Smart Street Light System Using IoT

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Abstract*—In several cities, street lighting stands as a significant cost, primarily due to the high power consumption of sodium vapour lights. This results in enormous expenses, which could be better utilised for the country's overall growth. Manual control of street lights, typically during the evening and morning, leads to significant energy loss when switching between ON and OFF states. Implementing an autonomous system presents several advantages, including reduced electricity wastage and substantial cost savings. This research paper introduces a computerised framework for automating park lamps, aimed at conserving energy. The proposed smart park lamp system aims to minimise energy usage through two approaches: turning off lamps during daylight hours and activating them only when brightness levels reach a defined minimum threshold, as well as reducing lamp intensity when no one is present in the park after sundown. Sensors attached to the lamp detect the presence of individuals, resulting in increased intensity, while the lamp dims to a low intensity when the sensors no longer detect anyone. This methodology promises significant energy savings and eliminates a considerable amount of manual labor.

I. INTRODUCTION

Cities all over the world incur enormous costs for street lighting, partly because traditional sodium vapour lamps use a lot of electricity. This wasteful spending can be better used to promote national development. At the moment, street lights must be manually turned on and off in the morning, using labour that could be used elsewhere. Additionally, leaving lights on all the time after it becomes dark wastes a lot of electricity. An autonomous system is suggested to automate park lamps and save electricity as a solution to these problems.

As technology develops, automation makes tasks easier for individuals everywhere. Automation is the process of reducing the need for human labour in the production of goods and services by using control systems and information technology. Automation considerably reduces the need for human physical and cognitive requirements, in contrast to earlier motorisation, which aided human managers in their practical needs. As programmable frameworks take the place of manual systems in the global economy and in daily life, it plays an ever-more-important role. Automated streetlight management is therefore implemented, which helps save electricity.

Smart park lamps have two goals: first, they should remain off throughout the day and only switch on when the ambient light level drops below a certain threshold; second, they should be turned down when nobody is using the park, usually after nightfall. The intensity of the lamps is controlled by sensors mounted to them so that it rises when a person is spotted and falls to a low level when they move out of range.

This strategy eliminates a sizeable chunk of manual labour in addition to saving a large quantity of energy. Smart city lighting also help reduce carbon emissions by using less energy, effectively battling climate change.

II. LITERATURE SURVEY

The Internet of Things (IoT), which has a wide range of applications in the areas of revenue creation, efficiency improvement, and resource conservation, has come under increasing attention in recent years. The term "Internet of Things" (IoT) technology refers to a network of physically connected, networked objects, including tools, automobiles, structures, and several other items [1]. These Internet of Things (IoT) devices may collect and share data, communicate with one another and with humans, and be monitored and operated remotely, frequently online. IoT technology seeks to improve efficiency, accuracy, and economic benefits by seamlessly integrating the real world with computer-based systems by enabling remote sensing and control via existing network infrastructure.

IoT is being practically used in smart lighting, which enables users to control lights in their homes or offices via smartphones or platforms for managing smart homes [2]. These systems use PIR (passive infrared) or proximity sensors, which are frequently IoT-enabled sensors, bulbs, or adapters. The use of PIR and proximity sensors for street lighting management, however, presents difficulties and constraints.

One of the primary issues is that these sensors are sensitive to environmental factors like temperature and humidity, which could cause issues with lighting control [2]. Another difficulty is that these sensors may have constrained detection ranges or have trouble identifying items that are moving slowly. False triggers can also happen, using up unneeded energy and wearing down the lighting system [2]. Some street lighting systems combine sensors, including PIR and proximity sensors, with supplementary technology, including cameras and radar, to overcome these problems. In order to improve sensor performance in a variety of environmental situations, these advanced systems frequently make use of algorithms and machine learning approaches. They strive to deliver more dependable and accurate movement and proximity detection.

There are various restrictions on the current smart street light systems. For instance, they could be unable to switch lights on or off automatically during cloudy weather [1]. Light Dependent Resistor (LDR) sensors are used to get over this problem because they register how much light is shining on them to determine the ambient light level [1]. Traditional DC power sources also have limitations [2], but using alternative sources like solar panels can assist overcome this restriction, enabling more sustainably and effectively using energy.

Another issue with smart street lights is their high initial cost [3]. To address this problem, though, cost-effective hardware solutions have been used. For instance, switching from PIR sensors to radar sensors gives improved operational range for street lighting as well as financial advantages. thereby enabling a quicker recovery of the initial investment [3].

In addition, a newly released study found a flaw in the present smart street lights, which is that they momentarily turn off if an object slows down or stops after sensing movement [4]. The flickering effect this behaviour produces could harm the light bulbs. The focus of future advancements and research in smart lighting systems will be on mitigating this problem.

III. PROPOSED SYSTEM

The "Sensor detection module" is the first of two distinct modules that make up the "smart street light system." With the aid of cutting-edge sensors and the micro controller "esp32," which is Bluetooth and WiFi enabled, it is responsible for gathering real-time data. The "Charging Module" is the second module; it uses solar energy to produce energy and maintains the readiness of our batteries.

4.1. Charging Module

Make connection as shown in the figure below and then do what follows:

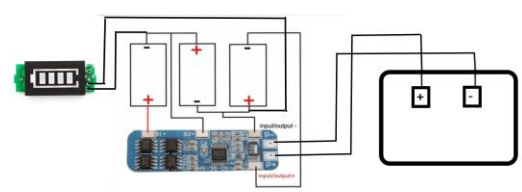


Figure 1. Charging Module Circuit diagram

Place the solar panel in sunlight. When sunlight hits a solar panel, the PV cells in the panel absorb the energy and convert it into electricity. This process happens as a result of an electrical charge within the cell that causes electricity to flow. This electricity is used to charge the Lithium ion batteries

The electricity produced by a solar panel is direct current (DC) electricity. Solar panel is 20 watt and 12 volts . it provides 1.67A DC current. They are 2600mah means they give 2.6A of current for an hour. But we can not directly connect the two as the batteries can be damaged due to overcharging or deep discharge. Batteries might even catch fire or explode.

We use a BMS to connect the two. BMS is a device that protects the battery from hazards and promotes battery life by preventing overcharging of battery. Once the batteries are fully charged BMS automatically disconnects the batteries from the solar panels and stops charging. Each individual battery is 3.7 volts. Batteries are connected in series connection and together provide a voltage of 11.1 volts .

To show the current battery level we have used a battery level indicator module. It is connected across the battery . It has 4 blocks which displays the battery level.
Battery range is divided into 4 sections

- <25%
- 25%- 50%
- 50% - 75%
- >75%

When battery is less than 25% only a red light will be illuminated

4.2. Sensor Detection Module

After all the connections of this module are made, the LDR sensor kickstarts the whole smart street light by allowing light to fall on its register. When light falls on the LDR, its resistance decreases, allowing more current to flow through it. When there is less light, the LDR's resistance increases, reducing the amount of current that flows through it. The sensor module measures this current and uses it to determine the amount of light that is present. If enough light is present, the lights will stay turned OFF.

The ultrasonic sensor kicks in if the LDR is unable to detect enough light because of the weather or because it is nighttime. Ultrasonic sensors works on the principle of echo. A sound wave is emitted by an ultrasonic sensor at a frequency that is above the range of human hearing, and the time it takes for the wave to bounce back after colliding with an object is then recorded. This data is used by the sensor to determine the object's distance.

*Distance of object = 0.017 * duration_of sound wave;*

If the distance is less than 200cms, then control is given to the radar sensor for further detection.

The radar sensor will handle the detection process. Radar sensor work on the principle of radio wave detection. It detects movement of objects . there range is 360 degrees. It will transmit a radio signal every second to ensure that any previously detected objects are still present in the smart street light's operational area. Radar sensors will continue to do this until they are unable to detect anything else, at which point they will hand back control to ultrasonic sensors.

If some movement is detected by the radar sensor then the LED is turned ON for 3 seconds, and controlis subsequently transferred to the radar sensors.

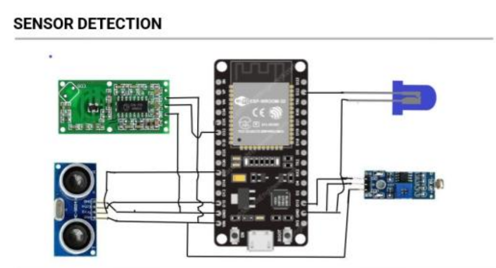
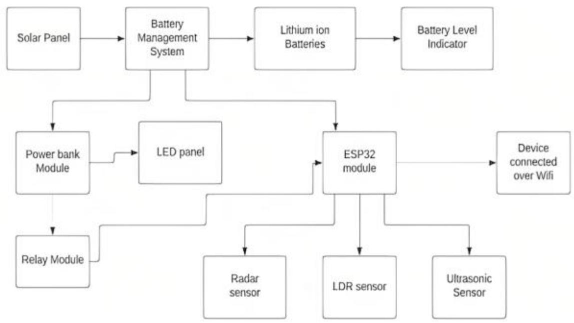


Figure 2. Sensor Detection Module Circuit Diagram

IV. RESULTS

With 92% accuracy, a smart street light was successfully created. We achieved all the points that we strived to achieve when we took over the project. Since perfection is an ideal that cannot be realised in reality, we have made every effort to come close to it. These were the primary concepts that were put into practise:

- Smart street light only glows during night time or during dim lighting due to harsh environments like heavy rain or monsoon.
- Intensity of light jumps up when the sensors detect a moving object in its working domain, and when nothing is detected, lights to back to glowing at a dim intensity.
- The power source used for the project is solar power.



- Multiple lights are connected to each other through a mesh network in which only one of them requires an active internet connection and others can pass on data or information using bluetooth
- In case of a system failure or harsh weather conditions, a notification will be sent via an internet network to a mobile application to a trusted person, who can then come and make the required repairments.

CONCLUSION

A smart street light using Internet of Things (IoT) technology can bring several benefits to cities and communities. Some of the main conclusions that can be drawn about the use of smart street lights using IoT technology include:

- Energy efficiency: Smart street lights using IoT technology can be more energy efficient than traditional street lights, as they can be programmed to turn on and off based on the amount of ambient light and the presence of pedestrians or vehicles. This can lead to significant energy savings for cities and communities.
- Cost savings: In addition to energy savings, smart street lights using IoT technology can also lead to cost savings for cities and communities. For example, smart streetlights can be remotely monitored and controlled, which can reduce the need for costly maintenance and repairs.
- Improved safety: Smart street lights using IoT technology can improve safety for pedestrians and drivers by providing better lighting conditions and by detecting and alerting authorities to potential hazards or suspicious activity.
- Enhanced traffic management: Smart street lights using IoT technology can also be used to enhance traffic management by collecting data on traffic flow and patterns, which can be used to optimize traffic signals and improve the flow of vehicles.
- Environmental benefits: Smart street lights using IoT technology can also bring environmental benefits, as they can reduce green house gase missions and light pollution.
- Overall, the use of smart street lights using IoT technology can bring a range of benefits to cities and communities including energy and cost savings, improved safety, enhanced traffic management, and environmental benefits.

FUTURE SCOPE

With the use of data from several sensors and devices, this system aims to build a smarter, more connected city where street lighting is intelligently maintained and controlled in real-time. This can enhance the overall user experience and quality of life in the city while also optimising energy use, cutting expenses, and minimising maintenance requirements. We are suggesting a model that can carry out the following tasks:

- Differentiate between humans and animals: It has the ability to intelligently determine if a human or an animal has entered its range. If a human is there, the lights will turn on; if not, they will remain off. This will save a lot of electricity since while most animals are out at night, it still wastes energy and money to keep street lights on all night.
- Power-saving mode: If the battery doesn't fully charge or if it runs out of power rapidly due to a cloudy day or for any other reason, the street light will enter this mode. When a device's battery is becoming low, power-saving mode, a Low battery condition mode, is turned on. By extending the amount of time between uses before a street light needs to be recharged, the low battery state mode aims to keep the lights on until a chance to do so. In this, the battery will light up dimly to conserve energy. The maintenance crew will receive a notification informing them of the battery's low power.

- Street lights can be connected to other smart city infrastructure, such as traffic systems and public safety networks, to give city planners and administrators access to real-time data and analytics. In addition to many other things, this will aid in traffic management, accident detection, women's safety, and city planning.
- We can control each bulb individually using an Android application. Obtain a report on their performance as well to determine whether or not they are operating correctly. The maintenance crew will find it simpler to identify the street lights that need to be repaired or serviced.
- Monitoring: A camera mounted on a street light may be used for monitoring. The camera will raise an alarm if it notices any criminal behaviour or suspicious activity, alert the area for assistance, and contact the appropriate authorities to report the incident so that prompt action may be taken. The illegal conduct will also be recorded.
- Heat sync: Overheating is the primary cause of LED failure. To prevent this, we can install a system that uses heat sensors to measure the amount of heat present. if the temperature rises over a predetermined level, which could harm or impair the performance of street lights. There will be a reduction in heat output since the street lights will automatically dim. cooling the street light as a result. This will lengthen the lifespan of the street light and lower the cost of maintenance.

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