Cloud based automatic street lighting control system

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Abstract. Conventional street lighting control systems is manual control, light sensitive control, and simple timing control while energy consumption and operators are unable to monitor street lights, that significantly disrupts management and maintenance. This work is based on the idea of maximize the maintaining and minimize an energy loss. Much of the energy produced daytime is saved in a solar cell and then will use to glow street lights throughout the night. The system also provides an energy-efficient operation mode by adapting the automated method. The lights switch on / off automatically according to vehicle movement or day / night sensor as well as to reduce management cost and monitor status information for each street lighting unit. In this paper two sensors are utilized that are Light Dependent Resistor (LDR) sensor to signalize a day/night time and Infrared Obstacle (IR) sensors to discover the movement on the street. Arduino microcontroller is utilized as a brain to control the street lighting system. In the other hand sensors data are analyzed and stored in Thingspeak cloud after are sent by Arduino UNO. Experimental results show that the system is stable and reliable as it can be applied as a model system.

1. Introduction

The rapid urbanization and continuous development of technology that made intelligent street lights an important part for building the smart cities [1]. Traditional street lighting systems consume a lot of energy as they run from evening to early morning and require a large installation cost which was the major drawback for develop our life [2]. The main objective of this paper is to provide an automatic street lighting system that can reduce the street light strength for roads. The rapid development of embedded systems has paved the way for the design and development of microcontrollers based on an automated control system. This paper introduces an automatic street lighting control unit using LDR[3]. The system can select bright or dark environment with LDR. When the weather is dark, the system allows the operation of street lights. Bright weather the system allows to turn off the street lights. This energy saving can be used in some cases as in villages, towns, etc. which can design smart street lights systems [2].
Several researches related to street lighting monitoring have been proposed. This paper suggested an automatic smart street light and traffic light system. The infrared sensor is used to automate the function of street lights, while at the same time calculating the traffic density in the path to monitor the timing of green and red signals for this specific lane. In [4] suggested smart street lighting technology using ARM7 based on a microcontroller. The system aims to decrease energy consumption by monitoring the light by the sensor, which is turned off during daylight while it is operating during night mode. Further enhancement was made to adjust the dimmer, which reduced energy consumption. Another research [5] suggested that the work uses several types of sensors to control switching lights. The system controls the operation of light according to the humans or vehicles utilizing an application specially developed via Android licensed personnel are allowed to deal with system operation such as manual control of lights and processing requests. In [6] the author demonstrated the ability of the Internet of Things as a suitable candidate for a light monitoring system. There is a possibility to improve the street light monitoring system by adding additional functions to the IoT department. The Internet of Things is basically a wireless data connection, which allows controlling utilizing removable devices such as a laptop or a smartphone via an Internet connection. The another research [7] implemented smart street lighting system which is used the photo voltage (PV). These street lights operate alone as a separate off-grid system but it is not connected to the other network for a larger system. In [8] author suggested a smart system that can control the intensity of street lighting efficiently. This paper utilized a TRIAC-based density control system. The intensity of the light is controlled based on the road traffic load weighted by the sensors and then the light is turned on/off automatically. The system can also be managed by some graphical user interface.

The proposed automated system is cloud based that includes automated data update for system lighting. Cloud computing supplies various services to clients such requirements as pay-per-use and on-demand service. Cloud computing was used to store and monitor a huge amount of data and [9]. During an emergency it even reads information from the base station. Two sensors are used; LDR sensor to indicate a day/night time and the Infrared obstacle IR sensors to monitor the street movement [3]. The Arduino UNO is utilized as brain to control the street light system, where is the programming language used to develop the program to the microcontroller (C). Node MCU (a small Wi-Fi microcontroller used for transmitting sensor readings to the cloud) connects to Arduino UNO and is used to wirelessly transmit data from the base station to the lighting system enabling for efficient street lamp control. Lastly, the system was successfully designed and can be used as a model system. Furthermore, the proposed work focused on reducing electrical waste to street lights using solar energy to provide a better operating solution which differs from the above related researches by using solar photovoltaic cells (SPC) used to generate electricity from the sun.

2. Materials and Methods

Recently, Smart road light system is main component of a smart city. The important task is to illuminate the city roads using sensors to save an energy. In the current system using regular road lights.

2.1. System Components Used in IoT:

The main components needed by the system are as follows:

2.1.1. Microcontroller

The microcontroller can be operated as a stand-alone system with memory, accessories and a processor. Peripherals, telephones, appliances and automobiles, mostly use microcontrollers as all computer systems are included in other devices, so that they can be used as an embedded system.
**Node MCU:** It is an open source development suite that utilizes a few lines of text. This part is based on ESP8266 which is a little-cost Wi-Fi chip that contains full TCP/IP stack and controller size. ESP8266 Node MCU as illustrated in figure 1 is a sophisticated device which has some of the characteristics of an ordinary Arduino board with internet access. Microcontrollers and Arduino units have been a good for integrating automation into the related project. But these units have some drawbacks because they don’t have built-in Wi-Fi ability. As a result, we'll need to add an external Wi-Fi protocol to these devices in order for them to work with the internet [10].

![ESP8266 Node MCU](image1)

**Figure 1.** ESP8266 Node MCU [10].

- **Wi-Fi Module ESP8266:** The microcontroller can connect to the Wi-Fi network by sending a coherent TCP/IP packet to the independent (Wi-Fi ESP8266). To provide Wi-Fi operation from a processor to an alternate application processor, the capabilities of ESP8266 are used [11].

- **Arduino UNO:** Arduino UNO is an open source platform, hardware and software. Arduino panels can read inputs sensor light and convert it to output on Light Emitting Diodes (LED) operation, publishing something on the Internet. Arduino IDE (Integrated Development Environment) is utilized to load programs into Arduino boards and these microcontrollers can be used to perform tasks as dedicated in figure 2 [12].

![Arduino UNO](image2)

**Figure 2.** Arduino UNO.
2.1.2. Sensors

Different types of sensors have been used in different enterprises and industries, but innovation in the Internet of Things has led to the growth of sensors to the maximum. With various sensors, the IoT provides different kinds of data.

- **IR sensor:** The infrared (IR) electronic unit. It is used to sense the object by infrared. Infrared sensors used with a specific light sensor to find a particular light wavelength in the infrared spectrum. Using LED gives equal wavelength as the sensor finds. When the object is near the sensor, the LED light reflects in the light sensor. The concept of an infrared sensor is used to detect obstacles to sending an infrared signal. The IR signal is reflected from the object and the signal is obtained at the infrared receiver [3]. Sensors are mainly chosen for their robustness, lightweight, low cost, and fast response time [13]. This sensor is controlled by Arduino UNO as showed in figure 3.

![Figure 3. IR sensor with Arduino.](image)

- **LDR sensor:** Is a sensitive device also called as a photo resistor, whose resistivity factor is an electromagnetic radiation function. Consequently, they are light sensitive devices similar to those of human eyes. LDR operates on the optical conductivity standard [5] as well as monitored by Arduino UNO as illustrated in figure 4.
2.1.3. **Other Components**

- **LED**: It is a lamp which is used for energy savings. Currently, many developed countries are committed to converting their cities into partially smart cities by introducing an energy-efficient street lighting system by using a set of LEDs in poles can be illuminated at night. Moreover, by turning on/off the LED at very high speeds reduce waste energy [14].

- **Solar cell**: Solar cells are devices that turn light into electricity. A photovoltaic device, such as a solar cell, is a type of photovoltaic device. Photovoltaic (PV) devices are a method of transform radiant solar energy into electrical energy [15].

- **Thingspeak**: ThingSpeak is a cloud and IoT analytical platform that supports real-time sensor data analysis and visualization. Requires a user account and a channel. The channel stores data sent to the Thingspeak [16].

2.2. **Implementation**

The parts that are utilized in the proposed system are shown in figure 5. The lamp module is the first part which consists of the movement and brightness sensors, the communication and control device.

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**Figure 4.** LDR sensor with Arduino.

**Figure 5.** Proposed system diagram.
Sensor module is the next part which composed of motion sensor, control device and communication device. Sensors must be deployed to a number of locations to ensure street lights are lit before the pedestrian passes. This part is utilized when the distance among the sensors and lamps is too large to be connected to each other. LDR sensors utilized to detect the light. In the daytime, the resistance decreases and the LDR sensors are turned off. Therefore, when anything passes, such as pedestrians or a car, the lights not turn on. In order to the resistance LDR only be high during the night. When the street is dark at night, the resistance increases and the LDR is turned on, so the light turns on when anything passes. These sensors are monitored by Arduino UNO which can be supplied power by solar cells.

Nowadays, there are high communication standards for data rate available in the world of communication, but none meets the needs of sensors and controllers. For limited bandwidth, communications technologies with a massive data rate necessitate low power consuming and low latency. The Arduino UNO system unit is the simplest and little cost used by other wireless sensor networks such as Bluetooth and Wi-Fi. If either IR or LDR sensors are detected to discover the movement or value of light, Arduino sends the value through the sequence (TX) and receives it (RX) to the node, each sensor detects and transmits this data to the controller which is called a Node MCU Wi-Fi ESP8266 and forwards them to the cloud.

This module communicates with the Thingspeak to manage LED lights on and off and to check if lights are operational. Based on HTTP protocol. ESP8266 NodeMCU is communicated to Wi-Fi and connected to IoT, Thingspeak platforms. Environmental data was collected from the sensors and sent to cloud and IoT platforms via Wi-Fi. Thingspeak cloud provides data collection and analysis.

3. Discussion and Results

Energy quality is improved on traditional street lighting system in an intelligent automatic manner. This will help cities to become a smart society. The use of energy electronics in various sectors of human life has increased dramatically. This technique is proving a good way to save resources. It includes the technology of lighting and turning off the lights automatically without human intervention, thus conserving a limited amount of energy.

This proposed system lights up the lights before vehicles or pedestrians passing, and turn them off after a period of time. Then brightness will be reduced to save energy. The light sensors sense the light intensity then send a response to microcontroller, which in turn starts the power unit. As a result, automobiles and walkers must take some time to exit the street lamps highlight region, as seen in Figure 6.

Figure 6. Proposed experimental system
In this paper the power efficiency is improved from traditional system to smart lighting system at night and according to the passage of anything that will illuminate the street. While walking at night, it also ensures road safety and avoids criminality. This will provide a smart city in the near future. Energy electronics are increasingly used in various sectors of human life. After data processing, the parameters are sent to the Thingspeak by HTTP. IR sensor parameters which is implemented in the motion, LDR sensor was presented with the light are depicted as a time series on Thingspeak as illustrated in Figure 7. Thingspeak served as the server, and the NodeMCU board was utilized as the client by connected it to a Wi-Fi.

This work has proven to be an economical and safe way to conserve energy. It merges the way lights are turned on, reducing lights and closing lights, thus keeping minimal energy.

4. Conclusion and Future Work

This paper describes a smart lighting technology in which a standard street light is converted to run on solar power. Additional functionalities were added to enhance the performance of the system by lowering overall power usage, which was accomplished by employing a motion sensor, or by employing a light sensor. These sensors were controlled by Arduino UNO microcontroller. This system is remote control monitoring. The environmental parameters for this system are light and motion. These parameters managed by the installed sensors which connected with NodeMCU. The ESP8266 NodeMCU was utilized to communicate to Wi-Fi and with IoT platforms-Thingspeak. After the environmental parameter data gathered from the sensors are handled and sent to the cloud platforms and IoT by Wi-Fi utilizing the HTTP protocol. Data was represented in time-series on platform of IoT, and users could acquire access to it and get real-time information on the internal environment.

The proposed system indicates that a smart lighting model supports save less power consumption in cities. Since energy saving plays an important role. This strategy provides an effective alternative for lowering energy use. In the future, we will utilize the camera to increase the security for the road.
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