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Smart Street Lighting System with Data Monitoring

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Smart Street Lighting System with Data Monitoring

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Abstract. Street lighting is required for the safety and convenience of street users at night time. A smart street lighting with data monitoring is proposed and designed in this paper in order to optimize the use of the street lamps, i.e. more effective and efficient. The system checks the sunlight brightness condition to determine when the system will start working since it is not needed on daytime. The sidewalk and vehicle sensors start working on night time, checking the pedestrian and traffic condition. If any vehicles on the street or any activities on the sidewalk are detected then the closest street lamp will be at its maximum brightness level. The farther from the detecting sensors they are, the lamps will be dimmed or turned off completely. Information on the public street condition can be monitored using a smartphone application. The application also displays temperature and humidity of the surrounding area, which is useful for the public street management. The result proves that the smart street lighting system works exactly as designed and required.

1. Introduction

Street lighting is a basic need for street users especially when driving at night time. As the street light demand increases, the electricity energy usage for street lighting also increases. In addition, as urbanization continues, the number of streets and traffic density also increases. All these makes street lighting really necessary [1], [2], [3].

A smart street lighting system is able to adapt to the street condition. It makes the street lamp usage more effective and also efficient since the lamps are not continuously turned on all the time. The system checks the street and sidewalk condition using several types of sensors. Each sensor has its own function in reading the street condition.

The system also detects the surrounding ambience light in order to determine when the system will start working, i.e. at a night time, or even on daytime when for some weather reason it gets dark enough. The street lightinf system will check the public street for any passing vehicles on the street or any people walking on the sidewalk. If there is no traffic or pedestrian then street lamps will be dimmed or even turned off completely, but if the sensors detect passing vehicles on the street or activities on the sidewalk then the closest street lamps will be at at their maximum intensity or slightly dimmed, proportional to the distance between the detected object and each street lamp. The system illustration is shown on Figure 1, while the block diagram of the system is shown on Figure 2. The data of all these conditions can be monitored on a smart phone for use by street management personnels.

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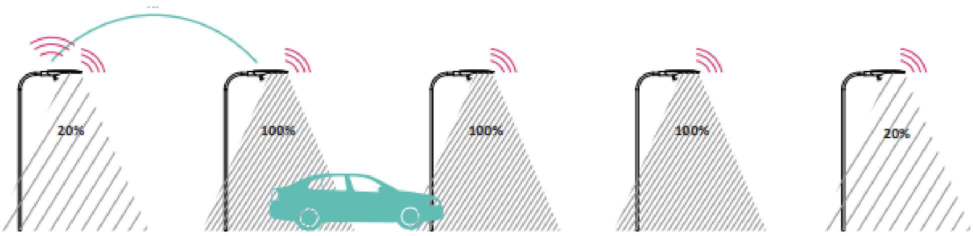

Figure 1. Smart Street Lighting Illustration

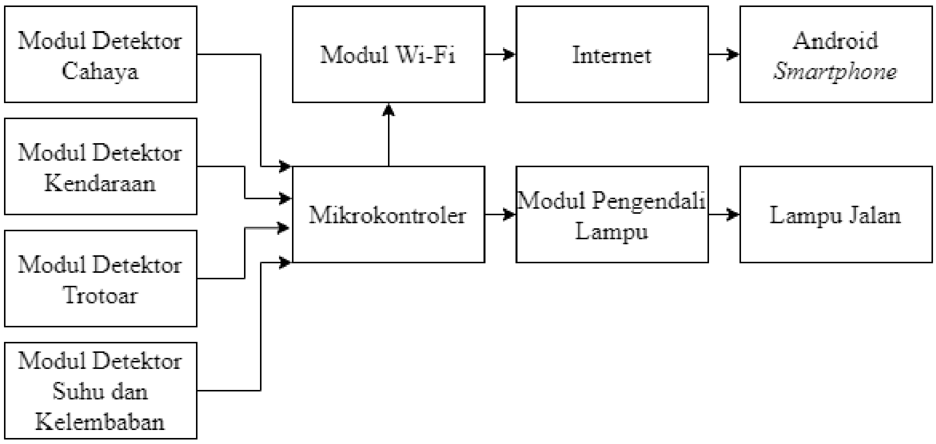

Figure 2. Block Diagram of Smart Street Lighting System

2. Design and Implementation

The following is a closer look at a few of several important modules used to design and implement the complete proposed smart street lighting system.

2.1. Light Dependent Resistor (LDR)

The LDR is used as the light intensity sensor. If this sensor is exposed to a light and there is a change in the intensity of, its resistance value will change [2-5]. The LDR sensor is made of cadmium sulphide and cadmium selenide, semiconductor materials that the resistance value depends on the amount or intensity of light they are exposed to [3-6]. As seen in Figure 2, the resistance value will decrease when the illumination is higher, the LDR resistance value is inversely proportional to the illumination [4], [5], [6], [7].

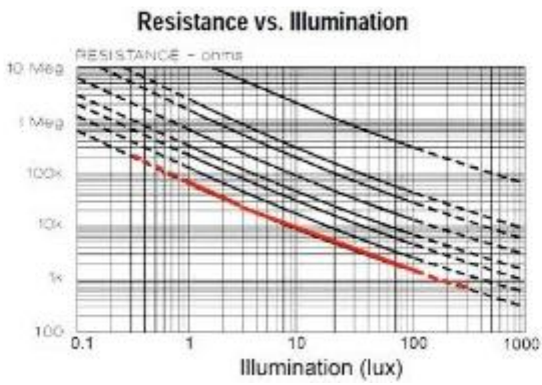

Figure 2. Resistance vs Illumination Graph of an LDR

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2.2. Infrared Sensor

Infrared sensor works by detecting the reflection of the infrared light transmitted by a transmitter and received by a receiver. It detects voltage change using infrared light [5-8]. If the infrared light detects an obstruction or an object blocks the infrared light then the receiver receives the reflected infrared light, but if the infra red light does not detect an obstruction then then there will be no reflection. Figure 3 shows this principle. The difference between the time the transmitter sending infrared light and the arrival time of the reflection producing electrical current sensor represents the distance between the sensor and the object [6-9]. In the infrared sensor module the reflection distance can be adjusted by changing the sensitivity level using a potentiometer,the adjustable distance limit that can be controlled by the potentiometer depends on the specifications of the infrared sensor used.

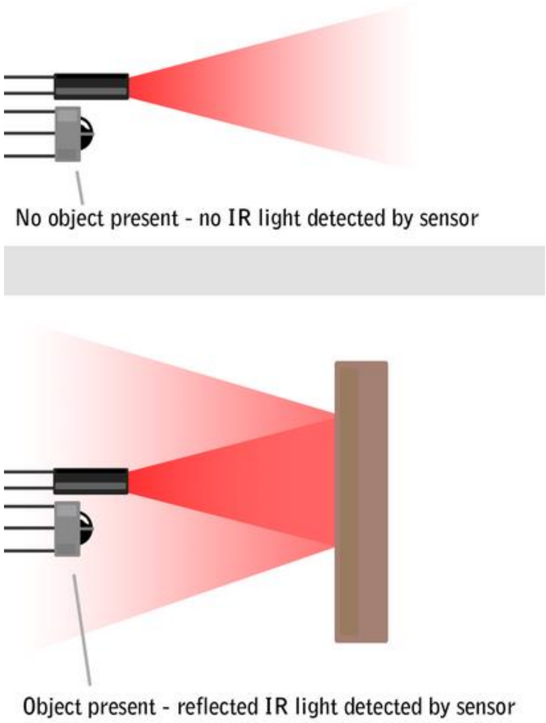

Figure 3. Infrared Sensor Detecting and Not Detecting an Object

2.3. Passive Infrared Receiver

The PIR sensor works by detecting infrared signal transmitted by human or animal bodies, mostly used for detecting human movements. The PIR sensor detects the temperature difference of human movement passing the area covered by the sensor. The room condition read by the sensor when there is no human movements is the initial value or set point used as the reference, compared to when there is human movements [7], [8]. [9], [10], [11]. The sensor is called PIR since it reads the surroundings without transmitting infrared light but by receiving external infrared light radiation [8], [9], [10], [11], [12].

2.4. Temperature Sensor

The temperature sensor provides output voltage that varies linearly proportional to the temperature values read [9-14]. The temperature sensor output is converted to digital data to be used by microcontroller for providing automatic temperature data and temperature threshold control [10], [11], [12], [13], [14], [15].

2.5. Humidity Sensor

The humidity sensor measures the amount of water vapor content of the air [11], [12], [13], [14], [15], [16]. The information becomes important since electronic devices or systems may become corroded if the humidity of its surroundings is high.

2.6. Pulse Width Modulation (PWM)

PWM changes the duty cycle of a square wave with constant amplitude and frequency [17], [18]. The pulse width is directly proportional to amplitude of the input signal [18]. Duty Cycle represents the time of high logic in a signal periode in percent (%) ranging from 0 to 100 [17], [18]. The PWM value can be generated by microcontroller on PWM pin using *analogWrite()* command on the program to provide varying duty cycle values, used to vary the brightness of LED lamps.

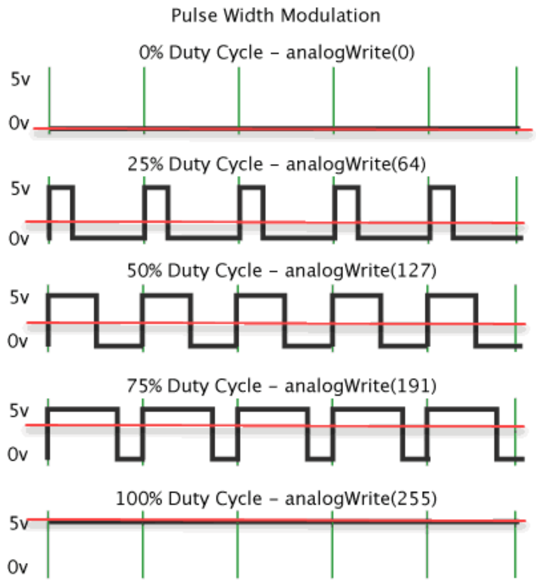

Figure 4. Pulse Width Modulation with 0 – 100 % Duty Cycles

3. Results and Discussion

The most important tests performed are on three most important modules. The first one is the light detector module since it determines when the system starts. Then the street and sidewalk detector module, checking that several lamps in front of the passing vehicles are turned on and those behind them are dimmed or turned off. The last one is object detection on sidewalk, the street lights have to be turned on at maximum brightness around activities on sidewalk.

Table 1. Light Detector Test Result

Light Detector Sensor Value	Lamp Condition
Value >100	Turned On
Value <100	Turned Off

Table 1 shows that if the obtained value is above the reference value then the lamp is turned on, means the ambience is dark enough, and if the obtained value is below the reference value then the lamp is turned off.

Table 2. Vehicle Detector Test Result

Infrared Object Detector	Lamp Output Voltage (volt)				
	Lamp 1	Lamp 2	Lamp 3	Lamp 4	Lamp 5
Infrared 1	2.78	2.78	2.78	0.98	0.98
Infrared 2	0.98	2.78	2.78	2.78	0.98
Infrared 3	0.98	0.98	2.78	2.78	2.78

Infrared 4	0.98	0.98	0.98	2.78	2.78
Infrared 5	0.98	0.98	0.98	0.98	2.78

Based on the data result in Table 2, when the infrared point detects the presence of a vehicle, lamp number 1, 2, dan 3 light up at high level.

Table 3. Sidewalk Detector Module Test Result

Sidewalk Object Detector Condition	Lamp Output Voltage (volt)				
	Lamp 1	Lamp 2	Lamp 3	Lamp 4	Lamp 5
Object detected	2.78	2.78	2.78	2.78	2.78
Object not detected	0.98	0.98	0.98	0.98	0.98

From Table 3, it can be concluded that if activities on the sidewalk were detected then all lamps were at their maximum intensity.

Finally, the result of overall test (not shown here) shows that each sensor reads the ambience light value in order to decide whether the street lamps would be turned on or not. When the lamps were turned on then the sidewalk and vehicle detector sensors would start working to determine the brightness level of each individual lamp. Temperature and humidity sensors send data about surrounding condition, with the resulting data sent to the Android application.

4. Conclusion

The system successfully detects the sun light level difference for determining when the street lighting system starts working. Once it starts working the system is able to detect and determine the brightness level adapting the reading result of vehicle on street and/or pedestrian on sidewalk detection. The temperature and humidity reading features works as expected, providing data/information displayed by the Android smartphone application.

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