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Efficient and Energy - Saving Street Smart Lighting System, Reducing Ozone Depletion and Minimizing UV Radiation Exposure for Reducing Cancer using Arduino Micro Controller

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Abstract: ***The depletion of the ozone layer and the increasing levels of ultraviolet (UV) radiation on Earth's surface pose significant threats to human health and the environment. To address this pressing issue, this research introduces a novel approach utilizing Internet of Things (IoT) technology and ultrasonic sensors to create a smart lighting system capable of reducing ozone depletion and minimizing UV radiation exposure. The first objective of this work is to create an efficient and energy-saving street lighting system equipped with ultrasonic sensors and an Arduino microcontroller. The second objective is to significantly reduce the electricity consumption of street lights during nighttime hours by applying an intelligent control system. Our proposed solution leverages ultrasonic sensors to detect human presence and movement within the vicinity of streetlights. These sensors, coupled with an Arduino microcontroller, enable the system to adaptively control the illumination levels. When there are no pedestrians or vehicles nearby, the system reduces the intensity of street lighting to a minimum, thus conserving energy. Conversely, when activity is detected, the system intelligently increases the brightness to ensure safety and visibility.The IoT infrastructure connects the sensors to a central control unit, which processes the data and communicates with the lighting system. In addition to occupancy-based lighting control, the system incorporates a UV sensor to monitor ambient UV radiation levels. This real-time UV data is utilized to adjust the intensity of lighting, creating an environment that safeguards occupants from overexposure to harmful UV rays. The system aims to strike a balance between illumination needs and UV protection, promoting both comfort and well-being.***

Keywords: ozone layer depletion, ultraviolet radiation, IoT technology, energy-saving lighting, Arduino microcontroller

1. Introduction

A significant amount of energy expenses for a city comes from street lights. Conventional street lighting systems with constant illumination drew attention where 60% of the government's total electricity expenditure used to meet the prevailing street lighting system. An early systematic study concluded with 10-38% of the total energy bill are made from street lighting to drive typical cities worldwide. Energy can neither be created nor destroyed; it can only be converted from one form to another. Due to this energy conservation, it is required to make the balance. From that point of view, an automatic light control system helps reducing energy consumption by up to 70% and boosts the sustainability of electrical equipment. Streets that are not always fully occupied, have examined with continuously turned ON streetlights either due to derelictions of duty by the operator or technical fault leads to potential wastage of electrical power.

An increasing number of studies have found where Light Dependent Resistor (LDR), IR (infrared) obstacle detector sensors and Arduino were proposed to develop controlling lighting system on the streets. In the way of advancement sun-tracking sensors are also incorporated to turn ON/OFF street lights where the integration of conventional and solar energy implemented to have better performance. A photoelectric control unit (PECU), wireless control system by using ZIGBEE, Programmable Logic Controller (PLC) controller circuit, and microcontroller programming control system are the previously made automatic control systems. All these techniques are operated based on the decreasing or increasing of the light level. The previous control system often does not operate efficiently due to less sensitivity of the light, receivers malfunction, and imperfect timing to switch ON or OFF the street lamp. It is believed, a need still remains active to design a system to suppress early The proposed work involves designing a smart lighting system using IoT technology and ultrasonic sensors to mitigate ozone depletion and minimize UV radiation exposure. The architecture integrates ultrasonic and UV sensors with an Arduino microcontroller, employing adaptive control logic to adjust street lighting based on occupancy and real-time UV data. The IoT infrastructure facilitates communication between sensors and a central control unit, which processes data and communicates with the lighting system. The system aims to minimize energy consumption by reducing lighting intensity in the absence of human activity while ensuring safety and visibility through intelligent brightness adjustments when movement is detected. The UV sensor further contributes to occupant well-being by dynamically adjusting lighting intensity to protect against harmful UV rays. Thorough testing and validation in real-world scenarios, deployment in a pilot area, and continuous monitoring will gauge the system's effectiveness, energy savings, and UV protection benefits, contributing to a balanced solution that promotes both environmental sustainability and human well-being.

Internet of Things

IoT is a network system in both wired and wireless connection that consists of many software and hardware entities such as manufacturing management, energy management, agriculture irrigation, electronic commerce, logistic management, medical and healthcare system, aerospace survey, building and home automation, infrastructure management, large scale deployments and transportation. The purpose of IoT is to turn traditional products into connected products by taking advantage of exchanging data and communicating with each other in order to monitor and control the objectives. The conception of IoT

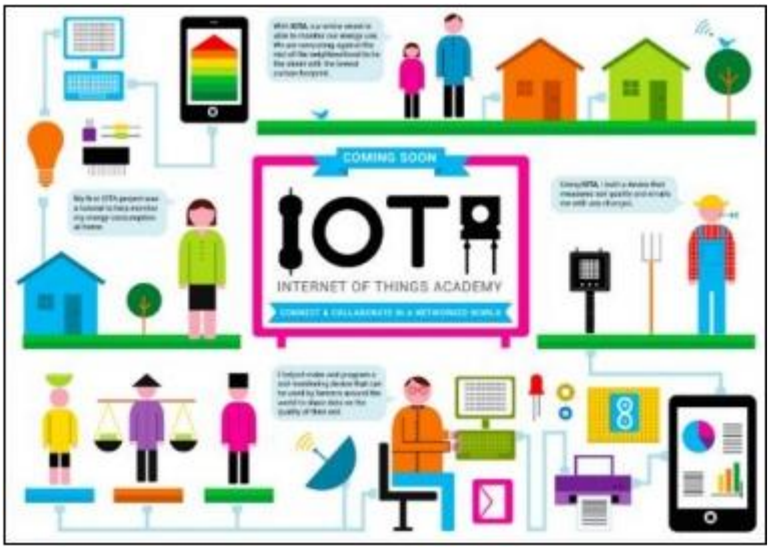

Figure 1.1: Conception of IoT.

The advantage of the IoT is obvious: it is efficient data collection and exchange. In addition, IoT provides cost-effective ways for saving energy and contributing to environment protection. In other words, IoT enables advanced security by interconnecting physical and virtual devices based on existing and evolving interoperable information and communication technologies. It involves a variety of protocols, domains and applications.

Automatic Street Light System by Saurabh Kadam, Anupam Teli, 2020
Streetlight monitoring system based on wireless sensor network. The systems are often set to run in automatic mode, which control streetlight consistent with Sunrise and Sunset Algorithm and lightweight intensity. This control can make an inexpensive adjustment consistent with the latitude, longitude and seasonal variation and arduino coding. Also this system can run in controlled mode. In this mode, we can take the initiative to control street lights. The system is equipped with the high-power relay output and can be widely applied in all places which need timely control like streets, stations, mining, schools, and electricity sectors then on.In this paper, we are to discuss the Automatic Street Light system which now days electric energy consuming more than the regular use after some days we are facing more electric power problem .so we can that solution that, The vehicles are passing over the road and we are placing the some ir sensors to the detect the vehical movement and a neighborhood of places are going to be consisting of less density areas and even no vehicle moments itself in few areas. But during night all street lights are going to be on in conventional street lighting system. To overcome from this issue, a proper energy saving due to density of light low save more light energy methods and lighting control to be implemented. The proposed work based on the combination of the arduino and other components to have two controls like, one is to switch of lights during no vehicle moments in streets and automatically turn on when vehicles comes and therefore the other modes are to offer less intensity lightto turn on bright mode during vehicle moments at sides on the roads. This circuit is totally based on arduino which here works as a micro-controller using the input from LDR. This system can be easily implemented on our Indian streets which needs this type of system as soon as possible.

Design and implementation of street light control system based on power line carrier communication by Xiaoqiang Xu, Ao Zhan, 2019
Traditional Street light control systems only support manual control, photosensitive control, and simple timing control while the energy utilization rate is low and the operators cannot monitor the working state of the street lights in real time, which causes great inconvenience to management and maintenance. This paper designs an intelligent street light control system based on power line carrier communication, which effectively utilizes the power grid resources. In view of the shortcomings in the insufficient distance of power line carrier communication, the signal relay method is adopted to effectively extend the communication distance. It realizes the real-time control and management of street lighting, therefore, meeting the need of intelligent lighting. The experimental results show that the system runs stably and reliably to have great popularization value. After analyzing the shortcomings of traditional street light control systems, this paper designs a new intelligent street light control system based on power line carrier communications. Aiming at the shortcomings of the insufficient effective communication distance of power line carriers, a static routing algorithm was used to relay the control signal. The experimental results show that the street light control system runs stably and reliably while having high application value. It can meet the demands of smart cities for intelligent lighting.

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2. Methodology

The existing system, prior to the implementation of the proposed smart lighting system, likely relies on traditional street lighting infrastructure. Conventional street lighting systems typically employ fixed-time schedules or basic motion sensors to control the activation and intensity of streetlights. These systems lack adaptability and intelligence, often leading to inefficiencies in energy consumption. Moreover, they may not address concerns related to ozone depletion and UV radiation exposure.

In the absence of advanced sensors and IoT technology, the existing system may not have the capability to dynamically adjust lighting levels based on real-time occupancy and UV data. It may lack features to minimize energy consumption during periods of low or no activity, potentially resulting in unnecessary electricity usage. Furthermore, the traditional system may not provide adequate protection against harmful UV radiation for pedestrians and occupants

3. Proposed System

The proposed smart lighting system represents an innovative solution to address both environmental concerns and human well-being. The architecture of the system integrates advanced technologies, including Internet of Things (IoT) and ultrasonic sensors, with the objective of mitigating ozone depletion and minimizing UV radiation exposure. The core components include ultrasonic and UV sensors seamlessly integrated with an Arduino microcontroller, forming the backbone of an adaptive control logic system. This logic allows for dynamic adjustments to street lighting based on real-time occupancy and UV data. The IoT infrastructure establishes a robust communication network between the sensors and a central control unit, facilitating data processing and bidirectional communication with the lighting system. The system's primary focus is on energy conservation, achieved by intelligently reducing lighting intensity in the absence of human activity. When movement is detected, the system ensures safety and visibility by dynamically increasing brightness levels. Importantly, the integration of a UV sensor introduces an additional layer of sophistication, dynamically adjusting lighting to protect occupants from harmful UV rays. To validate the system's effectiveness, a comprehensive testing and validation phase in real-world scenarios is planned, including deployment in a pilot area. Continuous monitoring will enable an assessment of the system's impact on energy savings and UV protection benefits. This holistic approach aims to strike a balance between environmental sustainability and human well-being, offering a promising solution for smart, adaptive lighting systems in urban environments.

Structure of the Proposed System

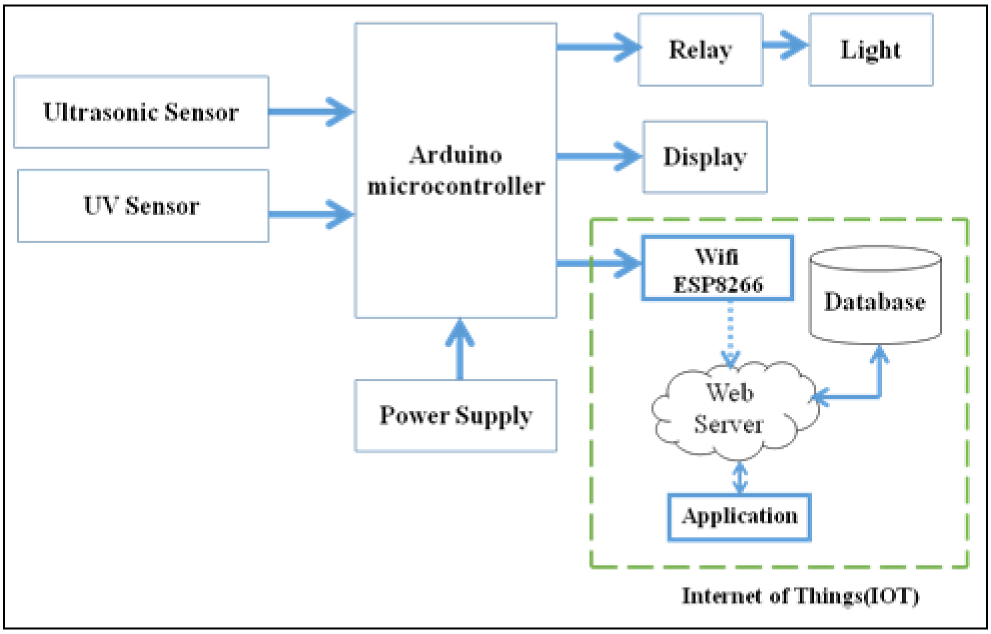

Figure 3.1: Block Diagram

A significant amount of electrical energy in many countries is consumed in lighting the streets. Actively illuminated street lights over the whole night lead to huge electrical energy consumption and shortening lifetime of the equipment. Savings of energy consumption, while no vehicles are on the street, plays an important role to compensate other declining energy resources. The main focus of this work to design an efficient and energy-saving street lighting system. It leverages ultrasonic sensors to detect human presence and movement within the vicinity of streetlights. When there are no pedestrians or vehicles nearby, the system reduces the intensity of street lighting to a minimum, thus conserving energy. Conversely, when activity is detected, the system intelligently increases the brightness to ensure safety and visibility. In addition to occupancy-based lighting control, the system incorporates a UV sensor to monitor ambient UV radiation levels.This real-time UV data is utilized to adjust the intensity of lighting, creating an environment that safeguards occupants from overexposure to harmful UV rays. The IoT infrastructure connects the sensors to a central control unit, which processes the data and communicates with the lighting

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system. It consists of different components such as Arduino Uno, WIFI Esp8266, ultrasonic sensor, UV Sensor, LEDs, and resistors. By detecting an obstacle, those sensors send electrical signals to the Arduino microcontroller.

Sensor Integration:

Integrate ultrasonic sensors and UV sensors into the street lighting system. Connect ultrasonic sensors to detect human presence and movement, and UV sensors to monitor ambient UV radiation levels. Ensure proper calibration and accuracy of sensor readings.

Arduino Microcontroller Programming:

Program the Arduino microcontroller to interface with ultrasonic sensors for occupancy detection and UV sensors for real-time UV radiation monitoring. Implement adaptive control logic to adjust lighting intensity based on sensor inputs.

Occupancy-Based Lighting Control

Develop an intelligent control of street lighting based on occupancy. When ultrasonic sensors detect no activity, reduce lighting intensity to a minimum to save energy. Increase brightness levels when human presence or movement is detected to ensure safety and visibility.

UV Radiation Monitoring and Control:

Implement algorithms to process real-time UV data from the UV sensor. Set thresholds for UV radiation levels, and adjust the lighting intensity accordingly to protect occupants from overexposure to harmful UV rays.

IoT Connectivity:

Establish a reliable IoT infrastructure to connect the sensors and the Arduino microcontroller to a central control unit. Utilize communication protocols such as MQTT or HTTP for data transmission. Ensure secure and efficient data transfer between the components.

Central Control Unit Development:

Create a central control unit responsible for processing data from sensors, making intelligent decisions based on algorithms, and communicating with the lighting system. Implement a user interface for monitoring and configuring the smart lighting system.

Energy Efficiency Optimization:

Implement additional features to optimize energy efficiency, such as scheduling functionalities to adjust lighting based on time of day, and incorporating energy-efficient lighting technologies like LED bulbs.

3.4 Component Used

- Arduino Uno
- Ultrasonic Sensor
- UV Sensor
- Relay
- Power Supply
- Display

Component Description

Ultrasonic Sensor

Ultrasonic sensors are based on measuring the properties of sound waves with frequency above the human audible range. They are based on three physical principles: time of flight, the Doppler effect, and the attenuation of sound waves. Whenever the vehicle is going on the desired path the ultrasonic sensor transmits the ultrasonic waves continuously from its sensor head. Whenever an obstacle comes ahead of it the ultrasonic waves are reflected back from an object and that information is passed to the microcontroller. In this project ultrasonic sensor HC-SR04 is used.

Figure 4.3: Ultrasonic sensor

UV sensor

A UV sensor, also known as an ultraviolet sensor, is a device designed to detect and measure ultraviolet radiation in various environments. These sensors utilize photodiodes or photodiode arrays specifically sensitive to UV light, allowing them to gauge the intensity and presence of ultraviolet rays. UV sensors are integral in numerous applications, including but not limited to skin exposure monitoring, UV sterilization processes, environmental monitoring, and even in wearable devices to alert individuals to excessive sun exposure. They work by converting incident UV radiation into an electrical signal, often calibrated to measure specific ranges of UV light, such as UVA, UVB, or UVC. The data retrieved from these sensors aids in ensuring safety measures, preventing skin damage, assessing environmental conditions, and implementing necessary controls in various industries, emphasizing the importance of UV sensors in modern technology and health awareness.

OLED Display

2.44 cm (0.96 Inch) I2C/IIC 128x64 OLED Display Module 4 Pin - White Color is a precise small, White OLED module which can be interfaced with any microcontroller using I2C/IIC protocol. It is having a resolution of 128x64. OLED (Organic Light-Emitting Diode) is a self light-emitting technology composed of a thin, multi-layered organic film placed between an anode and cathode. In contrast to LCD technology, OLED does not require a backlight. OLED possesses high application potential for virtually all types of displays and is regarded as the ultimate technology for the next generation of flat-panel displays.

OLEDs basic structure consists of organic materials positioned between the cathode and the anode, which is composed of electric conductive transparent Indium Tin Oxide (ITO). The organic materials compose a multi-layered thin film, which includes the Hole Transporting Layer (HTL), Emission Layer (EML) and the Electron Transporting Layer (ETL). By applying the appropriate electric voltage, holes and electrons are injected into the EML from the anode and the cathode, respectively. The holes and electrons combine inside the EML to form excitons, after which electro luminescence occurs. The transfer material, emission layer material and choice of electrode are the key factors that determine the quality of OLED components.

Relay

A relay is an electromechanical switch that operates using an electromagnetic force to mechanically open or close electrical contacts. It essentially acts as a bridge between a control circuit and a high-power circuit. When a small voltage is applied to the relay's coil, it generates a magnetic field, causing the switch mechanism to either close or open the circuit, depending on the relay type. This electromechanical action enables the control of a high-power circuit by a low-power signal, allowing for the isolation of different circuits and providing safety as well as control in various electrical applications.

Relays are crucial in various electrical systems, from simple circuits to complex industrial machinery. They serve multiple purposes, such as controlling high voltages and currents, providing isolation between circuits, and allowing for automation and remote control. With different types available—like electromagnetic relays, solid-state relays, and reed relays—each designed for specific applications, relays are versatile components that facilitate the operation and safety of numerous electrical devices and systems.

4. Result

- Power output from 10 tubelight is 400w per day
- Power output from 10 tubelight after the implemented the smart light system is 200w per day
- Power in Ultarviolet sensor 200w.
- Power output from 10 tubelight after the implemented the smart light system is 188w per day

5. Conclusion

In conclusion, the proposed smart lighting system, utilizing IoT technology and ultrasonic sensors for adaptive control, presents a comprehensive and innovative solution to address environmental sustainability and human well-being. The integration of ultrasonic and UV sensors with an Arduino microcontroller allows for dynamic adjustments in street lighting based on real-time occupancy and UV data, ensuring energy efficiency and occupant safety. The system's IoT infrastructure facilitates seamless communication between sensors and a central control unit, enabling intelligent decision-making and bidirectional communication with the lighting system. By reducing lighting intensity during periods of inactivity and dynamically increasing brightness in response to movement, the system aims to significantly minimize energy consumption. The incorporation of a UV sensor further enhances occupant well-being by dynamically adjusting lighting to protect against harmful UV rays. The proposed methodology provide valuable insights into the system's effectiveness, energy savings, and UV protection benefits.

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