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IoT-Based Solar Streetlight with USB Emergency Charging and Remote Monitoring

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Abstract: This paper introduces a solar-powered streetlight that tracks the sun automatically operates based on day and night cycles and includes emergency USB charging with battery awareness. The system uses a panel, rechargeable battery, ESP32 microcontroller, light-dependent resistor sensors, a motor mechanism, LED streetlight, USB charging circuit and three-color battery status indicators. The solar panel moves to follow the sun using LDR sensors and motor control which increases the amount of energy collected. The streetlight turns on at night and off during the day using light detection. The ESP32 checks battery levels. Manages USB charging using preset thresholds to ensure enough power is always available, for the streetlight. A green LED shows battery yellow indicates medium charge and red signals low charge. The ESP32 connects via Wi-Fi to a backend built with Java Spring Boot. A web app made with React and a MySQL database allows users to monitor battery level, solar charging status, streetlight operation and USB charging availability from anywhere. This system combines tracking, automatic lighting, smart battery management and IoT monitoring into one portable and practical design. Performance will be tested using a working prototype and functional tests.

Keywords: tracking, portable solar streetlight, automatic day-night control, ESP32, LDR sensors, battery management, emergency USB charging, Internet of Things (IoT).

I. INTRODUCTION

Solar energy is a source of energy that gives a practical alternative to usual electricity for outdoor lighting. Solar energy can light streets in places where the electrical grid's weak or where people want to use less grid power. The overall performance of streetlights depends on how much solar energy is collected how big the battery is and how well the stored energy is used. These points show that we need ways to collect solar energy and smarter battery management. In solar lighting systems the panels sit at a fixed angle. As the sun moves across the sky the amount of sunlight that hits a fixed panel changes. A solar tracking system can fix this by moving the panel toward where the light's strongest. In the system we are building, dependent resistor (LDR) sensors feel the difference in light intensity. A motor controlled by an ESP32 microcontroller then moves the panel. This method is meant to give the panel sunlight during the day. Automatic streetlight operation is also very important for saving energy outdoors. Turning streetlights on and off by hand can be inconvenient. Can waste energy. With sensors the streetlight we propose will turn on when the light level drops below a certain threshold. It will turn off when there is daylight. This lets the lights work automatically without a person having to keep turning them on and off. The system also gives an emergency USB charging station for phones. Because both the lights and the USB charger rely on the battery the battery must be managed carefully. The system watches the battery level. Only allows USB charging when the battery is above a set threshold. When the battery is low the streetlight gets priority. Three colored LEDs – green, yellow and red – show the battery status at a glance. To allow someone to watch the system from away we add Internet of Things (IoT) technology and a web-based monitoring app. The ESP32 sends data over Wi-Fi to a Java Spring Boot server. A React front-end and a MySQL database show the battery level, how well the solar panels are charging, whether the streetlight is, on and whether USB charging is available. In short the design

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mixes tracking, automatic lighting control battery-aware energy management and remote monitoring into a portable package. We will test a prototype to see if this idea works in practice. The main objective of this work is to build a solar streetlight that uses solar energy well turns lights on and off automatically offers emergency USB charging when the battery allows and lets a user see the system status from anywhere.

II. EXISTING SYSTEM

I have seen solar streetlight systems that use solar panels to turn sunlight into electricity. The electricity is stored in batteries and then used to power LED lights at night. Solar streetlight systems often use light-dependent resistor (LDR) sensors to sense daylight and darkness and automatically switch the streetlight OFF or ON. Some solar streetlight systems also use microcontrollers, sensors and Internet of Things (technology to monitor battery conditions solar panel performance and lighting status remotely. Previous research has explored IoT-based streetlight control using microcontrollers and wireless communication. Some solar streetlight systems provide monitoring through a web interface while others focus on energy conservation, remote control and fault detection. These features help reduce inspection and improve the management of solar streetlight systems. However conventional fixed-panel solar streetlights cannot automatically adjust the panel direction according to changing sunlight. Solar streetlight systems with monitoring may also lack integrated emergency USB charging and battery-dependent control of external loads. In addition a web-based monitoring facility depends on communication between the controller and the server although local lighting control can be designed to continue Therefore there is a need, for an integrated solar streetlight that combines automatic solar tracking day–night lighting control, battery-aware emergency USB charging, battery status indicators and web-based monitoring. The proposed solar streetlight system is intended to combine these functions using an ESP32 microcontroller and a web application developed with React Java Spring Boot and MySQL.

III. OBJECTIVES

The main objective of this project is to develop a portable solar streetlight that uses solar energy for lighting and provides automatic control, battery management, and web-based monitoring. The system is designed to improve the use of available solar energy, reduce unnecessary power consumption, and allow users to monitor its operation through a web application. The specific objectives are as follows:

1. **Solar-Powered Lighting:** To develop a portable streetlight that uses a solar panel to collect sunlight and store the generated energy in a rechargeable battery. The stored energy will be used to operate the streetlight, reducing dependence on conventional electricity.
2. **Automatic Solar Panel Tracking:** To design a tracking mechanism using LDR sensors, a motor, and an ESP32 microcontroller. The sensors will detect differences in light intensity, allowing the controller to adjust the panel toward the brighter direction. This mechanism is intended to improve sunlight collection compared with a fixed panel under suitable conditions.
3. **Automatic Streetlight Control:** To implement automatic day and night control using light-intensity sensing. The streetlight will remain off during sufficient daylight and switch on when the surrounding light level falls below a predefined threshold, helping avoid unnecessary energy use.
4. **Battery-Based USB Charging Control:** To monitor the battery level and control the emergency USB charging facility according to predefined battery thresholds. USB charging will be disabled when the battery level reaches the lower limit, helping preserve stored energy for streetlight operation. The controller will also consider whether the battery is charging or discharging when applying the charging rules.
5. **Battery Status Indication:** To provide visual information about the battery condition using coloured LEDs. The green, yellow, and red indicators will represent different battery-level ranges, allowing users to identify the battery status without accessing the web application.
6. **Web-Based System Monitoring:** To develop a web application using React and JavaScript for the frontend, Java Spring Boot for the backend, and MySQL for data storage. The ESP32 will send system information through Wi-Fi to the backend. The dashboard will display battery level, solar charging status, streetlight operation, and USB charging availability, making it easier to check the system remotely.
7. **System Performance Evaluation:** To evaluate the prototype through experiments under different lighting conditions and battery levels. The tests will examine solar panel tracking, automatic streetlight operation, battery-level monitoring, USB charging control, and data communication with the web application. The tracking performance may also be compared with a fixed-panel arrangement to assess whether the motorized mechanism provides a practical benefit after considering its energy consumption.

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IV. LITERATURE REVIEW

Research on solar-powered streetlights and renewable-energy charging systems has explored solar energy collection, automatic lighting, battery management, and remote monitoring. These studies provide a foundation for the proposed IoT-based portable solar streetlight. However, integrating solar panel tracking, automatic lighting, battery-based USB charging control, and web monitoring into one portable system remains the focus of this project.

A. Solar-Powered Portable Charging Systems

Previous studies have examined the use of photovoltaic panels and rechargeable batteries to provide charging facilities for electronic devices [1], [7], [8]. These systems offer an alternative source of power in locations where conventional electricity or charging outlets are not readily available. A regulated USB output can supply power to compatible devices, while a rechargeable battery stores energy for later use.

However, portable solar charging systems mainly focus on supplying power to electronic devices. They do not necessarily combine automatic streetlight control, solar panel tracking, and remote monitoring. The proposed system aims to extend this approach by integrating an emergency USB charging facility with a solar-powered streetlight and a battery management mechanism.

B. IoT-Based Smart Streetlight Control

Smart streetlight systems use controllers and sensors to automate lighting and reduce the need for manual operation. Research on intelligent streetlight control has also considered wireless communication, fault monitoring, and emergency notifications [2]. Such features can help users supervise lighting systems and identify operating problems more easily.

Although these functions are useful, a solar-powered streetlight also needs to manage the energy stored in its battery. The proposed system combines automatic day–night lighting with battery-level monitoring and controlled USB charging. An ESP32 microcontroller will coordinate the main hardware operations and support communication with the web application.

C. Web-Based Monitoring and Management

Web-based applications provide a convenient way to access system information from a remote location. The *Fix-It* public complaint management system [3] demonstrates the use of software components for managing information through a connected application. Although this work focuses on complaint management rather than solar lighting, its general approach to information handling provides background for the software side of the proposed project.

The proposed system will use React and JavaScript to develop the frontend, Java Spring Boot to implement the backend REST APIs, and MySQL to store system information. The ESP32 will transmit monitoring data through Wi-Fi. The dashboard is intended to display battery level, solar charging status, streetlight operation, and USB charging availability.

D. Renewable Energy Management for Street Lighting

Research on renewable-energy streetlighting has considered solar power generation, energy storage, and methods of improving the use of available energy [4], [6]. Solar panels supply energy to the system, while rechargeable batteries provide power when sunlight is insufficient. Maximum power point tracking (MPPT), discussed in solar energy research [6], is another method used to improve the electrical power obtained from a photovoltaic panel under changing operating conditions.

The proposed project focuses on a different combination of features. It will use LDR sensors and a motorized mechanism to adjust the solar panel toward the direction of higher light intensity. It will also apply predefined battery-level thresholds to control USB charging. The purpose is to manage solar energy collection and stored energy while maintaining the lighting function.

E. Intelligent Lighting and Remote Supervision

Previous work on smart streetlighting has explored sensor-based lighting control, remote supervision, and fault detection [5]. These approaches can help reduce unnecessary lighting operation and make system maintenance easier. Remote access also allows users to check system conditions without being physically present at the installation.

For a portable solar streetlight, lighting control must work together with battery monitoring and external charging requirements. The proposed system aims to combine these functions through an ESP32-based controller and a web monitoring platform. Local lighting and battery protection should continue to operate even if Wi-Fi communication or the backend service becomes temporarily unavailable.

V. RESEARCH GAP

The studies reviewed focus on parts of solar charging smart street lighting, renewable-energy management and web based systems [1]–[8]. Based on this the proposed project will bring together solar tracking, day–night streetlight control,

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battery-status indication, battery-aware emergency USB charging and web-based monitoring in one portable unit. The hardware centers, on an ESP32 microcontroller. The monitoring app uses React Java Spring Boot and MySQL. Testing a prototype will be needed to check how well the system works how reliable it is and how it performs with energy.

VI. METHODOLOGY

The proposed system, "IoT-Based Portable Solar Streetlight with Smart Tracking and Web Monitoring " integrates energy collection, automatic solar tracking, day–night lighting control, battery management, emergency USB charging and IoT-based web monitoring. The proposed system uses an ESP32 microcontroller to control the hardware components and transmit monitoring data to a web application.

A. System Requirements The proposed system requires hardware components and software technologies to perform tracking, automatic lighting, battery monitoring, USB charging control and remote supervision.

TABLE I HARDWARE REQUIREMENTS

Sr. No.	Component	Purpose
1	Solar Panel	Converts sunlight into electrical energy.
2	ESP32 Microcontroller	Controls sensors, the motor, lighting, and Wi-Fi communication.
3	LDR Sensors	Detect light intensity for solar tracking and day–night control.
4	Motor and Motor Driver	Adjusts the panel toward stronger sunlight.
5	Rechargeable Battery	Stores energy for lighting and emergency USB charging.
6	Solar Charge Controller	Regulates battery charging from the solar panel.
7	LED Streetlight	Provides outdoor illumination.
8	Battery Voltage-Sensing Circuit	Measures battery voltage to estimate battery condition.
9	Green, Yellow, and Red LEDs	Indicate battery status.
10	USB Charging Module	Provides emergency charging for external devices.
11	Voltage Regulator and Protection Circuit	Provides suitable voltage and protects connected components.
12	Portable Frame and Wiring	Supports and connects the system components.

TABLE I I SOFTWARE REQUIREMENTS

Sr. No.	Software/Technology	Purpose
1	Arduino IDE	Programs the ESP32 microcontroller.
2	Embedded C/C++	Implements sensor reading and hardware control.
3	React.js with Vite	Develops the web dashboard.
4	JavaScript and CSS	Implements dashboard functionality and design.
5	Java Spring Boot	Develops backend services and REST APIs.
6	MySQL	Stores system readings and monitoring records.
7	REST API	Transfers monitoring data between system components.
8	Wi-Fi	Enables communication between the ESP32 and backend.
9	Web Browser	Displays the monitoring dashboard.

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B. Solar Energy Collection and Tracking

The solar panel converts sunlight into energy, which is stored in a rechargeable battery through a suitable solar charge controller. LDR sensors detect the intensity of sunlight from different directions. The ESP32 compares the sensor readings. Controls a motor mechanism to orient the panel toward the direction of stronger light. This tracking mechanism is intended to improve energy collection compared with a fixed-panel arrangement.

C. Automatic Streetlight Control

The proposed system uses ambient-light sensing to control the LED streetlight. During daylight the streetlight remains OFF to conserve stored energy. When the surrounding light intensity falls below a predefined threshold the ESP32 switches the streetlight ON. This operation reduces the need for control and supports automatic lighting management.

D. Battery Monitoring and USB Charging Control

The ESP32 monitors the battery condition using a voltage-sensing circuit. Green, yellow and red LEDs provide an indication of the battery status. Emergency USB charging is controlled according to predefined battery thresholds to help reserve energy for streetlight operation.

The proposed battery-control logic during discharge is as follows:

- 71–100 % battery level: Green LED ON; streetlight and USB charging enabled.
- 51–70 % battery level: LED ON; streetlight and USB charging enabled.
- 50 % or below: Red LED ON; USB charging disabled while streetlight operation is maintained subject to battery energy and protection limits.

During recharging USB charging remains disabled when the battery level is, between 51 % and 70 %. It is enabled again when the battery reaches least 71 %. The controller must distinguish between charging and discharging states to apply the rules. Battery-level estimates and thresholds will be. Validated during prototype development.

E. IoT-Based Web Monitoring

The ESP32 sends system information over Wi-Fi to a Java Spring Boot backend using REST APIs. The backend takes the data processes it and stores monitoring records in a MySQL database. A web application built with React, Vite, JavaScript and CSS shows the data on a dashboard.

The dashboard is designed to display:

1. Battery level and battery status.
2. Solar charging status.
3. Streetlight ON/OFF status.
4. USB charging availability.
5. Solar. Overall system status, where supported by the implemented sensors.

This interface lets authorized users watch the system from away. Essential local lighting and battery-protection must keep working even if the Wi-Fi or backend stops working.

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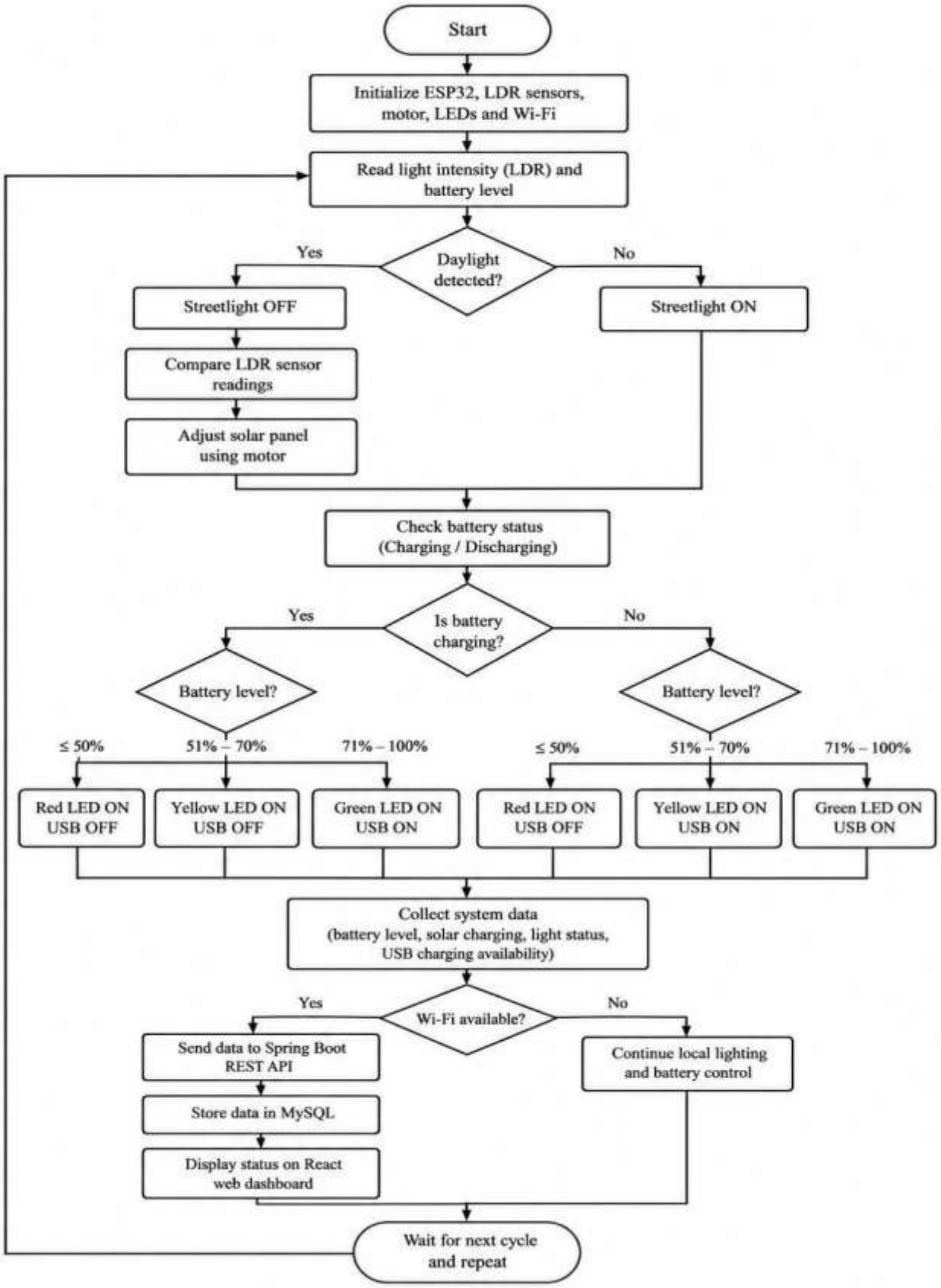


Fig. 1. Flowchart of the Proposed IoT-Based Solar Streetlight System.

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VII. SYSTEM ARCHITECTURE

The system architecture has four parts: the hardware layer, communication layer, backend layer and web application layer. These parts work together to gather energy control the streetlight manage battery power and allow remote monitoring.

A. Hardware Layer

The hardware layer includes a panel, solar charge controller, rechargeable battery, ESP32 microcontroller, LDR sensors, motor, motor driver, LED streetlight, battery voltage-sensing circuit, battery status LEDs and a USB charging module. The solar panel produces energy. This energy is stored in the battery. LDR sensors send light-intensity data to the ESP32. This helps the system track the sun and turn the streetlight on or off depending on daylight. The ESP32 also controls the streetlight shows battery status and manages USB charging based on the control rules programmed into it.

B. Communication Layer

The communication layer uses the Wi-Fi feature of the ESP32. It sends system data to the backend over the network. The data may include battery level, charging status, streetlight status, USB charging availability and tracking status if its available. Even if the network connection breaks, local control functions keep running.

C. Backend and Database Layer

The backend layer is built using Java Spring Boot. It offers REST APIs to receive, process and send system data. MySQL is used to save monitoring records. This layer links the hardware data with the web application.

D. Web Application Layer

The web application is built using React, Vite, JavaScript and CSS. It gives authorized users a dashboard to check battery level, solar charging, streetlight operation, USB charging availability and other system features. The dashboard gets its data from the Spring Boot backend.

E. Working Principle

The system collects energy and stores it in the battery. LDR sensors help the ESP32 point the panel toward stronger light and control the streetlight based on ambient light. The controller keeps an eye on the battery. Turns USB charging, on or off according to set limits. System information goes over Wi-Fi to the backend gets stored in MySQL where needed and appears on the web dashboard.

So the proposed architecture brings together energy collection, automatic hardware control, battery management and remote monitoring in one portable solar streetlight system.

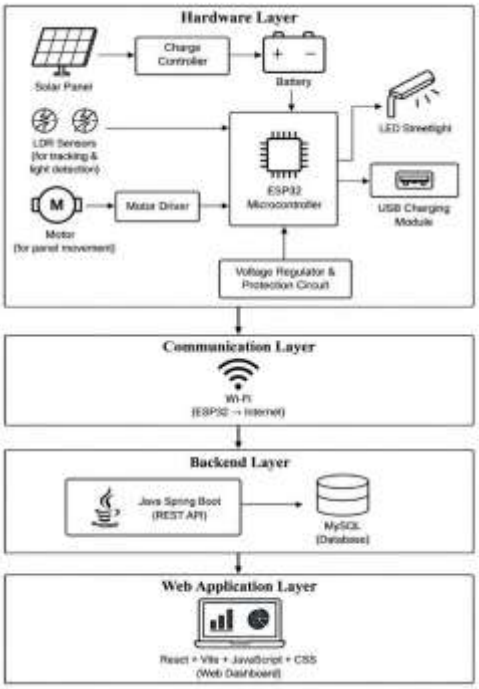


Fig. 2. System Architecture of the IoT-Based Portable Solar Streetlight with Smart Tracking and Web Monitoring.

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VIII. CONCLUSION AND FUTURE SCOPE

A. Conclusion

I am excited about the Portable Solar Streetlight with Smart Tracking and Web Monitoring because it offers a simple and portable way to light outdoor spaces with solar power. The IoT-Based Portable Solar Streetlight with Smart Tracking and Web Monitoring uses LDR sensors and a motor to follow the sun switches on and automatically at day and night watches the battery and provides emergency USB charging. The ESP32 microcontroller runs the hardware. Sends information via Wi-Fi to a web app built with React and Java Spring Boot storing data in MySQL.

I see the battery management mechanism in the Portable Solar Streetlight with Smart Tracking and Web Monitoring as a smart way to control USB charging based on set battery thresholds giving priority to the streetlight. The web dashboard lets authorized users watch battery level, solar charging, streetlight status and USB charging from anywhere. These features together help manage energy add convenience and keep the system under watch.

I look forward to work for the IoT-Based Portable Solar Streetlight with Smart Tracking and Web Monitoring. The plan is to build a prototype and test it under lighting and battery situations. We will compare how well the solar tracking works against a fixed panel. We will check how reliable automatic lighting, battery management, USB charging and web communication are. The results of these tests will show how useful the IoT-Based Portable Solar Streetlight with Smart Tracking and Web Monitoring really is, for outdoor lighting.

B. Future Scope

The proposed IoT-based portable solar streetlight can be further improved through hardware development, energy optimization, and additional monitoring features. Future work will focus on the following areas:

1. **Improved Solar Tracking:** The LDR-based tracking mechanism can be extended to dual-axis tracking to adjust the solar panel in both horizontal and vertical directions. Its performance can be compared with a fixed panel to evaluate the improvement in energy collection.
2. **Advanced Battery Management:** Battery voltage, current, and temperature monitoring can be incorporated to improve charge estimation and provide better protection against overcharging and excessive discharge.
3. **Intelligent Lighting Control:** Automatic brightness adjustment can be introduced to reduce energy consumption during periods when full illumination is not required, helping extend the battery operating time.
4. **Enhanced Web Monitoring:** The React-based dashboard can be extended with historical data, charging and discharging graphs, low-battery notifications, and fault alerts to support system supervision and maintenance.
5. **Improved Energy Management:** Future development can investigate methods for balancing streetlight operation, battery charging, and emergency USB charging under different sunlight and battery conditions.
6. **Prototype Testing and Field Deployment:** The system can be tested under varying weather and lighting conditions to evaluate tracking performance, battery operation, USB charging control, and communication reliability. Further testing will also help assess its suitability for rural roads, parking areas, gardens, and other outdoor locations.

These improvements could enhance the system's energy efficiency, reliability, and practical usability. Experimental evaluation will be required to determine the effectiveness of the proposed enhancements.

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REFERENCES

[1] K. Ramash Kumar, S. Kalaiyarasan, K. Keerthana, and K. G. Mohan Prasath et al., "Design and Fabrication of Portable Solar Tree Powered Mobile Charger," in Proc. 7th International Conference on Mobile Computing and Sustainable Informatics (ICMCSI), 2026, doi: 10.1109/ICMCSI67283.2026.11412563.

[2] P. Poornima, K. S. Kavitha Kumari, T. Rahul Das, T. Ashir Ali, and P. Mohamed Hasib, "Solar Energy Based Smart Street Lighting System Using Maximum Power Point Tracking Control," in Proc. Asia Pacific Conference on Innovation in Technology (APCIT), 2024, doi: 10.1109/APCIT62007.2024.10673519.

[3] R. Nalagandla and B. Pattanaik, "IoT Enabled Hybrid Renewable Energy System for Street Light Applications," in Proc. 2nd International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), 2023, doi: 10.1109/ICAISS58487.2023.10250645.

[4] M. Kanthi and R. Dilli, "Smart Streetlight System Using Mobile Applications: Secured Fault Detection and Diagnosis with Optimal Powers," Wireless Networks, vol. 29, pp. 2015–2028, 2023, doi: 10.1007/s11276-023-03278-9.

DOI: 10.17148/IARJSET.2026.131058

[5] F. A. Alenezy and M. Akhlaq, "Fix-It: Design and Implementation of a Public Complaint Management System," in Proc. International Conference on Computer Science, Information Technology and Engineering (ICCoSITE), 2023, pp. 858–862, doi: 10.1109/ICCoSITE57641.2023.10127715.

[6] J. K. Udayalakshmi and S. Mohammed Sulthan, "Design and Implementation of Solar Powered Mobile Phone Charging Station for Public Places," in Proc. International Conference on Current Trends toward Converging Technologies (ICCTCT), 2018, pp. 1–5, doi: 10.1109/ICCTCT.2018.8551180.

[7] A. N. Maroma, "Solar Powered Cell Phone Charging Station," Open Access Library Journal, vol. 1, no. 9, pp.1–7, 2014, doi: 10.4236/oalib.1101156.