12 hours. The light intensity of different types of weather is as follows: night: 0.01–10; rainy: 10–400; cloudy: 100–1500; sunny: 1500–35000. The test results of two different street lighting systems are shown in Table 3.

From the data in Table 3, we can conclude that the street lamp illumination system using the improved SVM dimming algorithm can automatically adjust the brightness of the street lamp according to the environment around the street lamp, such as the light intensity and traffic flow. The two systems consume 2.1-kilowatt-hour power for 12 LED lamps in an intelligent lighting system using an improved SVM dimming algorithm, and 6.3-kilowatt-hour power for 12 LED lamps in the traditional lighting system. Energy saving effect is obvious. We can conclude that the street lighting system using the improved SVM dimming algorithm is more energy-saving than the traditional lighting system, and the energy-saving efficiency has been significantly improved.

5. Conclusion

The development of IoT and AI has brought tremendous changes to the field of urban street lighting. With the construction of smart cities, the traditional urban street lighting control system has been unable to meet the needs of modern cities. The application of IoT technology in the urban lighting control system can realize remote control and

management of urban lighting systems, and save energy consumption. It is important to promote the construction of modern cities. Therefore, it is necessary to further increase the application of various technologies in the lighting control system. Meanwhile, aiming at the problems of the lighting control system in the application process, further optimization and solutions are put forward. This paper aims at two problems in the intelligent lighting system, which are the untimely phenomenon of adjusting the brightness of the street lamp intelligently according to the environment of the street lamp and the untimely failure of the detection of the street lamp. The corresponding solutions are put forward.

Firstly, aiming at the problem of untimely detection of street lamp faults, GIS technology is added to the intelligent lighting system to locate the location of the fault street lamp by using GIS, which is convenient for managers to find the faults in time and deal with them in time. To improve the accuracy of intelligent dimming, an improved intelligent dimming algorithm based on a support vector machine is proposed. Through experiments, it is found that: (a) the system can realize manual dimming and automatic dimming through an improved dimming algorithm. (b) the system can realize the function of street lamp fault alarm, and (c) the system can achieve a greater energy-saving effect.

Although this paper realizes the intelligent lighting and energy saving and consumption reduction of urban street lamps to a certain extent, there are still many shortcomings that need to be improved. The GPRS communication technology is used in this article. When the street lights transmit pictures or videos, the transmission speed of GPRS is far from meeting the requirements. Therefore, the 5 G communication module will be used instead of the GPRS communication module in the future. And the data collected in this paper is not much, which will affect the accuracy of the algorithm. In the future, the street lamp environmental data will be classified to realize a higher level of artificial intelligence in the urban street lamp intelligent lighting control system.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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