Intelligent street lamp control system with dynamic light control function

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***Abstract*—In order to solve the problem that the traditional street lamps cannot be controlled dynamically according to the specific conditions of the road at night, an intelligent street lamp control system based on speed and sensor detection information is designed to adjust the number of street lamps in front of the vehicle which are turned on in advance, including the illumination level of street lamps. The system combines Radio frequency identification technology to read the tag information of the vehicle through the reader installed on the street lamp and calculate the driving speed and the number of lamps to be turned on. The sensors are installed on the street lamp node to collect the environmental illumination and the vehicle driving information in real time. According to the fuzzy control strategy, the information is analyzed and calculated and the illumination level of the street lamp is adjusted accordingly. MATLAB simulation results show that the system can adjust the illumination level of the lamp quickly according to the result of the sensors, thus reducing the energy consumption of the system.**

***Keywords*-Dynamic control; Radio frequency identification; Vehicle detection; Fuzzy control; Sensor**

I. INTRODUCTION

With the deepening of the modernization process and the continuous expansion of the urban scale, people have put forward higher requirements for street lighting. Survey shows that about 30% of nighttime traffic accidents are caused by unscientific street lighting. In order to ensure the traffic safety, the relevant departments often work under the conditions of maximum illumination throughout the night, causing a waste of energy. Therefore, the problem of energy saving has become a research hotspot in urban lighting [1-3].

At present, there are three types of street lamp control modes: night lights, midnight lights, and dual light sources [4].The above control methods do not consider the actual conditions of the road vehicles, and the decision to turn on the lamps by the vehicle speed can minimize the energy consumption.

At present, the commonly used technologies for speed detection include geomagnetic coil velocity measurement, laser velocity measurement and velocity measurement based on video images [5,6].To avoid the disadvantages of the speed measurement methods above, Radio frequency identification technology (RFID) is used for vehicle detection.

This article uses RFID technology to determine the specific vehicle speed, calculate the number of street lamps that need to be turned on ahead of time. At the same time, according to the information detected by the light sensor and the motion sensor, the illumination level of the corresponding street lamp is determined through fuzzy decision, and simulation verification is performed through MATLAB.

II. STREET LAMP CONTROL SYSTEM DESIGN

As shown in Fig.1, the overall structure of the intelligent street lamp control system includes control nodes, gateway nodes and a monitoring center.

The control node is installed on the street lamp and has the functions of collecting and forwarding street lamp status and vehicle motion information. The control nodes include MCU, WIFI module, RFID module, motion sensor, light sensor and alarm module.

The street lamps are divided into groups and each gateway node is configured for each group. The gateway node can not only send relevant data information to the monitoring center, but also report the summarized status information of each control node after receiving the instruction of the monitoring center.

The monitoring center can manage the working status of all street lamps in the system. It receives the information sent by the gateway node, inquires about the data information of the control node, and can also send control information to the control node.

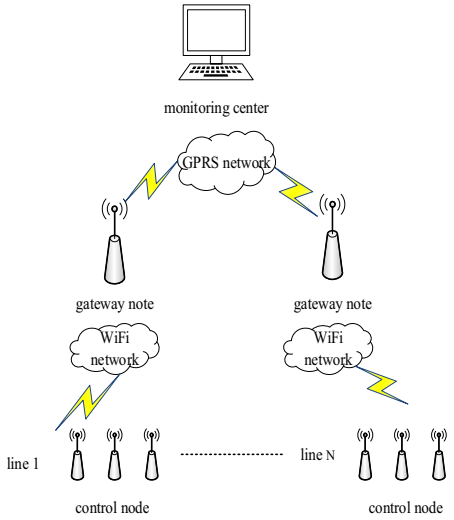

Fig.1 Schematic diagram of intelligent street lamp control system

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III.DYNAMIC LIGHT CONTROL

A.The principle of dynamic lighting control

First, the light sensor detects the illumination of the surrounding environment. If the average value of the illumination is higher than the set threshold, such as in the case of daytime or good light, the node enters the sleep mode. If the illumination average is lower than the set threshold, the node enters the operating mode.

If the environmental illumination meets the conditions, according to the detection information of the light sensor and the motion sensor, the corresponding illumination level of the street lamp is determined through fuzzy decision [7].

At the same time, readers installed on street lamps automatically identify RFID-bound vehicles through radio frequency signals, and obtain information such as license plate numbers, so as to realize the detection of different vehicles, and according to the speed, safety distance, and pre-start time determines the number of street lamps that need to be turned on in advance.

B. Speed calculation

1) constant road speed detection

It is known that the distance between two adjacent street lamps is L. Suppose the vehicle pass through node n at time t_n and pass through node m at time t_m. The average speed v of the vehicle can be obtained according to the formula:

$$v = L/(t_m - t_n) \tag{1}$$

2) multi-lane straight lane change speed detection

Suppose the vehicle pass through the x-lane node n at time t_n before changing lanes, and then pass through the y-lane node m' at time t_m .The width of the lane is d.

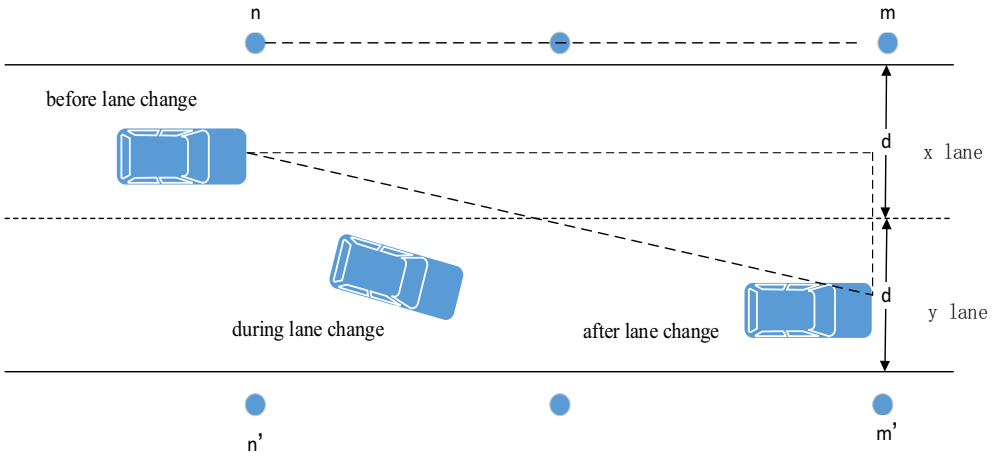

Fig.2 speed detection of multi-lane direct lane change

The formula for calculating the speed is

$$v = \sqrt{(m-n)^2 L^2 + d^2}\,/(t_m - t_n) \tag{2}$$

3) determine the number of street lamps

To determine the number of street lamps that need to be turned on in advance, consider the following two factors: First, the safety distance in front of the vehicle is w. Then the pre-starting time of street lamp is Δt. It is assumed that the vehicle runs at a constant speed v at this time, and the distance traveled is R:

$$R = v \cdot \Delta t \tag{3}$$

When the vehicle travels to the street lamp node n, the number of street lamps (f) that need to be turned on ahead of the vehicle in order to meet the lighting requirements is:

$$f = [(R+w)/L] + 1 = [(v \cdot \Delta t + w)/L] + 1 \tag{4}$$

[z] represents the largest integer not greater than z (z is any real number).

C. Street lamp illumination fuzzy control algorithm

In order to achieve street lamp classification dimming, a fuzzy control algorithm is introduced: the illumination information of the light sensor and the vehicle information collected by the motion sensor are taken as the input of the fuzzy control system, and the desired illumination level is taken as the output value of the fuzzy system. Through the fuzzy decision to determine the illumination level of the street lamp, the illumination of the street lamp in front of the vehicle is continuously increased, and the illumination of the street lamp behind the vehicle is successively reduced. There are 5 levels of illumination. Level 0 indicates that the street lamp is turned off, and level 4 indicates that the street lamp is on full power.

According to the road lighting standard specification, the average nighttime illumination of highways and main roads is 25 Lux. Therefore, the illumination information domain of the light sensor is set to [0,45], which is converted into three fuzzy sets. The rayless indicates that the illumination value is Between 0-15lux, moderate means that the illumination value is between 15-30lux, and bright means that the illumination value is more than 30lux.

The domain of motion sensor information is [0,20], and it is divided into two fuzzy sets. s indicates that the vehicle is detected and the motion sensor signal voltage is greater than or equal to 10v. n indicates that the vehicle has not been detected and the motion sensor signal voltage is less than 10v.

The street lamp illumination level domain is [0,4], which is divided into three fuzzy sets, where low denotes the illumination level of 0 to 1, medial denotes the illumination level of 2 to 3, and high denotes the illumination level of 4 to 5.

The fuzzy control rules are as follows:

If the motion sensor does not detect the vehicle, then the street lamp illumination level is low; if the motion sensor detects the vehicle, when the ambient illumination is low, medial and high, the corresponding street lamp illumination is high, medial and medial respectively.

According to the simulation results, when the ambient illumination is 8.88 Lux and the output voltage of the motion sensor is 13V, the illumination level of the street lamp is 4.5. That is, when the ambient light is dim and the vehicle passes by, the illumination of the street lamp is higher.

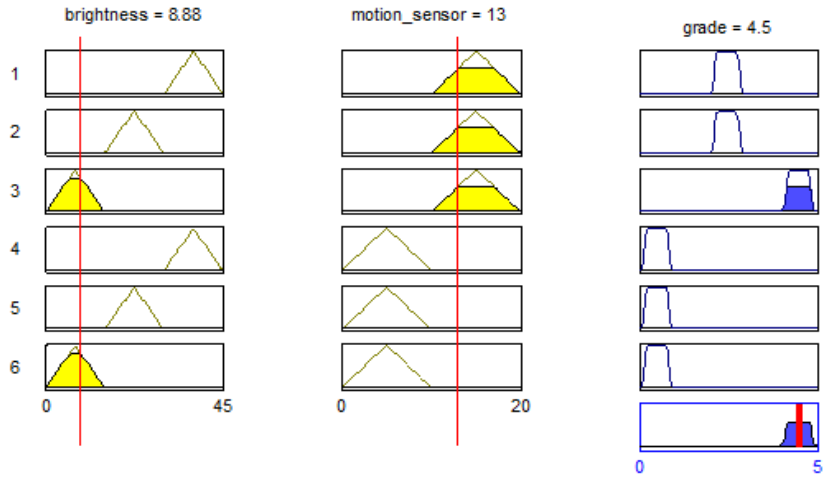

Fig.3 fuzzy decision simulation diagram

IV. CONCLUSION

In order to solve the problem of serious energy consumption in the street lamp control system, RFID technology is used to determine the number of street lamps that need to be turned on in advance according to the speed of each vehicle to achieve a small area of lighting. Through making the fuzzy decision, the street lamp illumination level can be adjusted according to the ambient illumination and the presence or absence of the vehicle. When there is a vehicle passing through, sufficient illumination is ensured. When the vehicle passes by, the street lamp maintains a low illumination to reduce the energy consumption of the street lamp system.

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