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A Segmented Management System of Smart Street Lights

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ABSTRACT

Electric energy conservation is meaningful for the development of any country. The roads in a city are equipped with street lights. After midnight, many pedestrians and vehicles are greatly reduced in these places, while all street lights still working. Therefore, it is important to apply more effective and energy-saving methods to road lighting systems. To solve this problem, many intelligent street lights have been designed. This paper summarizes the current status of smart street light technology and analyzes their advantages and disadvantages. Thereafter, it proposes a segmented management system of intelligent street lights based on wireless communication technologies and sensor technologies. This design will improve the flexibility and practicability of the intelligent street light systems.

Keywords: wireless communication, smart street light, segmented management

1. INTRODUCTION

As China has developed rapidly in recent years, its demand for energy has increased. At the same time, energy dissipation has also increased. So, energy conservation and pollution emission reduction[1] are very important for our country. At present, the main method of producing electric energy is thermal power generation, as shown in Figure 1. Coal is the main raw material for the production of electricity. Therefore, saving electric energy is very beneficial to the environmental protection.

Now there are sodium lamps[2] with a power of about 300 watts in the streets. The number of street lamps in China is increasing fast in recent years, with the numbers shown in Figure 2. It is meaningful to reduce the waste of electricity[3] caused by street lights, because it can contribute to reduce the use of coal. Many developed countries have done a lot of researches which aim at saving electric energy. All of them want to reduce the waste as much as possible.

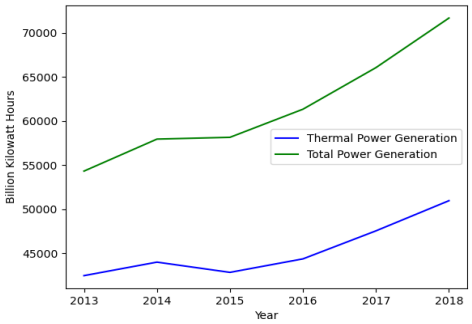

Fig. 1. Electricity production

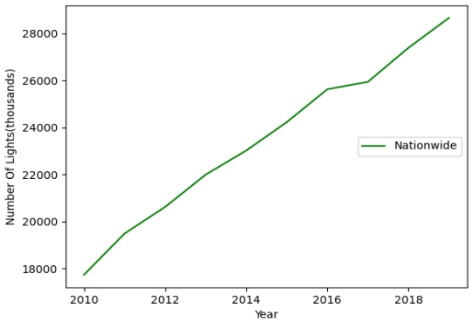

Fig. 2. Number of lights

2. RELATED WORKS

Started in 2009, Los Angeles, wanted to replace 140,000 street lights with LEDs in 4 years, which was expected to save 40% of energy. In fact, this project saved 63% of energy. The advantages of LED[4,5] lights are obvious. They have long lifespan, high luminous efficiency, low radiation and power consumption. The only disadvantage is that they are expensive. Although the above work is that street lamp was changed into an

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energy-saving lamp, their works did not improve the street light itself. At first, a street light system based on a sensor network[6,7] was proposed. The lights are turned on when pedestrians and vehicles appear, and turned off when there is nothing. Next, it was proposed to detect the presence of vehicles on the road by image processing[8,9], and the data would be sent to the terminal to further control the street lights. Then, it was proposed to use sensors[10] to collect data on road information and then transmit the data to the terminal which complete the processing of the data, in order to control the road lighting. Lately, based on the technology of the Internet of Things[11], the authors proposed to equip street lights with different types of sensors that can collect data. The data would be sent to the public digital platform. In recent years, smart street lights, based on communicate wirelessly[12], that would be centralized into the smart system for unified management were designed. Based on the method proposed above, China has now begun to run the LED bidding work year by year, as shown in Figure 3.

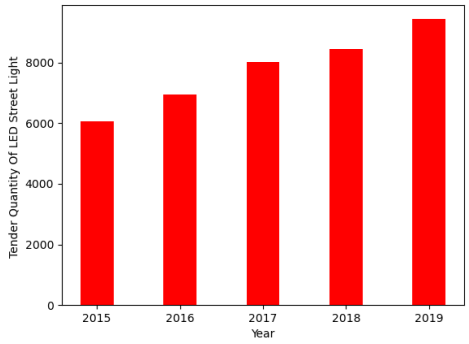

Fig. 3. Tender quantity of Led street light

And the methods mentioned above have obvious advantages and disadvantages. The advantages are that they can effectively reduce energy waste. No manual operation is required, saving a lot of human resources. The disadvantages include the high complexity and cost which need to install wireless communication modules and sensors on each street lamp. Moreover, the operation and maintenance costs [13]in the entire road system are very high, so it is not easy to spread out in large scale.

Therefore, in order to solve the problems above, based on smart city digital Energy Management[14], the segmented management system of smart street lights is proposed.

3. SEGMENTED MANAGEMENT

Many solutions which design intelligent street lights have been proposed, but most of them are about how to make a single street light intelligent, without considering whether the solution can be applied in a large scale in practice.

This paper proposes a segmented management system of smart street lights, not to make street lights more intelligent, but to make segmented area intelligent. The aim is that the installation of smart street lights can reduce costs and can be applied in a large scale. The system's workflow is shown in Figure4.

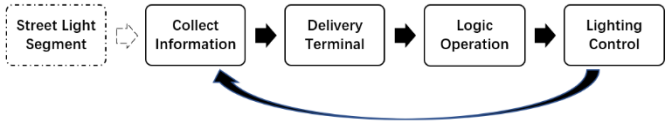

Fig. 4. System's workflow

The workflow is as follow. Firstly, the road will be divided into different sections, which can be counted as a whole for every one hundred, or two hundred, or even five hundred meters. Secondly, only street lights at the junction of the division can be equipped with sensors and wireless communication modules. Next, the data collected by sensors will be sent system terminal. Finally, the intelligent street light system processes the information of each segmented area, in order to control the brightness of the street lights or even turn them on and off.

4. SPECIFIC WORKING MECHANISM

The system needs to supervise the information fed back by the street lights in real time. For the street lights in the middle section, it does not need to monitor vehicles and pedestrians in real time, but only needs to wait for the command from the system's terminal. If there is a car entering the current intersection, the terminal sends supervision commands to first section of this street, and then each section performs OR operations with adjacent sections (1, if there is a car, otherwise 0) to further decide whether to adjust the brightness of street lights or not.

For example, the street is divided into four sections A, B, C, and D, and a car enters from section A, as shown in figure 5. At this time, the terminal sends a real-time supervision command to B. Because A has already detected the car, B should execute OR operation with A. If the result of B is 1, then the road section B needs to be monitored in real time through sensors. Once the sensors detect a car is coming, the illumination of the B

street light needs to meet the national standard. When the vehicle is in the section A, the section C and section B should execute OR operation. If their logical operation's result is 0, the section C should maintain current state, and it waits for the section B to become 1. And section D should execute the same operation like C.

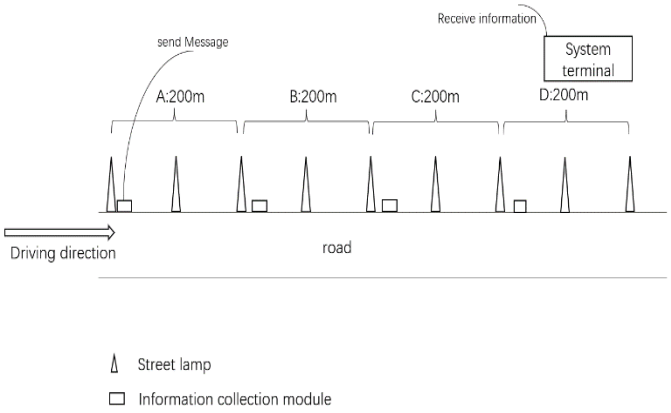

Fig. 5. Specific process

5. THE NOVELTY OF SEGMENTED MANAGEMENT

The difference between this paper and all of the literatures is that whether or not to make a single street light intelligent. In the previous methods, each street light is set up as intelligent. And street lights do not affect each other. But in our method, the situation is completely opposite.

Our method is to intelligently manage the segmented areas. In other words, it makes the segmented area intelligent, but not single light. Its feasibility is higher and the cost is lower.

The novelty is mainly the logic algorithm of adjacent blocks, which uses reasonable logic operations to reduce the use of lights and save energy. The second one is the application of an intelligent management system.

6. CONCLUSION

This paper proposes a new segmentation management system for intelligently controlling street lights, including dividing a road into different sections, using OR operation. It unifies the various modules to the terminal system for centralized management. Its real flaw is as follow. It requires high accuracy of the sensor and algorithm is relatively simple. What can be improved is to adopt more efficient algorithms in the future.

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