Enhancement of smart street light monitoring system based on LoRa technology

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ABSTRACT: The problem of the current street lighting system of Malaysia is high energy consumption and depending on timer controlling system, this has made the street light has the poor capability to the changes of the surrounding light. Therefore, this project is proposed to manage the on/off and output brightness of street lights using Internet of Things (IoT) and a feedback control system based on LoRa technology. Light Dependent Resistor (LDR) and microwave motion sensor implemented to detect the intensity of surrounding light and the movement on the street, and hence to control the output brightness of LED light. Next, Artificial Intelligence (AI) approach fuzzy logic will be used as a feedback control system to drive a suitable output signal. Moreover, LoRa technology will be used to monitoring the situation of street lights because it has a larger coverage area with a license-free ISM band. Last but not least, the Internet of Things (IoT), The Things Network (TTN), and TagoIO application will be used for the transmission of data and sensors to detect real-time changes. In conclusion, this smart LED street light could help to reduce power wastage and better monitoring system to enhance Malaysia's street lighting standard in the future.

Keywords: *Street light monitoring system; Fuzzy logic; LoRa*

1. INTRODUCTION

Street lights are important to light up roads at night and the conventional High-Pressure Sodium is the most common street light we can see. HPS street lights operate at higher internal pressure to light up the lamp [1]. However, this HPS street light is high energy consumption compared to LED light [2]. Moreover, the mercury element inside the sodium metal was a hazardous material that will lead the problems with trash disposal [3].

In the meantime, the HPS street light operates in a manual setup that operated from sunset to sunrise caused an energy wastage and lower device performance [4]. This system can only adjust the time switch of daily street lights and the operating condition of lighting facilities cannot be reflected in time, so this caused difficulty in maintenance work also [5]. Moreover, Global System for Mobile Communication (GSM) used in conventional street lights had charged up an expensive dedicated regional frequency and is said to have higher power consumption and cost operation [6].

Therefore, this project proposed to develop a smart LED street light through the implementation of a closed-loop control system with the fuzzy logic controller to control the output brightness and to analyze the sensor's data and simulate the program to monitoring the situation of the street light using LoRa technology.

2. METHODOLOGY

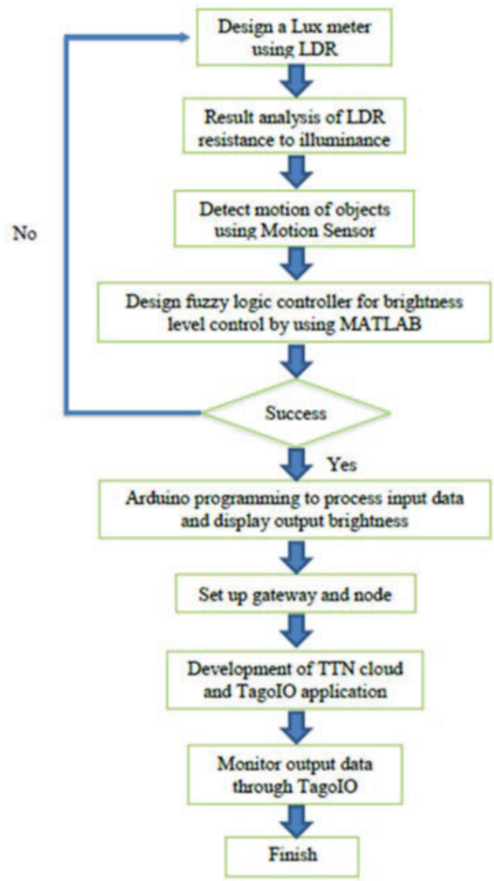

Figure 1 Flowchart of Smart street light monitoring system.

This research is divided into five experiments. The first and second experiment was to design a lux meter using LDR (GL5516) and a microwave motion sensor to collect surrounding light intensity and motion on the street. Next, a fuzzy logic controller was designed by using MATLAB to control the brightness level control in the third experiment. Afterward, LoRa gateway and node are set up in experiment 4 to enable the communication and transmission of data. Last but not least, the last part was to develop a TTN cloud server and TagoIO application for real-time monitoring. The node device is then placed outdoor for 3 consecutive days to collect consistent data for data analysis.

3. RESULTS AND DISCUSSION

At the end of this project, a smart LED street light had developed through the implementation of LDR and microwave motion sensors. LDR sensor is able to capture the level of illuminance that falls on it. It can be concluded that the illuminance is decreased inversely proportional to the average LDR resistance. Then, the best fit line was generated from the graph of Log (Lux) vs Log (Ω), and a linear equation was get as shown in Equation (1).

$$Y=-1.5143x+7.944 \quad (1)$$

$$Log_{10}(approximate\ lux) = m\ log_{10}(R) + c \quad (2)$$

The gradient and c-intercept are then substituted into Equation (2), and Equation (3) was the final summarized equation to find the approximate lux value.

$$Approximate\ lux = R^{-1.5143} \times 10^{7.944} \quad (3)$$

Equation (3) was rewritten in coding and the final illuminance value will be print on the serial monitor of Arduino software. While motion sensor emits continuous waves of microwave radiation to detect motion on the street. Continue to design a fuzzy logic controller for brightness level control using MATLAB software, a fuzzy logic rule evaluation was designed as showed in Table 1 below, and lastly, there is a total of 25 rules of membership function are set. The rules are then rewritten in coding and upload to the Arduino sketch board to simulate the result.

Table 1 Fuzzy logic rule evaluation

		Illuminance				
		VL	L	M1	H	VH
Motion	VLM	D	D	D	D	VD
	LM	B	N	N	N	VD
	M2	B	B	N	N	VD
	HM	VB	B	B	N	VD
	VHM	VB	VB	B	B	VD

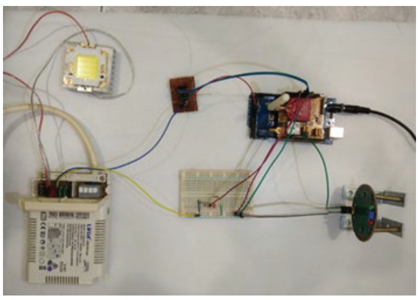

Figure 2 LoRa node setup

Lastly, The Things Network (TTN) and TagoIO application are developed to manage node device as shown in Figure 2 to store and display the output brightness of COB LED. The output brightness percentage will be upload to TTN cloud and TagoIO every 30 seconds by using LoRa technology. The node device is placed outdoor for 3 consecutive days, and the result was shown in Figure 3.

Figure 3 Overall output brightness percentage from 10 May 2021 (00:00am) to 13 May 2021 (00:00am)

Before sunrise, the brightness percentage maintains at minimum 20% when there is no motion detected. But when there is motion detected, the brightness percentage increase according to the time of motion detected. The higher the motion time, the higher the output brightness percentage. The LED turns off when sunrise at around 7:45 am. Any motion detected after sunrise will not turn it on, unless the LDR sensor detects a decrease in light intensity due to cloudy and rainy days. Figure 3 shows LED turn on in the afternoon time for all 3 days, this is because of the rainy day. Lastly, the LED turns on again when the LDR sensor detects a low light intensity.

4. CONCLUSION

In conclusion, a smart LED street light had successfully developed through the implementation of a closed-loop control system. The LDR and motion sensor manages to collect input variables and thus combined to drive suitable output brightness of COB LED by the fuzzy logic controller. The data is transmitted between gateway and node, while the TagoIO application is used to monitoring the situation of the street light. This project successfully minimize the electricity cost with the feature of auto dimming and brightening and hence can reduce global warming.

5. REFERENCES

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