ISSN 2616-5775 Vol. 5, Issue 7: 27-32, DOI: 10.25236/AJCIS.2022.050705

Intelligent Street Light Control System Based on Fuzzy Control Algorithm

Jinsong Wang[1], Pengju Yan[2]

[1]College of Mechanical and Electrical Engineering, Heilongjiang Institute of Technology, Harbin, Heilongjiang, 150000, China
[2]College of Information Science and Technology, Taiyuan University of Science and Technology, Taiyuan, Shanxi, 030024, China

Abstract: *In view of the low efficiency and intelligence of street lamps in the city street and the high proportion of manual monitoring, we designed an intelligent street lamp system. The street lamp system consists of hardware part and software part. The hardware part takes STM32F103ZET6 single chip microcomputer as the microcontroller of the main control system, the signal acquisition of the light sensor through I^2C bus, and uses PWM dimming technology to adjust the brightness of LED lamp. The software part mainly uses the fuzzy control algorithm to achieve the intelligent control of street lamps includes the designed lighting fuzzy controller and vehicle speed fuzzy controller. The algorithm is simulated and analyzed by using MATLAB, and the algorithm is combined with the hardware system for experimental test. The simulation analysis and test show that the system can simulate of manual control process and method intelligently, which provides a reference for the current use of street lamp lighting in conventional sections.*

Keywords: *STM32F103ZET6; Matlab simulation; Fuzzy control; Intelligent street lamp*

1. Introduction

China continues to develop leads to power shortage. Street lights lose a lot of power[1].A good smart street light solution is design a light that can intelligently adjust the brightness according to the road conditions[2-3].This paper proposes an intelligent street lamp based on STM32 and fuzzy control algorithm. On an empty street, it can ensure lighting at the set minimum brightness. Street lights can be intelligently adjusted brightness when pedestrians pass by. The fuzzy control algorithm can blur the uncertain factors such as light intensity and speed into intelligible independent variables[4].This algorithm is more practical than the mathematical model to control the street lights[5].

2. Overall system design

The system is mainly composed of STM32F103ZE6 microcontroller module, human body infrared detection module, ultrasonic ranging module and light sensor module. Figure 1 shows the block diagram of the overall structure of the system.

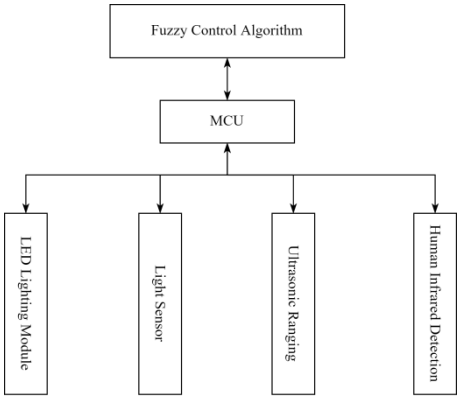

Figure 1: Block diagram of the overall structure of the system

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The detection circuit allows the MCU to analyze the data by inputting the detected sensor content to the MCU. According to the analysis result, the MCU obtains the output result from the set fuzzy control algorithm to adjust the brightness and time of street lights. Figure 2 shows the schematic diagram of the smart light.

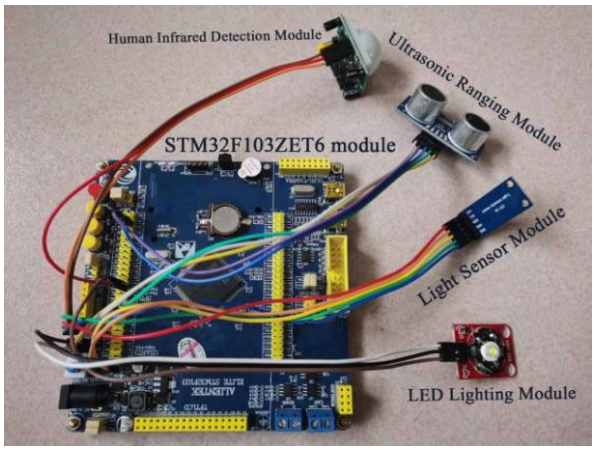

Figure 2: Physical schematic of the smart light

3. Main function module design of the system

3.1 Ultrasonic Ranging Module

HY-SRF05 ultrasonic ranging module can provide non-contact distance sensing function of 2-450cm, and the ranging accuracy can reach 3mm. In this design, the IO port Trig is used to trigger the ranging, and the ultrasonic ranging module is given a high-level signal of at least 10us, and the module automatically sends 8 square waves of 40khz, and automatically detects whether there is a signal returning. The IO port ECHO outputs a high level, and the duration of the high level is the time from the launch to the return of the ultrasonic wave. Test distance = (high level * speed of sound (340m/s))/2. Figure 3 is the circuit diagram of HY-SRF05.

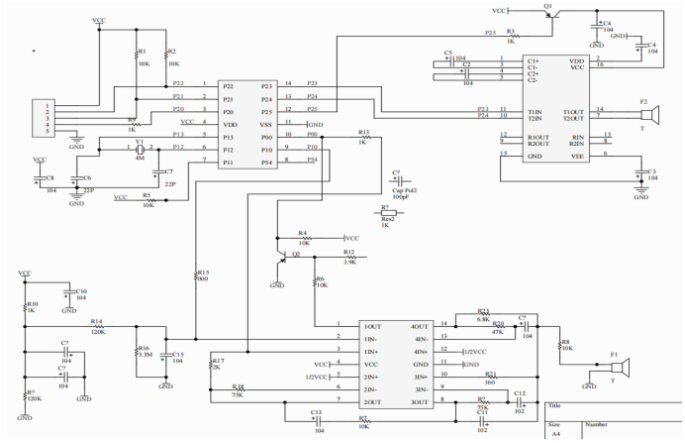

Figure 3: HY-SRF05 ultrasonic module circuit diagram

3.2 Human Infrared Detection Module

HC-SR501 is an automatic control module based on infrared technology. HC-SR501 human body infrared detection module has repeatable trigger mode and non-repeatable trigger mode. In the design of this system, this module adopts the repeated triggering method. Its working principle is when the signal value is high,for a period of time, pedestrians appear in the monitoring range, and the signal value will remain in this state until the person leaves, the signal value from high level to low level. Figure 4 is the circuit diagram of HC-SR501.

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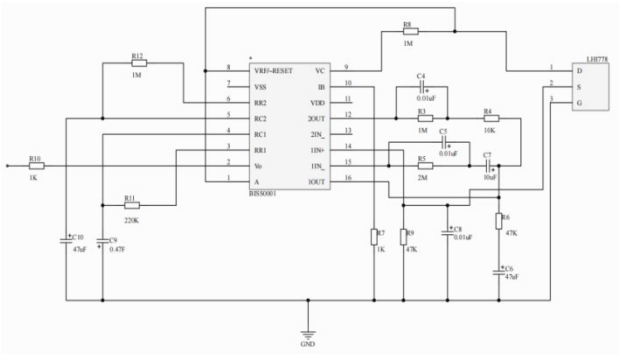

Figure 4: HC-SR501 module circuit diagram

3.3 Light Sensor Module and LED Lighting Module

The GY-30 module adopts the I2C bus and has a built-in 16-bit AD converter. The light range that can be measured is 0 - 65535lx. The circuit diagram of the GY-30 is shown in Figure 5.

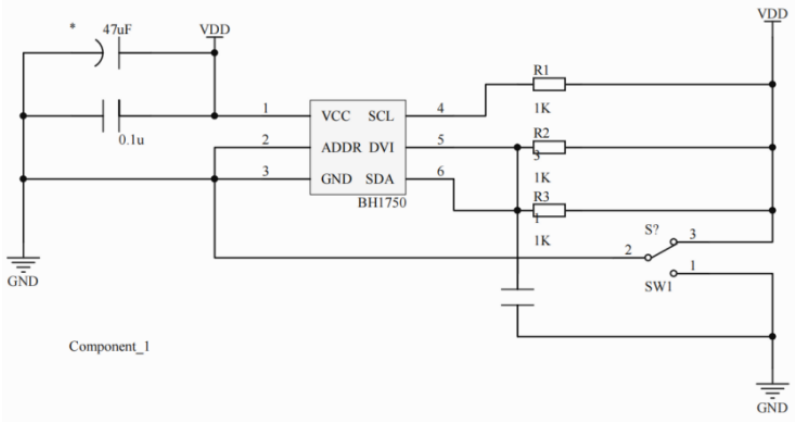

Figure 5: GY-30 light sensor circuit diagram

4. Control Algorithms

In the process of street light adjustment, external factors such as light intensity, speed are variables that cannot be accurately described because people's perception of different light intensities and the speed of the vehicle is different. Therefore, the dimming control algorithm of the intelligent street lamp uses fuzzy control algorithm.

4.1 Fuzzy control algorithm

Fuzzy control is an intelligent control method based on fuzzy set theory, fuzzy linguistic variables, and fuzzy logic reasoning. It is an intelligent control algorithm that imitates human fuzzy reasoning and decision-making process in behavior. This system is designed two controllers, one is the vehicle speed fuzzy controller and the other is the illumination fuzzy controller

4.2 Design of Illumination Fuzzy Controller

The blur control rules of the light fuzzier designed are when the light intensity is higher, the lower the output power of the smart street lamp, and when the light intensity is lower, the higher the output power of the smart street lamp. According to the measured ambient light intensity, select the S-type membership function that meets the data characteristics. The correspondence of the blur control rules under the light blur controller is shown in Figure 6.

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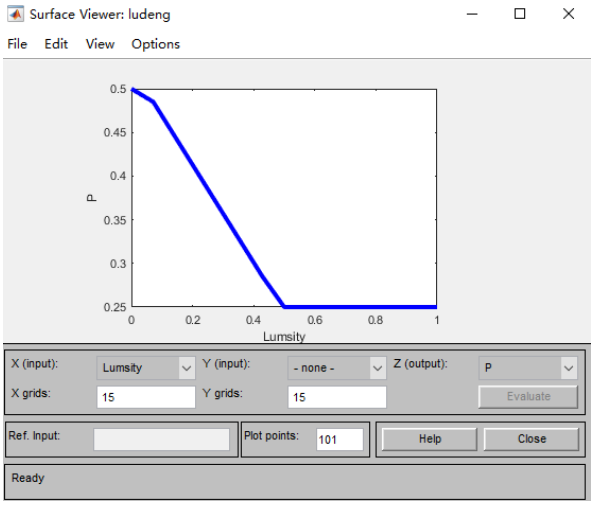

Figure 6: Fuzzy control rules of illumination fuzzy controller

In the chart above, Lumsity represents light intensity and P represents street lamp output power.

4.3 Design of Vehicle Speed Fuzzy Controller

We collected the speed data of the relevant road, and based on the characteristics of the vehicle speed data, we used the S-type membership function in the fuzzy control rules. The blur control rules of the light fuzzier designed are the faster the passing vehicle, the shorter the continuous brightness of the street lights, and the slower the passing vehicle, the longer the continuous brightness of the street lights. The correspondence between the fuzzy control rules under the vehicle speed fuzzy controller is shown in Figure 7.

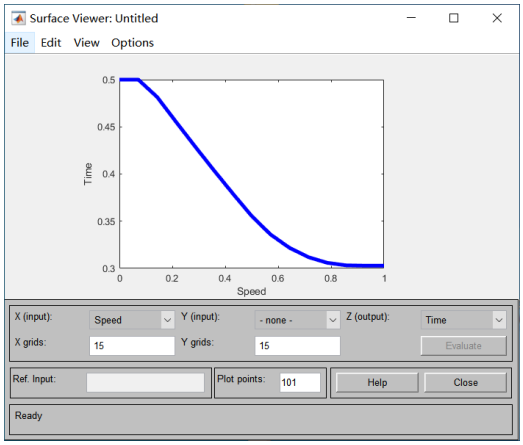

Figure 7: Fuzzy control rules of vehicle speed fuzzy controller

4.4 Algorithm Simulation in the System

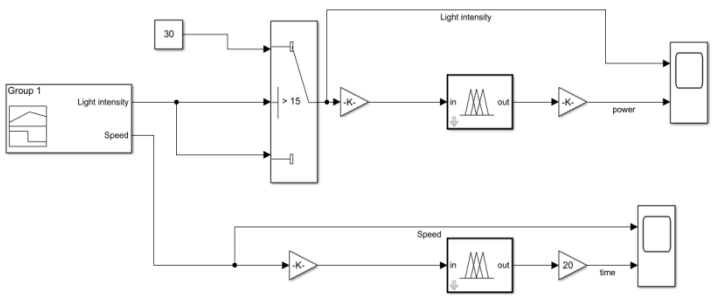

Figure 8: Simulation model of smart street light

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The system uses the simulink toolbox in Matalb for algorithm simulation. The switch module uses the 15 as the comparison value in this model, because the light intensity of the road in the city is not less than 15lx. The simulation model designed in this system is shown in Figure 8 below.

The workflow of MATLAB simulation model is shown in Figure 9 below

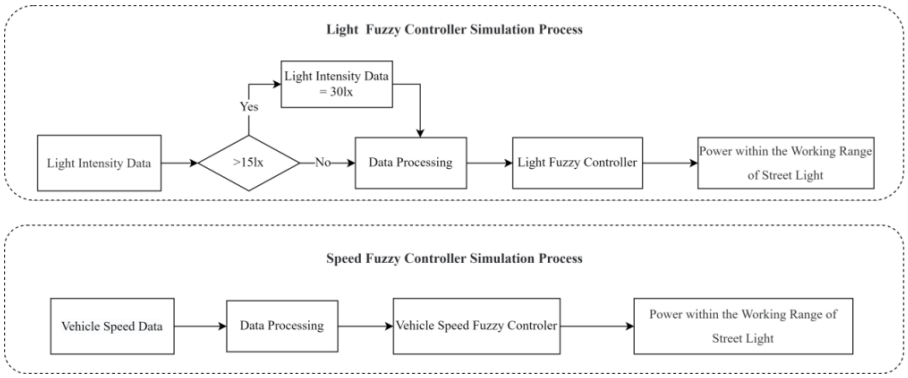

Figure 9: Simulation model workflow

5. Analysis of experimental results

In this simulation, we use GY-30 light sensor to measure light intensity ten minutes. By measuring the working state of the street lights during the time period, the LED lights can according to the change of the ambient light intensity to adjust the brightness so that the street brightness can reach 20lx .The test results are shown in Figure 10 below. The results of Figure 10 show that the LED light intensity controlled by the light blur controller is smarter and more energy efficient during the test time.

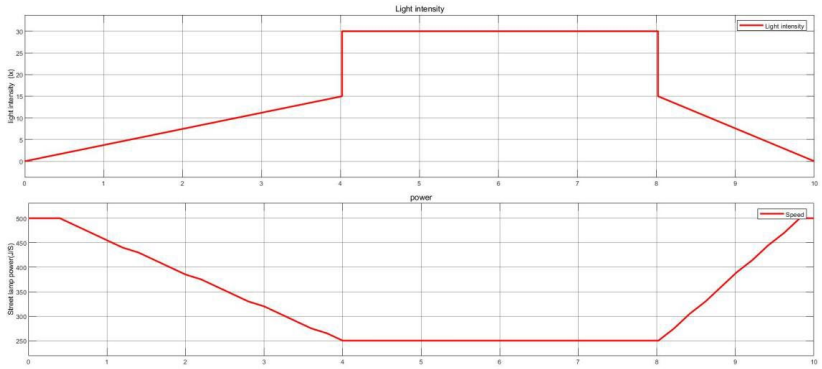

Figure 10: Test street light intensity and the power output of the street lamp

The data in Figure 10 shows that, when the light intensity is low, the power is high, and when the light intensity is high, the power is low.

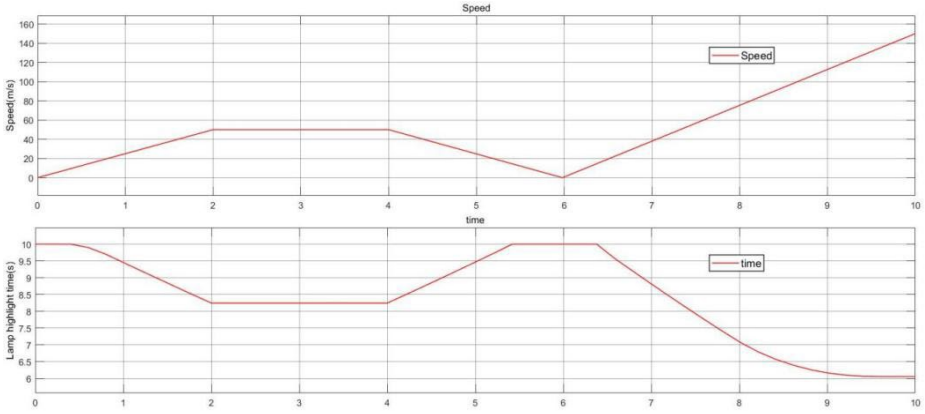

Figure 11: Street test of the speed of the car and Output result of vehicle speed fuzzy controller

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In this simulation, the ultrasonic ranging module is used to measure the speed of vehicles passing by the same street at the same time. The test data is shown in Figure 11. According to the oscilloscope simulation results, the highlight time of the LED lights regulated by the fuzzy control algorithm is significantly in line with the time before and after the vehicle passes the street according to the test speed, and the lighting work can be well completed. Compared with the lighting time of traditional street lamps, it has significant advantages of energy saving. The result is as shown in Figure 11

The data in Figure 11 shows that, when the vehicle speed is low, the LED continues to highlight for a long time, and when the vehicle speed is high, the LED continues to highlight for a short time.

6. Conclusion

In this paper, we designed an intelligent street light control system based on STM32 and fuzzy control algorithm, and the practical application is carried out through the simulink module of Matlab, which proves that the intelligent street light system designed in this paper has the advantages of saving electricity and efficient use. The hardware of the intelligent street light system is composed of a main controller, multiple sensors, and LED street light parts. The software of the intelligent street light system is composed of fuzzy control algorithm. This smart street lamps can extend the efficiency of street lamps, and improve the use efficiency of electricity. In the current situation of increasing shortage of power resources in my country, the street lights based on fuzzy control algorithm can better alleviate the situation of power shortage in our country.

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