Research on Classroom Lighting Energy Saving System Based on YOLOv3

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Abstract. After class, there are frequent cases of people walking but still lighting. In order to reduce the occurrence of this phenomenon, this paper proposes a classroom lighting energy-saving system based on YOLOv3. The system uses the installed monitoring equipment in the existing public area as the information collector, controls the lamps through the wireless control switch, and uses the Internet as a bridge to intelligently control the lamps. The system can judge the area where the lights need to be turned off and automatically turn off the equipment in the case of people leaving the lights. While ensuring lighting, the system not only prolongs the service life of lamps, but also reduces the cost of school funds. When the system is popularized to the country, it will save a lot of electric energy, and the future development force cannot be underestimated. It is of great significance to carry out energy conservation and emission reduction in China.

1. Introduction
At present, the teaching buildings in colleges and universities mainly rely on manual management, and there is often a 'long light' phenomenon. The waste of power resources in classrooms is serious[1]. In order to save energy and reduce emissions, low carbon and environmental protection, colleges and universities have also carried out rich and colorful theme education activities, such as strengthening the propaganda of energy saving consciousness, standardizing the rules and regulations related to classroom electricity consumption, reducing the number of open classrooms, sending experts to regularly patrol[2]. But it has not fundamentally solved the problem of energy waste. In this paper, a design scheme of classroom lighting energy-saving system that can be applied to teaching buildings is proposed to solve this problem, so as to improve the utilization of energy and reduce waste.

2. The Design Scheme of System
2.1. System general structure
The classroom lighting energy-saving system extracts the frame image of the video surveillance by importing the image processing program into the monitoring, and divides the frame image (that is, the classroom image) into several regions by using the plane two-dimensional coordinate system. Each region has corresponding lights in practice. Based on YOLOv3 algorithm, it identifies whether there are people in each region and returns the corresponding information. Then the system processes the obtained information, transmits instructions and controls the light switch. The overall structure of the system is shown in Figure 1:
2.2. Image processing module
The idea of the image processing module is probably as follows: the image processing program is programmed in the existing monitoring system in the classroom, and the screen of the video frame is extracted. The yolov3 algorithm is used for recognition and detection to determine whether there are people in the corresponding area divided by the screen and return relevant information. If someone returns the corresponding number of the area where the person is located (see the regional division map), and if no one returns 0[3-4].

2.2.1. Recognition algorithm
In order to identify whether there is anyone in the classroom, YOLO3 framework is used to detect and identify targets. This technology is an object recognition and localization algorithm based on deep learning neural network. Its biggest feature is that the recognition speed is fast [5], which can be used in real-time systems and reflect the current recognition situation in time. Moreover, the detection showed excellent resistance to rotation, scale change and body occlusion. Even if the people in the classroom are only left in the upper half due to the occlusion of the table and chair, they can also be successfully detected with high robustness. The basic idea of YOLO algorithm is as follows. Firstly, the input feature is extracted through the feature extraction network to obtain the feature map output of a specific size. The input image is divided into 13 × 13 grid cell, and then if the center coordinates of an object in the real frame are located in a grid cell, then the grid cell is used to predict the object. Each object has a fixed number of bounding boxes, YOLO v3 has three bounding boxes, using logistic regression to determine the regression box used to predict.

Due to the low frequency of personnel activities in the classroom and the small difference between the background and the target, this study adopts the frame difference method based on the background [6] to obtain a smaller target recognition area before detection, so as to reduce the calculation amount and improve the recognition speed. The whole recognition process can be briefly described as follows: Firstly, the current video frame is found by the difference frame method. Compared with the previous frame image, the possible target region (i.e., different regions compared with the previous frame) is found. Then, the YOLO3 recognition of the region image is carried out to determine whether it is human and return the relevant signal. If someone in the region returns the corresponding number of the region (see Figure 2 in the regional division diagram), and if not, returns 0.
2.2.2. Test result
When the resolution of the input image is 640 × 480, the detector can reach the speed of 23 fps on the GTX-1050Ti GPU. Some test results are shown in Figure 3.

![Front gate division](image1)

![Back gate division](image2)

**Figure 2. Classroom area division diagram**

![Partial test results](image3)

**Figure 3. Partial test results**

To detect the recognition effect of the recognition algorithm on indoor personnel, the algorithm is applied to the personnel recognition of classroom monitoring video. The use of surveillance video is: 20 min, mp4 format, resolution is 640 × 480, each frame interval is 5 s, a total of 240 frames, which does not contain 65 frames of indoor personnel, including 175 frames of indoor personnel. Run the module to identify indoor personnel in each frame, and compare with the results of manual observation to calculate the correct recognition rate of the algorithm. The calculation method is as follows:

\[
R = \left( \frac{\sum Mc \times Fc}{\sum Mt \times Ft} \right) \times 100\% \tag{1}
\]

In the formula: \( R \) is the correct recognition rate, \( Mc \), \( Fc \) are the number of recognition and the frame number of the situation, \( Mt \), \( Ft \) are the number of manual observation and the frame number of the situation.

The experimental results show that the average recognition time is 0.2 s, that is, the recognition module can detect indoor personnel in videos below 5 frames / s. When there is no person in the frame, the correct recognition rate is 100 \%, that is, the module will not misidentify the classroom background as a person; When there are people in the frame, the recognition result is shown in Table 1 according to the difference of people in the frame.
Table 1. Detection results for frames containing indoor personnel

| The actual number of people in the frame | Number of people detected | Frame number | Correct recognition rate |
|----------------------------------------|---------------------------|--------------|-------------------------|
| 1                                      | 1                         | 26           | 100%                    |
| 2                                      | 2                         | 29           | 100%                    |
| 6                                      | 6                         | 15           | 100%                    |
| 9                                      | 8                         | 25           | 95%                     |

Found in the detection process:

a. When the indoor contains people, the number of people identified is less than or equal to the actual number, that is, other objects will not be mistakenly identified as people;
b. When the classroom contains fewer people, the correct recognition rate is 100%;
c. When the classroom contains more people and the personnel interval is dense, it is easy to identify people close to the distance as one person.

Although there are deficiencies in the identification module when there are more people in the room, the focus of the identification in this module is to determine whether there are people in the divided area, that is, when there are more people in each area, fewer people are identified without affecting the final results, and the module will return the information of people in the area and then control the area to turn on. In short, the recognition effect of the algorithm meets the subsequent requirements.

2.3. Wireless control module

2.3.1. Principle of Control Module
The digital signal returned after image processing is transmitted to the PC, and ESP8266WIFI module[7] is selected. The WIFI module is controlled by AT command to access the Internet and send to the ESP8266 module through the LAN. The module communicates with arduino through serial port. After receiving the instruction, arduino executes the corresponding instruction operation, enlarges the digital signal, and projects it to a small simulation experiment, corresponding to the LED lights in different regions. The structure of this part is shown in Figure 4:

![Figure 4. Structure Diagram of Wireless Control Module](image-url)
The control module realizes the functions of serial port attribute setting, data loading and reading by calling computer serial port object support function in arduino MCU. The arduino built-in functions to be used include: instantiated soft serial port SoftwareSerial mySerial (2, 3), and defined serial port int led_pin0 = 8. int ch[4] = {led_pin0, led_pin1, led_pin2, led_pin3}; Query serial bool valid_cmd = false; and read/write serial port Serial. println (mySerial.read()); cmd[i++] = mySerial.read(); and Serial. println (cmd)[8-9].

2.3.2. Simulation test
1. When the received signal is: 13, four LED 1, 3 lights, 2, 4 lights out. (Figure 5.1 shows)
2. When the received signal is 1234, four LED lights are fully displayed. (Figure 5.2 shows)

3. Conclusion
Through the analysis of the demand for classroom lighting control, this paper introduces a classroom lighting energy-saving system based on YOLOv3 algorithm to realize the unattended automatic closure of lights, which makes up for the lack of classroom power management in colleges and universities and achieves the purpose of energy-saving control. The design of the system is of great significance to the classroom lighting control of various schools and has a good prospect of popularization and application.

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