Development of an Automated Parking System with Lighting Control and Slot Status Feedback

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ABSTRACT

This paper describes the design and development of a diorama-scale automated parking system using sensor-based feedback control. The system combines automatic lighting and parking status display on a single embedded platform to improve energy efficiency and parking space management. Light-Dependent Resistors (LDRs) detect ambient light and parking slot occupancy. An Arduino processes sensor data with threshold logic and controls outputs. When low ambient light is detected, the parking lights are automatically activated; when sufficient lighting is present, they switch off. Simultaneously, an LCD display provides real-time information on parking slot occupancy and availability. Experimental testing was conducted through ten trials under varying lighting and occupancy conditions to evaluate system performance. Results show consistent system responsiveness and accurate detection of occupied and vacant parking slots in all test cases.

The developed system effectively demonstrates the integration of sensing, processing, and actuation within a closed-loop control framework. Although implemented as a diorama-scale prototype, the system architecture is representative of real-world embedded control applications. Thus, the project serves as an effective instructional model for feedback and control systems as well as a scalable framework for automated parking and lighting control solutions.

Keywords: Automatic Parking System, Light-Dependent Resistor (LDR), Arduino Microcontroller, Sensor-Based Control, Parking Slot Indicator

INTRODUCTION

Background of the Project

Parking facilities automation has emerged as a key field of deployment in intelligent transportation systems and smart infrastructure. The unrelenting growth of vehicle traffic, particularly in cities, has highlighted the importance of parking systems that effectively manage space use and reduce unnecessary energy consumption. The traditional parking areas are typically based on hardwired or manual lighting systems and physical inspection to determine the availability of parking slots. These solutions are inefficient because the lights are left on at all times, regardless of ambient conditions, and users cannot detect empty parking spots instantly, particularly in low-light conditions (Idris et al., 2009).

Past studies on smart parking systems emphasize the use of sensor-based systems to detect vehicle presence and provide real-time parking slot information via visual displays, visual interfaces, or electronic platforms (Geng and Cassandras, 2012). Simultaneously, light-dependent resistor-based automatic lighting control systems have become widely adopted to manage lighting based on environmental conditions, thereby minimizing power consumption and enhancing energy savings (Patel et al., 2023). Microcontrollers are widely used in these systems to interpret sensor signals and make real-time control responses.

The proposed project is the design and development of an automatic parking lighting and slot status indication system in the form of a scaled diorama prototype. The system has LDR sensors that measure ambient light intensity and determine parking slot occupancy. The system architecture is similar to that of embedded control systems in the real world, although it was formulated as a physical model, emphasizing modularity, real-time responsiveness, and closed-loop control (Bolton, 2015).

The design uses unified sensing, processing, and decision-making logic to control lighting and detect whether slots are occupied, operating as a single system rather than separate ones, as in current solutions. This integrated approach reduces system complexity and demonstrates a complete closed-loop control process: sensing, processing, and actuation. The diorama-sized prototype highlights the system's novelty as both a teaching model and a practical automation application.

Importance and Relevance of the Study

The given study is important because it illustrates the usage of embedded system design, sensor interfacing, and feedback control in a single platform. The project depicts how a combination of environmental sensing (through occupancy of parking slots) and environmental control logic (through automatic lighting control) can be used to generate intelligent behavior of the system.

From a computer engineering perspective, the project supports fundamental technical principles like the acquisition of analog signals, sensor calibration, decision making based on thresholds, the control of digital output, and hardware-software integration. These ideas play a central role in the design of real-time embedded systems (Monk, 2022). Moreover, the system is compatible with the real-life engineering uses, including intelligent parking management, automated lighting systems, and intelligent building controls, which can be considered as the important elements of the contemporary smart infrastructure and intelligent transportation systems (Geng and Cassandras, 2012).

The prototype is a base upon which it can be improved in the future, such as additional wireless communication, IoT-based monitoring, and system optimization based on the data. The improvements correspond to the tendencies of Industry 4.0 and smart cities, which makes the study more relevant technically and practically.

REVIEW OF RELATED LITERATURE

Smart Parking Systems and Slot Occupancy Detection

The intelligent parking systems are created with the aim of solving the inefficiencies in the old parking systems, especially in the determination of parking spaces. The review made by Idris et al. (2009) of different smart parking technologies has highlighted that sensor-based systems enhance the efficiency in use of parking places and decrease unnecessary traffic flow. Their research emphasized that real-time parking slot detection is important but many of the current systems use complicated sensing techniques, which do not necessarily fit small-scale or instructional applications.

To address the allocation of parking spaces effectively, Geng and Cassandras (2012) suggested a smart parking system that incorporates the sensing and controlling process to control parking space allocation. Their activity, despite being based on large-scale systems with reservation and optimization policies, confirms the topicality of real-time slot occupancy information in the context of enhancing the management of parking and user awareness.

Automatic Lighting Control Using LDR Sensors

Light-dependent resistors (LDRs) are used in automatic lighting control systems to measure the intensity of the ambient light and adjust the amount of lighting to that intensity. The authors reveal that lighting systems based on LDRs can also be used as an efficient way of turning lights on and off according to the environmental illumination, which reduces energy use (Patel et al., 2023). Their results prove that LDR sensors are effective and cheap in outdoor and parking lots lights application when they are integrated with threshold-based control logic.

Arduino-Based Embedded and Control Systems

Arduino microcontrollers have found extensive application in embedded system designs because of their simplicity, real-time processing and simplicity in connecting with sensors. It was stressed by Monk (2022) that

Arduino platforms are appropriate to apply sensor-based automation projects, especially in learning and prototyping. Arduino allows sensor inputs to be continuously monitored and output devices to be controlled in real-time.

The Control Systems Theory says that the feedback plays a vital role in controlling the behavior of the system and ensuring that the desired conditions of the output (O) are achieved (Ogata, 2010). In light and automation systems, feedback enables the system to dynamically respond to sensor measurements by changing outputs. Bolton (2015) went on to elaborate that embedded control systems are normally intrinsically closed-loop, with sensor signals being constantly fed into control to manipulate the actuator actions.

The majority of the available research works are concerned with either parking slot detection or lighting automation as a single system. The current study incorporates two functions into one closed-loop control system, which is built on the Arduino platform, showing sensing, processing, and actuation on the same embedded platform.

Table 1. Comparison Matrix of Related Studies and Current Research

Study	Sensors Used	Controller	Main Outputs	Scope	Key Features	Gap Addressed by This Study
Idris et al. (2009)	Ultrasonic, IR sensors	Microcontroller based systems	Parking availability indicators	Smart parking review	Overview of sensor-based parking systems	Does not include automatic lighting control or integrated feedback
Geng & Cassandras (2012)	Various parking sensors	Centralized control system	Parking allocation information	Large-scale parking management	Optimized parking space utilization	Focused on large-scale systems; no lighting automation
Patel et al. (2023)	Light-Dependent Resistor (LDR)	Microcontroller	Automatic street lights	Lighting automation	Energy-efficient light control based on ambient light	No parking slot occupancy detection
Monk (2022)	Various sensors	Arduino microcontroller	Actuator control outputs	Embedded systems education	Real-time sensor processing and control	No specific parking or lighting application
Bolton (2015)	Not sensor specific	Embedded controllers	Actuator responses	Control systems theory	Closed-loop feedback control concepts	No practical prototype implementation
Current Study	LDR (ambient	Arduino microcontroller	Parking lights, slot	Small-scale parking prototype	Integrated lighting control and slot detection	Combines lighting automation and parking slot

(Automated Parking System with Lighting Control and Slot Status Feedback)	& slot)		LEDs, LCD display		with feedback	status in one closed-loop embedded system

Problem Statement and Objectives

Problem Statement

The current parking space does not have adaptive lighting control and automatic parking slot occupancy monitoring meaning that they are inefficient in terms of energy consumption and situational awareness of the users. The operation of fixed lighting is also a contributor of unnecessary power usage, and there is no real-time slot status indicator thus making it hard to identify available parking space. Secondly, parking systems do not dynamically react to the environmental lighting and occupancy conditions due to the absence of sensor-based feedback mechanisms (Ogata, 2010).

It is necessary to have an automated parking system incorporating real-time processing of information, environmental sensing, and various output actuation. This system is expected to use sensors to measure the ambient light and parking slots occupancy, then use a microcontroller to work with the received data and additionally offer clear visual feedback by using controlled lights and slot status indicator.

General Objective

To create and design an automatic parking system and control lighting and update on parking slots status using sensor-based feedback.

Specific Objectives

- To detect the ambient light conditions with light sensors.
- To automatically turn off and turn on the parking lights depending on the light intensity.
- To know the occupancy of parking slots or not.
- To show parking slots status in terms of LED indicators and LCD.
- To illustrate sensing, control and actuation within one system.

SYSTEM DESIGN AND METHODOLOGY

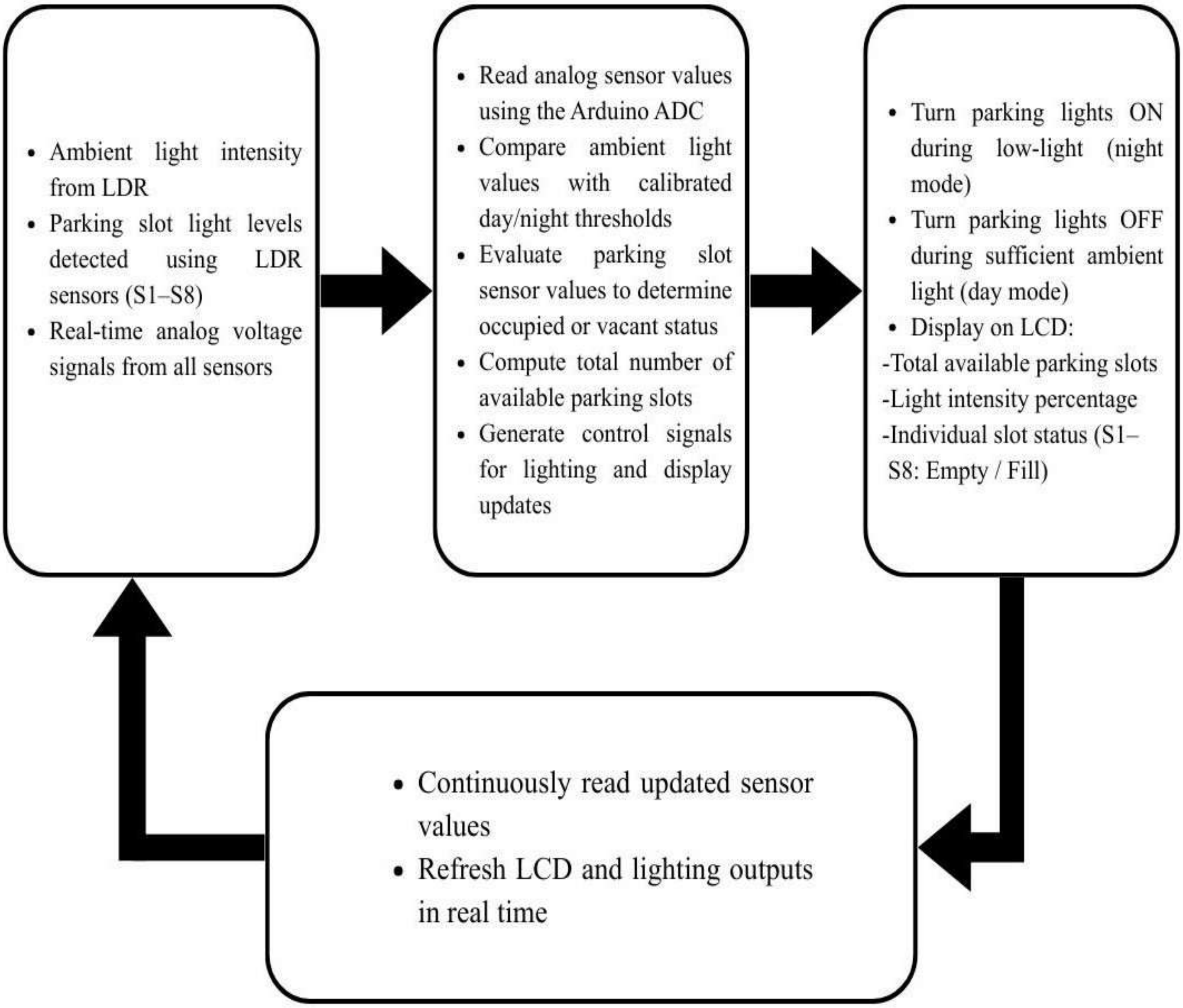
Research Design

This study employed a developmental and experimental research design, which purpose was to design, build, and assess an automatic parking lighting and slot status indication system. The system was realized as a miniature diorama prototype to make it possible to control the tests and to have a clear visualization of the sensor-based feedback control mechanisms. This method allows testing of the functionality of the embedded system while keeping it realistic in an academic lab setting.

Input–Process–Output (IPO) Model

The Automatic Parking Lighting and Slot Status Indication System works according to the Input-Process-Out (IPO) model. At the input stage, the light-dependent resistors (LDRs) are applied to monitor the environmental lighting conditions and parking slot occupancy whereby one LDR monitors the ambient light intensity to differentiate between daytime and nighttime operation with the rest of the LDRs monitoring the presence and absence of the vehicles in each parking slot based on the received light. These signals of the analog sensors are then read by the Arduino microcontroller which then constantly reads the inputs using the analog-to-digital converter and compares them using threshold-based decision logic that is calibrated to reference light levels. On the basis of this processing, the system will recognize the right lighting condition state and whether parking slots are occupied or not. These decisions are then transformed into system actions in the output stage where the parking lights will automatically switch to the ON position when the ambient light is low and switch to the OFF position when adequate ambient light is detected, parking slot indicator LEDs indicate the slot occupancy status, and the LCD displays real-time information of parking availability and system operation. The interaction between actuation, sensing and processing is a continuous process that goes around to close the operation of the system.

Figure 1. Input–Process–Output (IPO) Model of the Automatic Parking Lighting and Slot Status Indication System



System Architecture

The suggested system has a closed-loop embedded control design with three main subsystems namely: sensing, processing, and actuation. The general design follows basic mechatronics and control system principles according to which sensor feedback is constantly applied to control system behavior (Bolton, 2015).

The sensing subsystem uses light-dependent resistors (LDRs) both in the ambient light measurement and parking slot occupancy detection as the input devices. Change in light intensity due to environmental factors or cars

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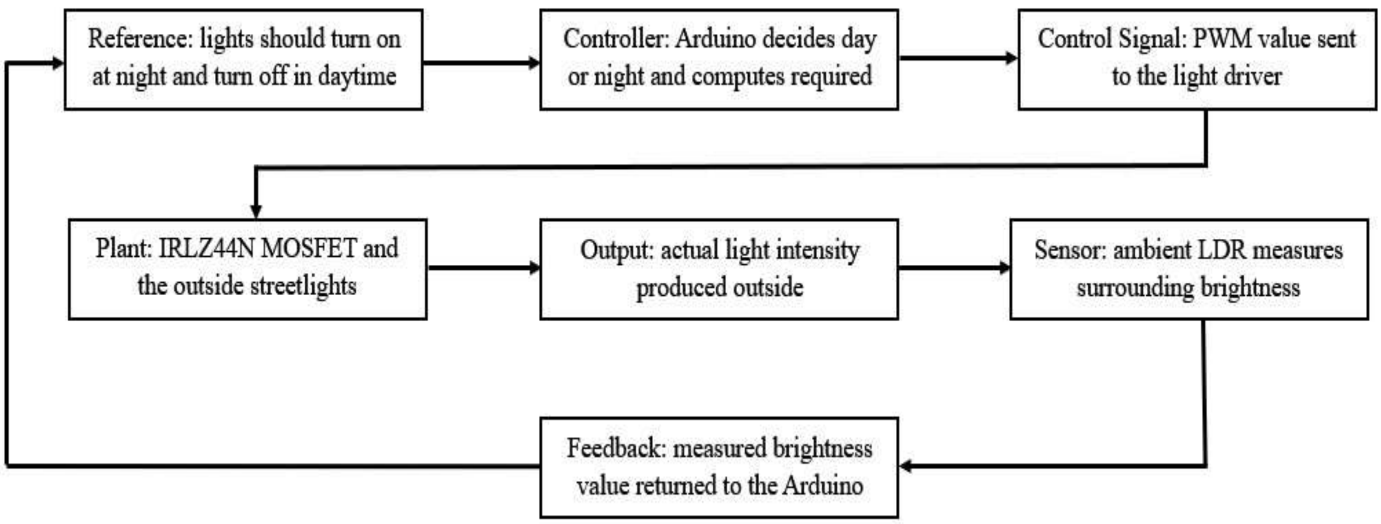
cause change in resistance in the LDRs which is then transformed into analog voltage values to be further processed.

The processing subsystem is realized with the help of an Arduino microcontroller, which converts the sensor signals and digitizes them with the help of analog-to-digital converter. The integrated software uses decision logic software of threshold-based functionality to calculate the ambient lighting conditions and set the occupancy of each parking slot with reference values that are calibrated.

The actuation subsystem will be comprised of LED-based parking lights and LCD display module. The parking lights are also automatically regulated to ensure that it offers light during low-light conditions and the LCD shows the real-time parking slots occupancy and the slots available. These outputs are constantly updated depending on processed sensor data and thereby completing the system feedback loop.

Block Diagram

Figure 2. Closed-Loop Feedback Control Block Diagram of the Automatic Parking Lighting System



The proposed system is considered to be a closed-loop feedback control system of automatic parking area lighting. An LDR is an ambient light-dependent resistor (LDR) that delivers real-time data on the brightness to an Arduino microcontroller, which comparatively measures the resultant brightness with set day and night reference levels. According to this comparison, the controller produces a signal pulse-width modulation (PWM) signal used to operate an IRLZ44N logic-level MOSFET to control the parking street lights. The sensor constantly measures the resulting light production thus allowing stable and adaptive lighting control in different environmental conditions.

Schematic Diagram

The Figure 3. Schematic Diagram of the Automatic Parking Lighting System shows the entire hardware schematic of automatic parking lighting and slot status indication system proposed. Several light-dependent resistors (LDRs) are wired into an Arduino microcontroller in the form of a voltage divider network (VDN) with a CD74HC4067 16-channel analog multiplexer, to allow scaling of collection of ambient light and parking slot occupancy data. The microcontroller converts analog-to-digital, and uses the threshold-based control logic to produce pulse-width modulation (PWM) signal, which drives an IRLZ44N logic-level N-channel MOSFET to control the parking lighting loads. I^2C based LCD module to give real-time visualization of parking slot occupancy and number of slots available to complete the sensing, processing and actuation chain in a closed-loop implement an embedded control architecture.

Figure 3. Schematic Diagram of the Automatic Parking Lighting System

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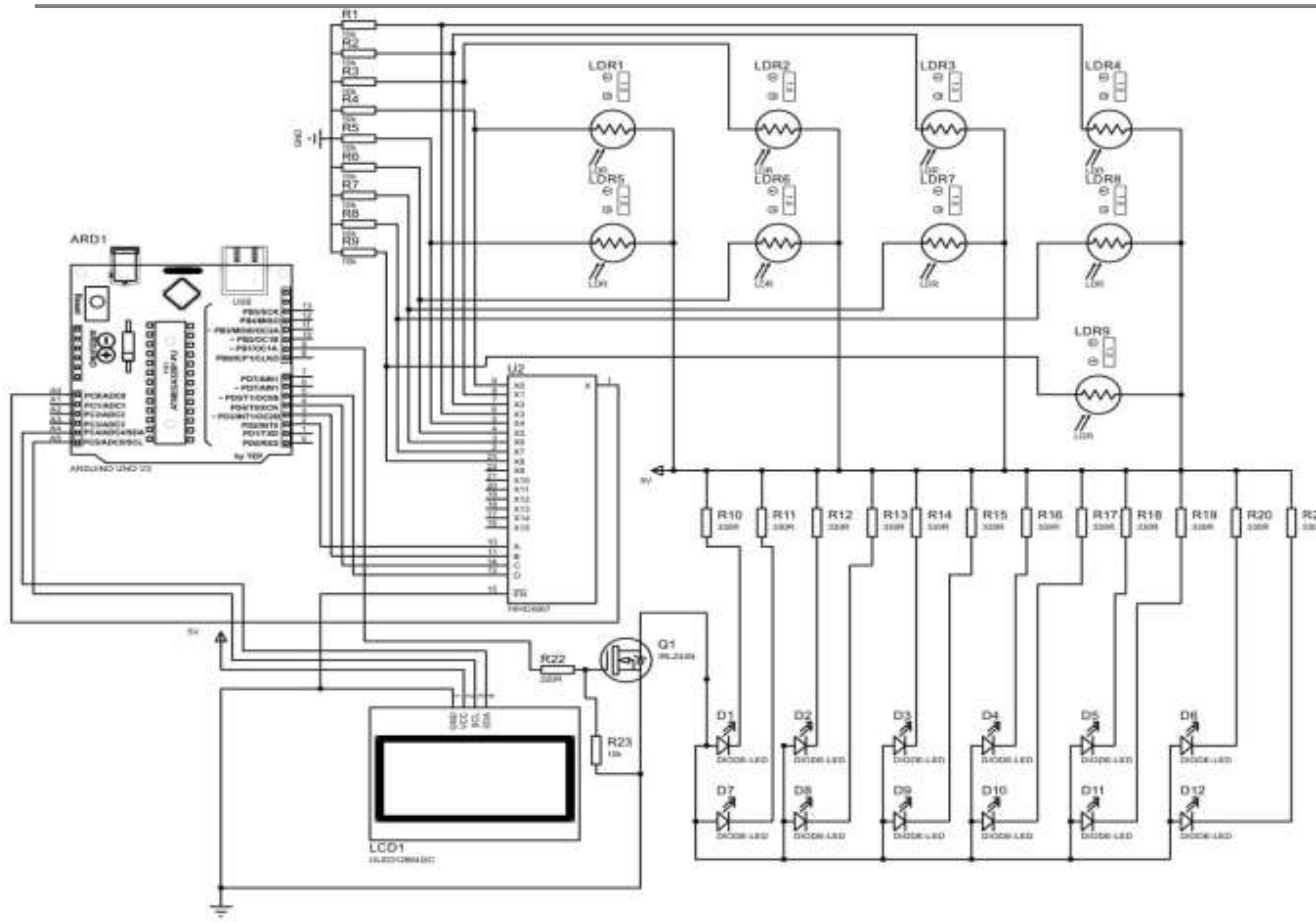


Components and Their Functions

The system is composed of input sensors, a central controller, and multiple output devices. Each component performs a specific role in implementing the sensor-based feedback control mechanism of the automated parking system.

Table 2. System Components and Corresponding Functions

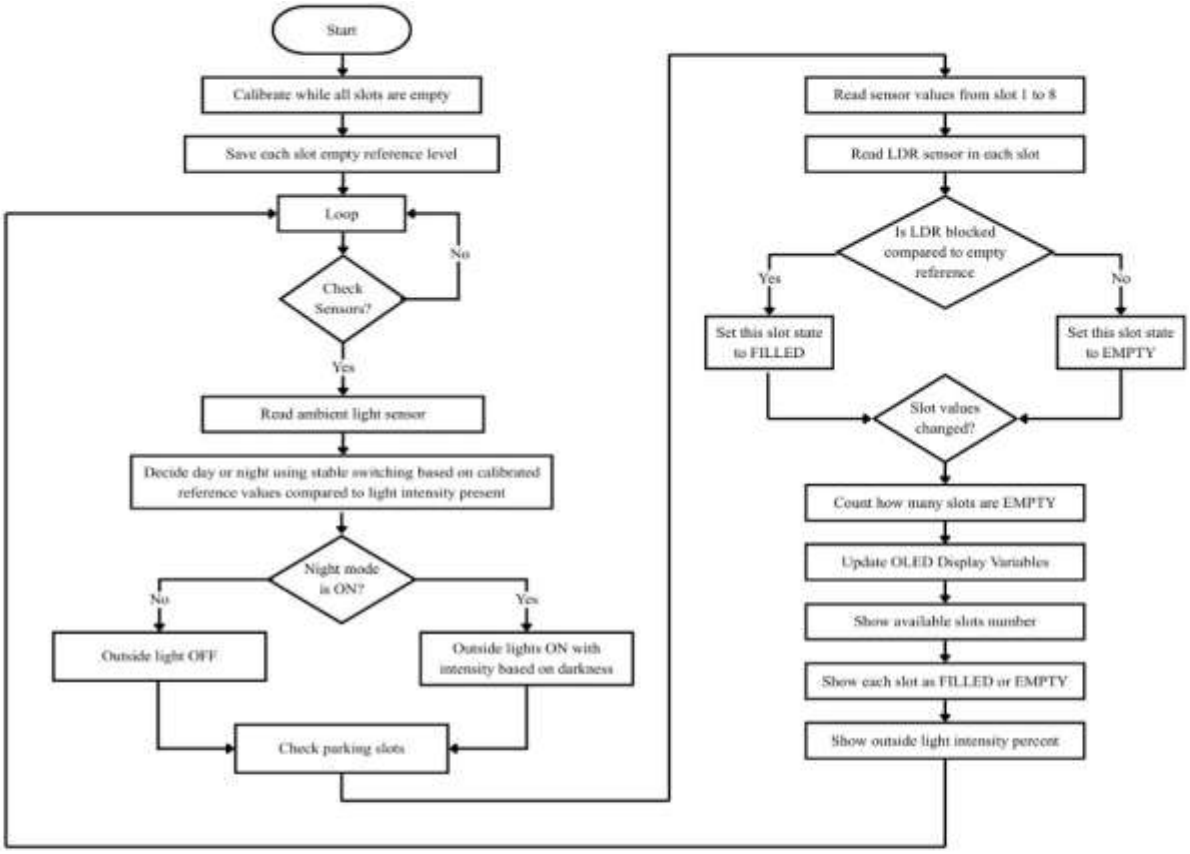
Category	Component	Function
Input Components	Light-Dependent Resistors (LDRs)	Measure ambient light intensity to determine day/night conditions and detect changes in light caused by vehicle presence in parking slots
Input Components	CD74HC4067 16-Channel Analog/Digital Multiplexer	Expands the number of analog input channels by allowing multiple LDR sensors to be read sequentially using a single Arduino analog input
Controller	Arduino Microcontroller	Processes analog sensor data, executes control logic based on predefined thresholds, and generates control signals for output devices
Output Components	LED Parking Lights	Provide illumination for the parking area and are automatically activated under low-light conditions
Output Components	Parking Slot Indicator LEDs	Visually indicate whether individual parking slots are occupied or vacant
Output Components	LCD Display	Displays real-time system information, including parking slot availability and system operating mode (day/night)
Output Components	IRLZ44N Logic-Level N-Channel MOSFET	Acts as a power switching device that enables the Arduino to control higher-current parking LEDs using PWM signals

Supporting Components	Resistors (10kΩ, 220Ω, 330Ω)	Used for voltage divider circuits, current limiting, and signal stability
Supporting Components	Breadboard and Jumper Wires	Provide temporary connections and circuit prototyping
Supporting Components	Power Supply (5V from Arduino)	Supplies power to all system components

Operation Flow of the System

In order to demonstrate the flow of operations and decision-making process of the proposed system, a flowchart is provided. The flowchart explains the process of the sensor inputs being obtained, processed in the microcontroller and converted into control measures of the parking lights and slot status indicators. This depiction underscores the closedness of the system which suggests that sensor feedback will always have a continuous effect on system behavior.

Figure 4. Flowchart of the Automatic Parking Lighting System



Hardware And Software Requirements

List of Hardware Components

- Arduino Microcontroller
- Light-Dependent Resistors (LDRs) — 9 total (8 slots + 1 ambient)
- LEDs and LED Street Lamp Lighting
- OLED display (0.96" SSD1306, I2C)
- Resistors (10kΩ, 220Ω, 330Ω)
- Breadboard and Jumper Wires
- Red and Black Wires (22 AWG)
- IRLZ44N Logic-Level N-Channel MOSFET
- CD74HC4067 16-Channel Analog/Digital Multiplexer Module
- Power supply (5V from Arduino)

Software Tools and Platforms Applied

1. Arduino Integrated Development Environment (IDE).

- Writing, compiling, and uploading the control program to the Arduino microcontroller Writing and compiling of the control program Uploading the control program to the Arduino microcontroller
- Deals with library administration, serial handling and deployment of codes.
- To be used as the main development platform of the embedded system.

2. Adafruit GFX Library

- To be used in graphical representation on the LCD/OLED display.
- Offers text, layout and simple graphics capabilities to represent the parking slot status and availability.

3. Adafruit SSD1306 Library

- Fraudulently made to communicate with the SSD1306-based LCD/OLED module.
- Driver of the display starting, screen refresh and pixel management.

4. Wire (I^2C) Library

- Built-in Arduino library
- Allows the I^2C communication between the Arduino microcontroller and the LCD/OLED display.
- Applied to data transmission like slot status and the number of available slots.

5. No Simulation Software Used

- Validation The system was directly hardware verified.
- There was no use of circuit simulation tools (e.g. Proteus, Multisim).

Hardware and Software Integration or Communication.

The proposed system attains integration of hardware and software by the coordination of sensor data acquisition, control processing and actuator output. LDR sensors produce analog signals which are then LDR sensors, connected through a CD74HC4067 multiplexer and read by the Arduino microcontroller on its analog-to-digital converter. These signals are processed by the software to identify the conditions of ambient lighting and occupancy of parking slots and it produces PWM control signals to operate the parking lights through an IRLZ44N MOSFET. Status and availability of the slot are reported to the LCD via I^2C protocol and hence real-time feedback and monitoring.

Testing And Results

Testing Procedures and Scenarios

The testing of the systems was done to ensure that the flow of the systems described in the system flowchart was working as expected. This was done through sensor calibration, ambient light condition determination, and parking slot occupancy determination as well as system response evaluation. Ten (10) trial tests were conducted with an improved prototype of the diorama.

Initially, the system was set up and parking slots cleared at the beginning of every trial to enable the calibration phase to detect the reference light levels in empty parking slots. Following the calibration, varying of ambient lighting environment to simulate daytime and nighttime condition and putting miniature vehicles in chosen parking slots were used as well as the testing conditions. Each of the trials tested the system and its capacity to make a correct change of day and night modes, identify blocked LDR sensors within occupied parking slots and identify the number of available parking spots, as well as update the OLED display.

Results of System Testing (10 Trials)

Table 3. System Testing and Validation Results

Trial No.	Input Condition	Observed Output	Expected Output	Pass / Fail	Remarks / Behavior Explanation
1	Bright ambient light, all slots empty	Day mode; lights OFF; LCD shows correct slot status and light intensity	Lights OFF; correct LCD display	Pass	Correct day operation
2	Bright light, some slots occupied	Day mode; lights OFF; LCD updates slot status correctly	Accurate slot detection	Pass	Slot sensing correct
3	Low ambient light, some slots occupied	Night mode; lights ON; LCD updates	Lights ON at night	Pass	Correct night switching
4	Low ambient light, multiple slots occupied	Night mode; lights ON; correct LCD count	Accurate occupancy count	Pass	Multiple inputs handled correctly
5	Bright ambient light, mixed occupancy	Day mode; lights OFF	Day mode maintained	Pass	Ambient light prioritized
6	Low ambient light, one slot occupied	Night mode; lights ON	Correct lighting and LCD update	Pass	Single-slot detection correct
7	Low ambient light, all slots occupied	Night mode; lights ON; LCD shows full occupancy	No available slots shown	Pass	Full occupancy handled
8	Bright ambient light after night mode	Day mode restored; lights OFF	Smooth mode transition	Pass	Stable switching
9	Low ambient light, mixed occupancy	Night mode; lights ON; LCD accurate	Correct LCD output	Pass	Matches actual LCD display
10	System reset under bright condition	Day mode; lights OFF	Safe default state	Pass	Correct initialization

Observations and System Performance Analysis

Based on the experimental trials, the system performed consistently and reliably given different ambient lighting conditions and parking slot arrangements. The mechanism used to sense the ambient light was able to differentiate between the bright and the low-light conditions as well and this enabled the system to correctly switch the parking lights on or off. The application of calibrated reference values allowed the stable system behavior and the avoidance of unplanned switching between the active modes.

The occupancy detection of the Parking slots was correct in all the test cases and the LDR sensors were able to detect blocked and unblocked states in relation to the occupied and vacant slots. The system would always compute the number of free parking slots and indicate the status of slots and LCD display in real-time. There were also minor differences in sensor readings; these were caused by the intervention of external light; nevertheless, they did not considerably influence the general functioning of the system. Overall, the system demonstrated consistent behavior, sensitive output control, and efficient combination sensing, processing and actuation systems. The findings suggest that the sensor-based feedback control strategy can be applied to small-scale automated parking systems. It offers effective real-time control over both lighting and parking slot status.

Problems Encountered and Solutions Applied

Some problems were experienced during the system development and testing regarding sensor sensitivity, calibration, and the control of outputs. The preliminary testing procedure indicated that the LDR sensors were sensitive to the high rate of variations in the ambient light and reflections, which sometimes resulted in the

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unstable readings. This was addressed by having threshold-based comparison on known reference values and injecting controlled delays between consecutive sensor values to enhance measurement stability.

The second limitation that was observed was that the system required that the initial calibration conditions were in order. Parking slot detection to see all parking slots correctly, all parking slots needed to be empty at the time the system was started so that the LDR sensors could record the correct empty reference light levels. Inaccurate slot status detection occurred as a result of incorrect reference values being stored in the event that a vehicle was in a slot during power-up. This was solved through the implementation of a controlled start-up process where all slots were held empty during the calibration process which guaranteed good baseline measurements in the future. Also, initial experiments indicated variable LED brightness on direct drive of parking lights on the microcontroller. This problem was addressed by the combination of a PWM control with an IRLZ44N logic level MOSFET to offer a stable current supply to the lighting load. Moreover, the issue of reading numerous parking slot sensors with a restricted number of analog inputs was tackled effectively by the means of utilizing a CD74HC4067 analog multiplexer that allowed letting the sensors be obtained sequentially and with a high degree of reliability.

DISCUSSION

System Effectiveness and Practical Implications

Experimental trials confirm that the system is effective in applying sensor-based feedback control for automated parking lighting and parking slot status control. A light-dependent resistor (LDR) was also used with high reliability to respond to changes in ambient light, enabling the system to switch between day and night operating states. This practice aligns with previous research showing that LDR-based lighting automation systems are effective (Patel et al., 2023).

The Arduino microcontroller also handled multiple sensor inputs and adjusted multiple outputs simultaneously, demonstrating that the system could indeed operate as a real-time embedded system. Across ten experimental trials conducted under different lighting and occupancy conditions, the system achieved correct lighting control and parking slot detection in all cases, corresponding to a 100% functional accuracy within the defined testing scope.

The system's closed-loop nature comes from continuous interaction between sensor inputs and actuator responses. This is a fundamental characteristic of feedback control systems (Ogata, 2010). Although ambient light interference caused minor sensor fluctuations, threshold-based calibration minimized their impact on system performance.

Although the system was implemented as a diorama-scale prototype, its architecture reflects the architecture of real-world embedded control applications. The observed limitations primarily relate to sensor sensitivity rather than control logic, suggesting that the system can be further enhanced by deploying alternative sensing technologies in larger-scale environments.

CONCLUSION

This study successfully designed and implemented an automated parking lighting and slot status indication system based on sensor-driven feedback control. Using light-dependent resistors, an Arduino microcontroller, and multiple output devices, the system demonstrated reliable sensing, processing, and actuation within a closed-loop control framework. Experimental results confirmed consistent system behavior under varying lighting and parking occupancy conditions.

The project not only demonstrates theoretical concepts but also provides practical laboratory exposure for students in embedded systems and feedback control. The system, which was put into practice as a smaller-scale prototype diorama, nevertheless captures much of the guidelines and principles of automated parking and lighting control processes in the real world. The results indicate that implementing sensor-based automation may lead to the full-time involvement of energy and sensitivity of the system in parking lots.

From an application perspective, the proposed system demonstrates a scalable control framework that may be adapted for actual parking environments such as school campuses, residential complexes, and small commercial parking facilities. While implemented as a prototype, the sensing and control strategy remains applicable to real-world deployment with appropriate sensor scaling, enclosure design, and power management considerations. This confirms that the system is not only instructional in nature but also relevant to practical automation and smart infrastructure applications.

In summary, the system developed can reasonably carry out all the mentioned objectives and can be used as both a working and learning prototype to apply in embedded systems. This project will be the basis of future work since it offers a sound foundation of enhanced sensing technologies, more expansive systems, and monitoring platforms through wireless or IoT-based approaches. Therefore, the study adds to the knowledge on but forms the foundation of the use of automation control systems in the design of smart infrastructure.

Future Enhancements

Compared to ultrasonic and infrared proximity sensors commonly used in parking systems, light-dependent resistors were selected for this study due to their simplicity, low cost, and suitability for instructional and prototype-scale applications. While ultrasonic and infrared sensors offer higher accuracy and are less affected by ambient lighting conditions, they require more complex circuitry, calibration, and signal processing. The use of LDR sensors in this project allowed the system to clearly demonstrate fundamental sensing and feedback control principles, making it appropriate for educational purposes while maintaining functional reliability.

The system's future enhancement might involve the use of ultrasonic or infrared proximity sensors together with the existing system which will not only enhance detection precision but also make the system less dependent on varying ambient light conditions. Moreover, the adding of wireless communication modules like Wi-Fi or Bluetooth would mean the data could be transmitted in real-time to an IoT platform for being monitored and analyzed from a distance. The possibility of the future development can also include control algorithms of high sophistication, extension of the parking slots, and integration of green energy management solutions such as solar-assisted operation among others. The intended high scalability, dependability, and real-world applicability would be achieved through these enhancements.

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REFERENCES

1. Bolton, W. (2015). Mechatronics: Electronic control systems in mechanical and electrical engineering (6th ed.). Pearson Education. https://dokumen.pub/mechatronics-electronic-control-systems-inmechanical-and-electrical-engineering-6nbsped-9781292076683-9781292081595-97812920816011881881881-5355375375-1292076682-1292081597.html
2. Geng, Y., & Cassandras, C. G. (2012). A new “smart parking” system based on optimal resource allocation and reservations. IEEE Transactions on Intelligent Transportation Systems, 14(3), 1129–1139. https://www.researchgate.net/publication/287135069_A_new_smart_parking_system_based_on_optimal_resource_allocation_and_reservations

3. Idris, A., Leng, Y. Y., Tamil, E. M., Noor, N. M., & Razak, Z. (2009). Car park system: A review of smart parking system and its technology. Information Technology Journal, 8(2), 101–113. https://scialert.net/abstract/?doi=itj.2009.101.113
4. Monk, S. (2022). Programming Arduino: Getting started with sketches (2nd ed.). McGraw-Hill Education.https://agsci.colostate.edu/wp-content/uploads/sites/95/2020/03/Programming-Arduino.pdf
5. Ogata, K. (2010). Modern control engineering (5th ed.). Prentice Hall. https://repository.unikom.ac.id/50540/1/Modern%20Control%20EngineeringKatsuhiko%20Ogata%20(Prentice%20Hall%202010)(904s).pdf
6. Patel, A., Shah, R., & Mehta, K. (2023). Automatic street light control system using LDR and microcontroller. International Research Journal of Modernization in Engineering, Technology and Science.https://www.irjmets.com/upload_newfiles/irjmets70700003377/paper_file/irjmets70700003377.pdf

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Ms. Maria Micaella Cari Gonzales is a Computer Engineering student of the institution all the way from the province of Bulacan. She is a simple yet admirable person that loves being connected to people and nature. Her life outside the school is truly amazing because she still manages to be a dedicated minister in their local church as a dancer. Life might be tough on her but she always finds a way to stand and smile meaningfully to all the people that surround her. Ms. Gonzales could have many reasons to stop but she always finds courage and strength to overcome everything. She is a fighter.

Mr. Mark Dennis L. Larioza is a student and a budding practitioner in the computer engineering discipline in Eulogio “Amang” Rodriguez Institute of Science and Technology. Through school-work, project, and practical experiences, he has established the base of knowledge in computer hardware, software system, and the new technologies. He is interested in embedded systems, automation, programming, and modern computing technologies and constantly strives to deepen his knowledge through the use of new tools and practical application of theory to solving real-world problems. Curiosity and great interest in technology are what motivate him to enhance his expertise and make a contribution to future technological advances in the sphere of computer engineering.

Mr. Alsel F. Macaspac is a student of Computer Engineering in Eulogio "Amang" Rodriguez Institute of Science and Technology. He has a certification in Computer Systems Servicing giving him the practical experience in hardware and networking. At the moment, he is concentrated on his degree accomplishment and on broadening his technical background. Being a future professional, Alsel is diligent in acquiring new technologies and upbuilding his skills in the sphere of computer engineering.

Ms. Mikaella Jane T. Reyes is a Computer Engineering undergraduate student in Eulogio "Amang" Rodriguez Institute of Science and Technology in Manila, Philippines. She is currently undertaking an undergraduate degree in Computer Engineering and enjoys getting involved in practical work, combining hardware design, embedded systems and software development to solve practical engineering problems. Mikaella develops hardware installation and configuration, circuit prototyping CAD design, computer assembly, and network equipment installation skills. Course work, lab work, enable her to develop expertise in developing workable prototypes addressing real-life computing issues.

Ms. Jhanna Samson is a Computer Engineering student who is majoring in systems design and technical innovation. At the moment, she is working on her Bachelor of Science in Computer Engineering at Eulogio "Amang" Rodriguez Institute of Science and Technology. Her education has provided her with a solid training in hardware and software development. She is situated in Quezon City and is very much into examining the meeting points of new technology and engineering solutions.