OUTDOOR LIGHT MONITORING USING EMBEDDED SYSTEMS

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Abstract: The present light system consumes about 40% of power generation and it unnecessarily illuminating at high intensity even on a time which causes tremendous light pollution in the world. This project intended to vary the intensity of those lights using micro controller and Internet Of Things. The Arduino board is used as central micro controller which is connected with sensor such as temperature, humidity, Passive Infrared sensor, Light Dependent Resistor sensor to get the data from environment. Based on these, the micro controller produce output voltages to LED lamps through pulse width modulation. This in turn varies output intensities of those lights, thereby reducing pollution without compromising the safety. This can be implemented in street lights, Educational institutions (especially near Hostels), Railway stations and bus stands. The data is stored in internet which can be used for further processing and it will be a good start for smart cities and helps in terms of reduction in pollution as well as power saving.

Keywords: Arduino, Embedded systems, IOT, Smart cities, Light pollution

1. Introduction

As world progressing towards urbanization the effects of pollution should be tackled effectively to make a city as a sustainable city. The present city infrastructure is such a way that more than 40% [2] of the power consumption of any corporation goes in the outdoor lights. With high intensity lights causing light pollution and also affect animals, birds and marine species biologically by changing their nocturnal cycles [3]. It is impossible to get away from street lights because of security issue and vision limitations of human. So this paper proposes an effective way to manage outdoor lights using embedded systems and Internet of things. Traditional lighting systems have disadvantages such as lack of pervasive and effective communications, monitoring, automation, and fault diagnostics problems. With advancement in technology LED lights prove to be efficient lightening system for modern smart cities due to the features like dimmable, less power consumption, high switching speed [4] and also can produce lights in high intensity with different colors. Even in places like museums[5], gallery where lightening is crucial as it needs balance of visibility and spoil of old artefacts this LED system gives best solution. The Internet Of Things also giving promising future in smart city urban light monitoring. The existing systems use fuzzy logic of data from real time clock and Light dependent resistor [6] to reduce the power consumption of the lights. This technique also can be applied in home automation. [7] [8]. The present system is very inefficient in tackling light pollution that produced in the urban premises.

1.1 Light Pollution

The use of inappropriate or excessive artificial light is known as light pollution. It can lead to serious environmental consequences for humans, wildlife, and our climate. The components of light pollution are Glare, sky glow, clutter and light trespass. Light pollution is a side effect of industrial civilization [9]. It has sources include building exterior and interior lighting, advertising, commercial properties, offices, factories, streetlights, and illuminated sporting venues. It is unfortunate that much outdoor lighting used at night is inefficient, overly bright, poorly targeted, improperly shielded, and, in many cases, completely unnecessary. This light, and the electricity used to create it, is being wasted by spilling it into the sky, rather than focusing it on to the actual objects and areas that people want illuminated. Inability of naked eye to see milky way galaxy in night sky in half of the world, accidents baby of sea turtles in roads, birds hitting buildings, loss of wetland amphibians are the side effects of light pollution. It has also impact on cardiac rhythm in human beings which also increase stress levels.

Table 1. Light pollution levels in urban areas in India

<table>
<thead>
<tr>
<th>Places</th>
<th>Intensity (lumen/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Delhi</td>
<td>118.57</td>
</tr>
<tr>
<td>Navi Mumbai</td>
<td>53.80</td>
</tr>
<tr>
<td>Bangalore</td>
<td>56.58</td>
</tr>
<tr>
<td>Chennai</td>
<td>52.32</td>
</tr>
<tr>
<td>Gangtok</td>
<td>5.08</td>
</tr>
<tr>
<td>Port Blair</td>
<td>25.13</td>
</tr>
<tr>
<td>Rameshwaram</td>
<td>19.35</td>
</tr>
<tr>
<td>Kodaikanal</td>
<td>2.39</td>
</tr>
</tbody>
</table>
1.2 Smart cities

A smart city refers to a city with the urban development schemes with help of Internet Of Things and communication achieve efficiency and sustainability. IOT plays major role in street light monitoring, Railway station and Bus stand light monitoring, Traffic controlling. Monitoring of natural calamities like Earth Quake Tsunami. Due to the development in Machine to Machine communication and Machine learning the emergence of this type of city is achieved.

2. Block Diagram

The micro controller gets environmental data from four main sensors. First one Real time clock gives exact time so that it helps to determine whether it is night and peak hour or not. Second Humidity sensor gives humidity value. High humidity is the sign of rainfall. Third sensor value is PIR which detect movement of the people and finally LDR to improve the performance and power savings by predicting presence of sunlight. Combining all these data, presence of rainfall, peak hour, movement of people and presence of sunlight determined. Based on these data, controller sends PWM signals to control the light intensity of the LED bulbs.

Figure 1. Overall block diagram

PWM determines the intensity of the LED bulbs. It ranges from 0 to 255. In which 0 makes glow OFF and 255 makes to gleam at full intensity. It is also possible to give any values in between so unnecessary illumination of the light can be reduced there by reducing power and light pollution. The data through Wi-Fi shield goes to internet. Then it can be seen by user/ area in charge/ Station master so that further analysis of process can be done. It can be done using website or android app. The power supply given through plugs to microcontroller.

3. Hardware Descriptions

These are the hardware used in this project:

**MCU:** The Aurdino Uno R3 board with micro controller Atmega 328P at 16MHZ oscillator frequency is used as central micro controller. 6 PWM outputs can go to 6 Lights. Sensors are connected to analog pins. Power supply is given through adapter. Aurdino is preferred for its simplicity in programming using Aurdino 1.6.12. Software. The codes are written in Embedded C language.

**Temperature sensor:** LM 35 is used as temperature sensor. The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors as it calibrated in Kelvin, The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C. It operates properly in −55°C to 150°C temperature range.

**Real Time Clock:** The DS1307 serial real-time clock (RTC) is a low power, full binary-coded decimal (BCD) clock/calendar. It provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year (Compensation Valid Up to 2100).The DS1307 uses an external 32.768 kHz crystal to keep the timing. It communicates using I2C protocol to microcontroller.

**Humidity sensor:** The DHT 11 is used to sense humidity of the surrounding place. It operates at 5V. Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms. Data consists of decimal and integral parts. A complete data transmission is 40bit, and the sensor sends higher data bit first. When power is supplied to the sensor, do not send any instruction to the sensor in within one second in order to pass the unstable status. One capacitor valued 100nF can be added between VDD and GND for power filtering.

**LDR:** A Light Dependent Resistor (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. They are made up of semiconductor materials having high resistance. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls, the electrons
in the valence band of the semiconductor material are excited to the conduction band. (These photons in the incident light should have energy greater than the band gap of the semiconductor material). Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased.

Wi-Fi shield ESP8266: ESP8266-Based Serial Wi-Fi Shield for Arduino is designed and developed by Shenzhen Doctors of Intelligence & Technology (SZDOIT). The shield is designed based on esp8266 by Espressif Systems; Wi-Fi module is industrial-grade chips ESP8266, which is ESP-12E with metal shield, strong anti-interference ability. Shield is pin-compatible with Arduino Uno, Mega2560 and other control board. A voltage converter chip is used to deal with 3.3V (Esp8266) and 5V (Arduino). It acts as interface between internet and environment.

4. Simulation Results

Figure 2. Circuit diagram

The simulation is done in proteus tool. Proteus 8.0. As it has many advance tools to simulate system. Since the sensors works in analog values the variable resistors are used in the place of sensors as shown in figure 2. And based on the above conditions the output PWM wave is generated using function which is shown in figure 3.

5. Algorithm

Figure 3. PWM output for 20% and 50% intensities

Figure 4. Flow chart of program

Initially the micro controller checks for time, during day time lights are going to be off. So it need not check other values. After evening it checks LDR value so that light intensity at outdoor is measured if it is too low it goes to next sensor value. The temperature sensor gives temperature and humidity sensor gives the humidity value based on these two values relative humidity is calculated and this will predict the presence of the rainfall. Based on the above conditions, a suitable PWM waveform is generated for the LED. This will control the intensity of the output light. In real
time dimmer circuit used to control the LED output intensity and act as the control system of the lights.

6. Hardware Implementation

A prototype is made using above architecture as shown in figure 5. Led arrays are built for this purpose and connected to PWM pins of the micro controller. The limitation of the microcontroller made the size of the LED array restricted to 10 led in a row. (Aurduino Uno has maximum output current of 10mA)

In real world, it can be eliminated by using dimmer circuit consist of TRIAC. The PWM pin output is given to TRIAC base and the output to LED is taken at collector end. The data from controller is (as shown in figure 4) sent through ESP into Wi-Fi from that the data can be taken through android app or website which can be used for further processing.

6.1 Role of IOT

IOT helps in collecting data from various nodes. Each Arduino Board can cater 6-14 light. To do in large area, they needed to form a network that can be done with help of Wi-Fi shield. IOT collects data from the network and try to analyze the data from it. Based on the data, Government can go for power saving plans, better lightening methods.

7. Conclusion and Future Works

In this project, it is clear that intelligent lightening system based on sensors save power and also reduce light pollution occurs in the urban areas. In future these data from the lights can be analyzed using data analysis tool like hadoop and better efficient lightening solution and planning can be done in city level. Integrating with IR camera also provides high security to people and makes the city safer.

References


ecosystem services research and management (Elsevier 2012)


