IoT based Streetlight Controlling System

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ABSTRACT

The idea of designing a new system for the streetlight that do not consume huge amount of electricity and illuminate large areas with the highest intensity of light is concerning each engineer working in this field. Providing streetlight is one of the most important and expensive responsibilities of a city. Lighting can account for 10–38% of the total energy bill in typical cities worldwide. Streetlight is a particularly critical concern for public authorities in developing countries because of its strategic importance for economic and social stability. Inefficient lighting wastes significant financial resources every year, and poor lighting creates unsafe conditions. Energy efficient technologies and design mechanism can reduce cost of the street lighting drastically. Manual control is prone to errors and leads to energy wastages and manually dimming during midnight is impracticable. Also, dynamically tracking the light level is manually impracticable. The current trend is the introduction of automation and remote management solutions to control streetlights.

This project Streetlight Controller System is used to ensure, low power consumption, status monitoring, and light dimming as per external lighting conditions. Our proposed system consists of smart street lights that have external light sensing that automatically turns on at desired intensity based on amount of lighting needed. The system also allows the controller or monitoring person to check the status of intensity of the light as per the external light.

This system also detects the movement of people through which the intensity of the light is extremely bright. This project saves the extreme consumption of light and also reduces the cost of electricity. This project helps us to keep track on all activities.

I.   INTRODUCTION

The "Internet of Things" (IOT) – devices connected to the internet (and/or to other devices) which interact with the physical world by gathering, processing, and sharing data. IOT devices are also referred to as connected devices or as smart devices. Similar to robotic devices, IOT devices follow a "sense-think-act" cycle to interact with the physical world. IOT devices also "communicate" through an internet or network connection.

Likewise, in this project intelligent light sensing refers to public street lighting that adapts to movement by pedestrians, cyclists and cars. Intelligent street lighting, also referred to as adaptive street lighting, dims when no activity is detected, but brightens when movement is detected. This type of lighting is different from traditional, stationary and illumination, or dimmable street lighting that dims at pre-determined times. The research work shows control of streetlights as a result of which power is saved to some extent. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist the users with muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well. Basically, street lighting is one of the important parts. Therefore, the street lamps are relatively simple but with the development of urbanization, the number of streets increases rapidly with high traffic density.

There are several factors need to be considered in order to design a good street lighting system such as night-time safety for community members and road users, provide public lighting at cost effective, the reduction of crime and minimizing it is effect on the environment. At the beginning, street lamps were controlled by manual control where a control switch is set in each of the street lamps which is called the first generation of the original street light.

After that, another method that has been used was optical control method done using high pressure sodium lamp in their system. Nowadays, it is seen that the method is widely used in the country. The method operates by set up an optical control circuit, change the resistance by using of light sensitive device to control street lamps light up automatically at 9 during dusk and turn off automatically after dawn in the morning. Due to the technological development nowadays, road lighting can be categorized according to the installation area and performance, for an example, lighting for traffic routes, lighting for subsidiary roads and lighting for urban center and public amenity areas. The sensor network helps in improving the network sensing for street lighting. Meanwhile, street light system can be classified according to the type of lamps used such as incandescent light, mercury vapor light, metal halide light, high pressure sodium light, low pressure sodium light, fluorescent light, compact fluorescent light, induction light and LED light. Different type of light technology used in lighting design with their luminous efficiency, lamp service life and their considerations. The LED is considered a promising solution to modern street lighting system due to its behavior and advantages.

Apart from that, the advantages of LED are likely to replace the traditional street lamps such as the incandescent lamp, fluorescent lamp and high-pressure Sodium Lamp in future but LED technology is an extremely difficult process that requires a combination of advanced production lines, top quality materials and high precision manufacturing process. Therefore, the research work highlights the energy efficient system of the street lights system using LED lamps with LDR and PIR sensors interface for controlling and managing.

For an application, project uses basic software requirements the platform in which the project is developed, the front-end tool that provides the interaction with the users and the back-end tool that stores the data.

Arduino IDE

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs light on a sensor, a finger on a button and turn it into an output for activating a motor, turning on an LED, publishing something online.

The term "Arduino-compatible coding" refers to all Arduino and Arduino-compatible microcontroller boards that can be programmed and uploaded using Arduino IDE.

Embedded C

Embedded C programming builds with a set of functions where every function is a set of statements that are utilized to execute some particular tasks. Both the embedded C and C languages are the same and implemented through some fundamental elements like a variable, character set, keywords, data types, declaration of variables, expressions, statements. All these elements play a key role while writing an embedded C program.

II.   HARDWARE SPECIFICATIONS
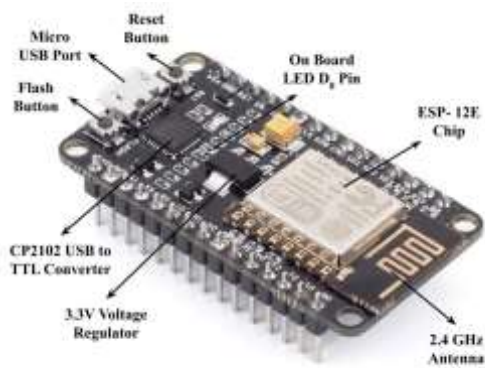
1.   Node MCU (AMICA Processor, WIFI – ESP8266) :

Fig 1.1 Node MCU

The Node MCU (*N*ode *M*icro *C*ontroller *U*nit) is an open-source software and hardware development environment built around an inexpensive System-on-a-Chip (SoC) called the ESP8266. The ESP8266, designed and manufactured by Espressif Systems, contains the crucial elements of a computer: CPU, RAM, networking (WiFi), and even a modern operating system and SDK. That makes it an excellent choice for the Internet of Things (IoT) projects of all kinds.

However, as a chip, the ESP8266 is also hard to access and use. We must solder wires, with the appropriate analog voltage, to its pins for the simplest tasks such as powering it on or sending a keystroke to the "computer" on the chip. That also have to program it in low-level machine instructions that can be interpreted by the chip hardware. This level of integration is not a problem using the ESP8266 as an embedded controller chip in mass-produced electronics.

Hardware Store

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

2.   LDR – Light Sensor

Fig 1. 2 LDR (Light Dependent Resistor)

An **LDR (Light Dependent Resistor)** is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. The most common type of LDR has a resistance that falls with an increase in the light intensity falling upon the device (as shown in the image above). The resistance of an LDR may typically have the following resistances:

- Daylight= 5000Ω
- Dark= 20000000Ω

The most obvious application for an LDR is to automatically turn on a light at a certain light level. An example of this could be a street light or a garden light. A **Light Sensor** generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light", and which ranges in frequency from "Infra-red" to "Visible" up to "Ultraviolet" light spectrum. The light sensor is a passive devices that convert this "light energy" whether visible or in the infra-red parts of the spectrum into an electrical signal output. Light sensors are more commonly known as "Photoelectric Devices" or "Photo Sensors" because the convert light energy (photons) into electricity (electrons).

Light Dependent Resistor

As its name implies, the **Light Dependent Resistor** (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs in the material.

The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photoresistive cells have a long response time requiring many seconds to respond to a change in the light intensity.

Materials used as the semiconductor substrate include, lead sulphide (PbS), lead selenide (PbSe), indium antimonide (InSb) which detect light in the infra-red range with the most commonly used of all photoresistive light sensors being **Cadmium Sulphide** (Cds).

Cadmium sulphide is used in the manufacture of photoconductive cells because its spectral response curve closely matches that of the human eye and can even be controlled using a simple torch as a light source. Typically then, it has a peak sensitivity wavelength (λp) of about 560nm to 600nm in the visible spectral range. Hence, this LDR Light sensor senses the ambient light of the streets and gives the intensity that is needed.

3.   PIR - Motion Sensor

Fig 1.3 PIR - Motion Sensor

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", **"Pyroelectric"**, or **"IR motion"** sensors.

PIRs are basically made of a pyroelectric sensor (which you can see below as the round metal can with a rectangular crystal in the center), which can detect levels of infrared radiation. Everything emits some low level radiation, and the hotter something is, the more radiation is emitted. The sensor in a motion detector is actually split in two halves. The reason for that is that we are looking to detect motion (change) not average IR levels. The two halves are wired up so that they cancel each other out. If one half sees more or less IR radiation than the other, the output will swing high or low.

Along with the pyroelectric sensor is a bunch of supporting circuitry, resistors and capacitors. It seems that most small hobbyist sensors use the **BISS0001 ("Micro Power PIR Motion Detector IC"),** undoubtedly a very inexpensive chip. This chip takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analog sensor. Hence, this PIR sensor detects the movement or motion in the streets and gives the intensity according to them.

4.   LED Light

Fig 1.4 Light Emitting Diode(LED)

A **Light Emitting Diode (LED)** is a device which converts electrical energy in to light. LEDs are preferred light sources for short distance (local area) optical fiber network because they are inexpensive, robust and have long life (the long life of an LED is primarily due to its being a cold device, i.e. its operating temperature being much lower than that of, say, an incandescent lamp), can be modulated (i.e. switched on and off) at high speeds. A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode, which emits light when activated.

When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs primarily offer advances in efficiency, controllability, and life span. The key strength of LED lighting is reduced power consumption. LED's are available with at the most Lumen efficiency of 110 Lm/Watt compared to 65-80 Lm/Watt of CFL and FTL, 45 Lm/Watt of Mercury vapour and 75 Lm/Watt of metal halide or 94 Lm/Watt of Sodium Vapour. Hence these LED lights are used as Street Lights to show the intensity produced.

5.   Monitor

Fig 1.5 Monitor

When the streets atmosphere is detected by the LDR and PIR sensors it indicates to the microcontroller and we can see the status of the streets through the monitors. It is used to display the output of the system.

6.   USB Cable

Fig 1.3.6 Universal Serial Bus

The term **USB** stands for **"Universal Serial Bus"**. USB establishes communication and power supply between computers, peripherals and other computers. This USB gives for about **3.3V** current to the microcontroller.

7.   Prototyping Board

Fig 1.7 Prototyping or Bread Board

The prototyping board plays an important role in connecting. This board is used to connect the wires with the microcontroller, resistor, LED lights and sensors. Without this board the wire cannot connect the sensors with Resistor.

8.   Connecting Wires

Fig 1.8 Connecting wires

The connecting wires are used to connect the node microcontroller unit with a resistor. So the resistor can give the signals to the LDR and PIR Sensors. So that sensor can reduce the intensity accordingly and display the result in the monitor
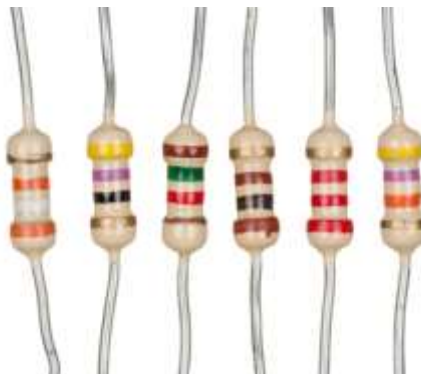
9.   Resistor

Fig 1.9 Resistors

It is a passive component having two terminals that is used to manage the current flow in the circuit. A current that flows via a resistor is directly proportional to the voltage that appears across the resistor. Resistors are of two types:

- Fixed Resistor – having a fixed value of resistance

- Variable Resistor – whose value of resistance can be changed for example if we have a resistor of 5K then the value of resistance will vary from 0 to 5 k.

Value of resistance can be calculated with the help of multimeter or with the color code that is visible on the resistor.

III. IMPLEMENTATION AND WORKING PRINCIPLE

Block Diagram

It is a diagram of a system in which the principal parts or functions are represented by blocks connected by lines that show the relationships of the blocks. They are mostly used in hardware design, electronic design, software design, and process flow diagrams. It is also used to design new systems or to describe and improve existing ones. Its structure provides a high-level overview of major system components, key process participants, and important working relationships.
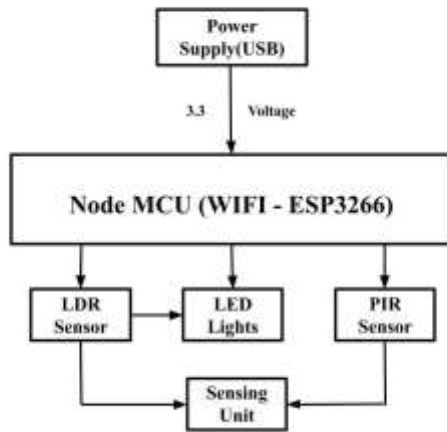

Fig 2.1 Basic Block Diagram of Streetlight Controlling System

The block diagram consists of various sub systems like Sensing Unit, Node Microcontroller unit (WIFI-ESP3266) and the LED Lights. The Sensing unit consists of both LDR and PIR sensors to detect the ambient light and movements of the lane. Power supply of 3.3V Node microcontroller is attached with sensing unit to adjust the level of lighting based on the detected details. The microcontroller is connected to the LED Lights. This whole unit gets powered from the USB cable that is connected to the operating system. The sensing unit will give the internal communication for the intensity of lights along the path.
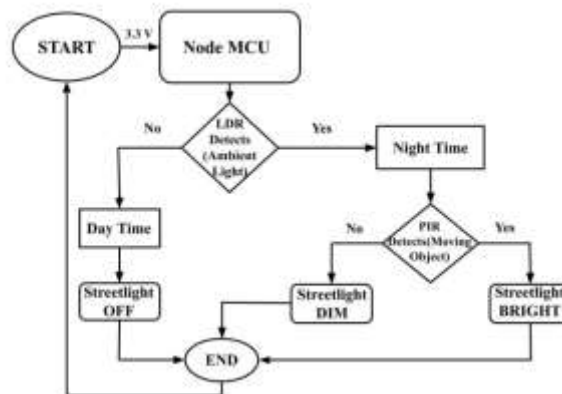
Flow Chart Diagram

Fig 2.2 Flow Chart Diagram of Streetlight Controlling System

The above shown flowchart diagram briefly depicts the way on which the project is designed and also how the process flows step by step. Firstly in this project the LDR detects the amount of light energy that it has been receiving or we can also say that it

detects the ambient light that is the reason why it is called as light detecting resistor and when the LDR also detects the light it sends an signal to the microcontroller, after receiving the signal from the LDR and microcontroller performs its function which in this case is to switch on the LED lights which are connected to the microcontroller through the prototyping board using connecting wires. So, now the lights will be turned ON, and they will be turned OFF again when the LDR sensor will not receive any kind of input from the light which is the sunlight or the atmospheric light, as during the night time there will be no sunlight or any atmospheric light the street lights will be tuned ON the whole night with full intensity, in our proposed system of project we have found a solution for this problem, which can be solved using the PIR sensor, because the PIR sensor can detect the motion of the objects, we will be using this feature of the LDR and PIR sensor to reduce the amount of energy that is consumed even in the night time through the streetlights as our main aim of the project is to reduce the consumption of the electricity. In this project LDR and PIR to reduce the power consumption even during the night time, as we know that the PIR sensor can detect the motion of the object, so as soon as any vehicle gets closer to the street light the PIR sensor which is present in the light sends an signal to the microcontroller which automatically turns ON the streetlight and which are connected in series, and they gets turned OFF when the vehicle leaves, by following this process we can reduce the consumption of large amount of electricity that is consumed.

IV. INPUT DESIGN

Input Design converts the user-oriented inputs to computer-based formats. Inaccurate input data are the most common cause of errors in data processing. Error data entered by the data operator can be controlled by the input design. The goal of designing input is to make the data entry easy, logical and as free from errors as much as possible.

The proposed system is completely menu-driven. It is a powerful tool for interactive design. It helps the user comprehend the range of alternatives available and also prevents them from making an invalid selection. All entry screens are interactive in nature. It has been designed taking into account all the constraints of the end-user.

Some other features included are

- The form title clearly states the purpose of the form
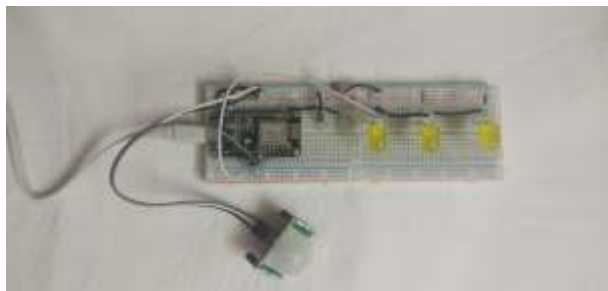- Adequate space is given for data entry

Fig 3.1 Micorcontroller, Sensors, LEDs, Resistors are fixed in the prototyping board with connecting wires
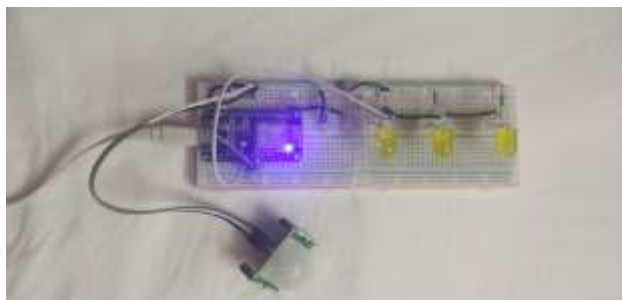

Fig 3.2 3.3 V Current is passed through USB and Micorcontroller is connected to WiFi
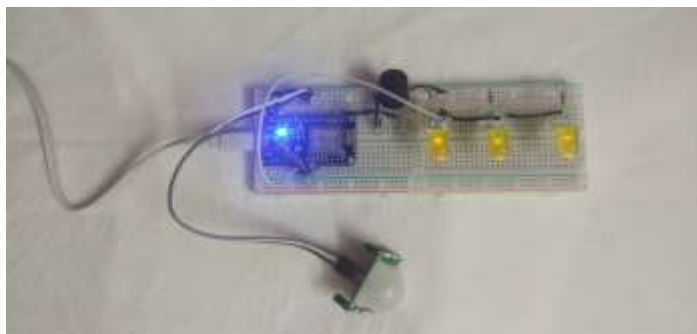

Fig 3.3 LDR is covered with black object its dark, but no movements detected so the Light is DIM
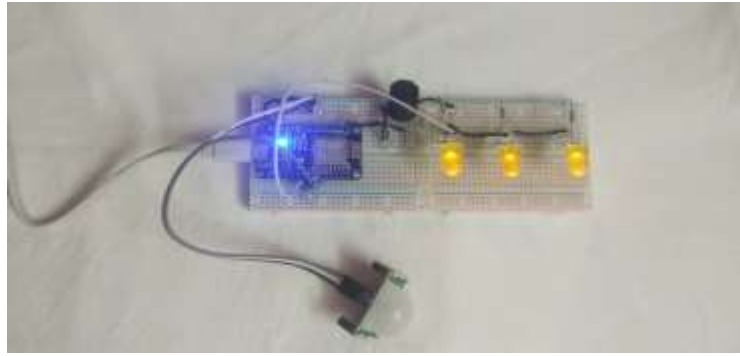
Fig 3.4 The LDR is still covered and now the movement is detected so the light is BRIGHT

V.RESULT

Outputs are the most important and direct source of information. Outputs are used to make permanent hard copy of the results for later consultation. The output generated by the system is often regarded as the criteria for evaluating the performance of the system. The output design was based on the following factors.

- Usefulness determining the various outputs to be printed.
- Differentiating between the outputs to be displayed and those to be printed.
- The format for the presentation of the output.

For the proposed system, it is necessary that the output should be compatible with the existing manual reports. The outputs have been formatted with this consideration in mind. The outputs are obtained after all the phase, from the system can be displayed or can be produced in the hard copy. The hard copy is highly preferred since it can be used by the controller section for future reference and it can be used for maintaining the record.

Fig 3.5 LDR detects Brightness (Day Time)

Fig 3.6 LDR detects Darkness (Night Time)

Fig 3.7 LDR and PIR detects Dark and Object movement (Night Time)

The above output design gives the overall view and result of the proposed system. In **Fig 3.5** the streets are filled with atmospheric light that is the ambient light is bright and even the motion status is also idle. So, all the streetlights (LEDs) are turned OFF.

And in **Fig3.6** the streets are dark and there is no ambient light and there is no movement in the streets. So, all the streetlights (LEDs) are turned ON but they give Half Brightness that is needed and works in the Power Saving mode.

In **Fig 3.7** still the streets are dark (night time) with no ambient light and vehicles are moving around the streets, which is detected by the PIR sensor. So, all the streetlights (LEDs) are turned ON and they give Full Brightness for the people who are moving around the street.

VI. CONCLUSION

From this project we conclude that this is a system which is need of implementation for our country especially because the street lamps are not maneuvered properly by the management. Especially to overcome the traditional streetlight system, where there is a large amount of energy loss. The experimental results show that the street light control system runs stably and reliably while having sensed by the effective sensors.

The goal of this project is to control the intensity of the street lights between 7.00 pm until 7.00am when the streetlight are switched ON all the time with full intensity of current. This project is really important to be implemented because it can reduce the huge waste of power consumption by conventional street lights. The system detects the movement on the road and increases the intensity of the lights, then reduces the intensity after the movement has passed.

VII. SCOPE OF FUTURE ENHANCEMENT

Energy efficiency is one of the key factors while designing indoor or outdoor lighting systems. The street lights consume almost 30%–40% of the entire city power consumption. The old or traditional lighting systems are not suitable and resulting in energy losses. So, we can implement this concept in future to save large amount of energy.

This project has scope for improvement and many enhancements can be done to make it more reliable and interesting. For example, when a vehicle or a person meet with an accident street light remains on, and a system can be introduced to inform the respective authorities. Similarly, a system can be introduced to inform the technicians about the default. All this will be possible, however, only through innovation, hard work and above all proper use of technology.

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