Design and Development Smart Parking Slot Finder System

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***Abstract*—The rapid growth of vehicles in urban areas has created serious challenges in parking management, leading to congestion, increased fuel consumption, and time wastage. This research paper presents the design and development of an intelligent parking slot finder system based on a dual LDR–laser sensing mechanism integrated with an Arduino Uno microcontroller. The system utilizes two pairs of Light Dependent Resistors (LDRs) and laser modules positioned at a fixed distance to detect vehicle movement and determine entry and exit operations based on beam interruption sequences. – Additionally, the system is capable of differentiating between two-wheelers and four-wheelers using time-based and simultaneous detection logic. A 16×2 LCD module is employed to display real-time parking availability. The proposed system is economical, easy to implement, and reliable for small to medium-scale parking applications. Experimental observations indicate high detection accuracy, quick response time, and stable performance under different conditions.**

***Index Terms*—Smart parking system, LDR sensor, Laser module, Arduino Uno, Vehicle detection, Automated parking management**

I. INTRODUCTION

In recent years, the exponential increase in the number of vehicles has led to significant challenges in parking management systems, particularly in urban and semi-urban regions. The difficulty in locating vacant parking spaces not only results in driver frustration but also contributes to unnecessary fuel consumption, increased traffic congestion, and environmental pollution. Traditional parking systems rely heavily on manual monitoring or basic infrastructure, which lacks efficiency and real-time information.

To overcome these limitations, intelligent parking systems have been developed using advanced technologies such as ultrasonic sensors, image processing, Internet of Things (IoT), and wireless communication. While these technologies provide effective solutions, they often involve high installation costs, complex configurations, and maintenance challenges.

This research proposes a simple yet effective parking slot finder system using a dual LDR–laser sensor arrangement. The system is designed to detect vehicle movement at entry and exit points using interruption patterns of laser beams. Unlike conventional systems, the proposed model introduces a unique approach to distinguish between two-wheelers and four-wheelers based on sensor activation timing and sequence. The system is controlled using an Arduino Uno microcontroller and provides real-time information through an LCD display. The objective of this research is to develop a cost-effective, reliable, and easily deployable parking management solution.

II. LITERATURE REVIEW

A considerable amount of research has been conducted in the field of smart parking systems over the past decade. Various approaches have been proposed to enhance parking efficiency and reduce congestion. Ultrasonic sensor-based parking systems are among the most widely used solutions due to their ability to accurately detect vehicle presence. However, these systems require multiple sensors for large parking areas, increasing overall system cost and complexity.

Camera-based parking systems utilize image processing techniques and computer vision algorithms

to identify available parking spaces. Although highly accurate, these systems require high computational power, continuous monitoring, and complex software integration, making them less suitable for low-cost applications.

RFID-based parking systems are commonly used in controlled environments such as corporate offices and toll systems. These systems allow vehicle identification and automated entry but are not efficient for open public parking spaces.

IoT-based parking systems provide real-time monitoring and remote accessibility through cloud platforms. While these systems enhance user convenience, they depend heavily on network connectivity and involve higher implementation costs. LDR-based systems have gained attention due to their simplicity and affordability. However, most existing LDR-based designs are limited to basic presence detection and lack the ability to determine vehicle direction or type. The proposed system addresses these limitations by incorporating dual LDR sensors and intelligent logic to identify entry, exit, and vehicle type using beam interruption patterns.

III. METHODOLOGY

The development of the proposed parking slot finder system follows a systematic engineering approach that includes design, implementation, and testing phases. Initially, system requirements were identified, including the need for accurate vehicle detection, differentiation between vehicle types, and real-time display of parking availability.

A dual LDR–laser sensor configuration was selected as the core detection mechanism due to its low cost and ease of implementation. The sensors were positioned at a specific distance based on the average length of vehicles to enable detection of different vehicle types. The Arduino Uno microcontroller was chosen as the control unit due to its flexibility and compatibility with multiple input/output devices.

The system was designed such that each LDR continuously receives a laser beam under normal conditions. When a vehicle passes through the detection area, it interrupts the laser beam, causing a change in LDR resistance. This change is detected by the Arduino, which processes the sequence and timing of interruptions to determine whether the vehicle is entering or exiting and whether it is a two-wheeler or four-wheeler.

The programming of the Arduino was carried out using embedded C language. The code was developed to continuously monitor sensor inputs, analyze interruption patterns, and update parking availability on the LCD display. After assembling the system, multiple tests were conducted using different vehicle types to evaluate accuracy, response time, and reliability.

IV. SYSTEM DESIGN

A. Hardware Architecture

The system consists of an Ardiuno microcontroller, two LDR sensor modules, two laser modules, and a 16×2 LCD display. The Ardiuno acts as the central processing unit that receives input signals from the sensors and controls the output display. Here below working flow of system layout.fig1.

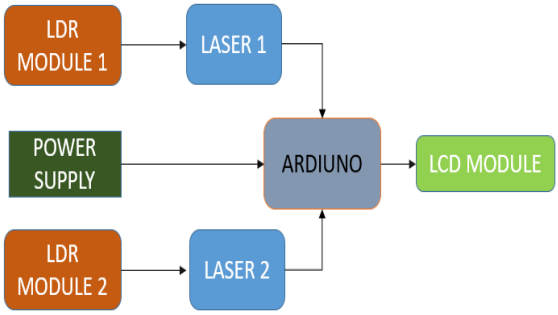

Fig. 1. WORKING FLOW LAYOUT

B. LDR Sensor Module

The Light Dependent Resistor (LDR) is a passive electronic component whose resistance varies according to the intensity of light falling on it. When exposed to a strong light source such as a laser beam, the resistance of the LDR decreases significantly. Conversely, when the light beam is interrupted, the resistance increases. This property is used to detect the presence of a vehicle.

C. Laser Module

The laser module emits a focused beam of light directed toward the LDR sensor. It provides a consistent and precise light source, ensuring reliable detection. The alignment between the laser and LDR is critical for proper system operation.

D. LCD Display (16×2)

The 16×2 LCD module is used to display real-time information about parking availability. It shows the number of vacant slots and system status. The display is interfaced with the Ardiuno using digital pins and is programmed to update dynamically .In fig.2 system explain view in practical scenarios.

Fig2. front view of smart parking slot finder system

E. Sensor Placement and Entry Control System

Two LDR–laser pairs are installed at the entry/exit point of the parking area. The distance between them is carefully selected based on vehicle dimensions. This arrangement enables detection of vehicle direction and type by analyzing the sequence of beam interruptions.

V. CONTROL ALGORITHM AND PATH PLANNING

START
↓
Initialize System
↓
Read LDR1 & LDR2
↓
Is Beam Interrupted?
↓
YES → Check Sequence
↓
LDR1 → LDR2 → Bike Entry
LDR2 → LDR1 → Exit
Both Same Time → Car Entry
↓
Update Parking Count
↓
Display on LCD
↓
REPEAT

A. Control Algorithm

The control algorithm is designed to detect vehicle entry and exit using two LDR–laser sensor pairs. The Arduino continuously monitors both sensors. When a vehicle interrupts the laser beam, the system detects changes in LDR resistance. If both sensors are interrupted simultaneously, it indicates a car entering. If interruption occurs from LDR1 to LDR2, it indicates bike entry, while the reverse sequence (LDR2 to LDR1) indicates vehicle exit. A timing threshold is used to ensure accurate detection and avoid false signals. The system then updates the parking count and displays it on the LCD in real time.

B. Path Planning Strategy

The system uses a logical path planning approach instead of physical movement. A fixed detection zone is created between the two sensors. The sequence of sensor activation determines vehicle direction, where LDR1 to LDR2 represents entry and LDR2 to LDR1 represents exit. This method ensures accurate tracking of vehicle flow and efficient parking management.

VI. FUTURE SCOPE

The proposed intelligent parking slot finder system provides a strong foundation for developing advanced and scalable parking management solutions. Although the current system performs reliably using LDR–laser sensors and Arduino, it can be further improved by integrating modern technologies to enhance efficiency and real-world applicability. One major improvement is the development of a mobile application interface, allowing users to check real-time parking availability, reserve slots, and receive notifications, thereby reducing time and effort in finding parking spaces.

Another significant enhancement is the implementation of an IoT-based monitoring system. By integrating communication modules such as Wi-Fi or GSM, the system can transmit data to cloud platforms for remote monitoring and centralized

control. This would enable parking operators to analyse usage patterns, manage peak hours, and improve overall system efficiency. Additionally, automatic parking guidance systems using LED indicators or digital signboards can be introduced to guide drivers toward available slots, reducing congestion within parking areas.

Further advancements can include the use of artificial intelligence and machine learning for predicting parking availability based on historical data, as well as camera-based systems for improved detection and number plate recognition. The system can also be made more sustainable by incorporating solar power. Moreover, expanding the system for multi-level and large-scale parking areas through networking multiple units would make it suitable for smart city applications. Overall, these enhancements can transform the system into a comprehensive and intelligent parking solution.

VII. EXPERIMENTAL RESULTS

During experimental testing, it was observed that the performance of the system is not significantly affected by the distance between the LDR sensors and the laser modules. This is because each LDR sensor is enclosed within a protective tube that prevents interference from ambient light, ensuring that only the laser beam influences the sensor readings. Additionally, the laser modules provide a strong and focused light source, allowing reliable detection even when the distance between the sensor and laser is increased. As a result, the system operates effectively across varying distances without any noticeable impact on detection accuracy.

The system was tested under different parking gate conditions, including both narrow and wide entry points. In all cases, the system successfully detected vehicle movement and accurately counted both two-wheelers and four-wheelers based on the sequence of laser beam interruption. The logic implemented in the Arduino ensured consistent performance regardless of gate width, demonstrating the flexibility and adaptability of the system in real-world scenarios.

However, one limitation of the system was observed in high fog conditions. In such environments, the laser beam becomes scattered and less effective in reaching the LDR sensor, especially over larger distances. This can lead to improper detection or delayed response. Despite this limitation, under normal environmental conditions, the system performs reliably and provides accurate vehicle counting and parking management.

VIII. CONCLUSION

In conclusion, the proposed intelligent parking slot finder system presents a practical and cost-effective solution to the challenges associated with modern parking management. By utilizing a dual LDR–laser sensor mechanism, the system effectively detects vehicle entry and exit while also distinguishing between different vehicle types. The use of Arduino as a control unit ensures flexibility, ease of programming, and reliable performance. The system demonstrated high accuracy, quick response time, and consistent operation during experimental testing. Its simple design and low implementation cost make it highly suitable for deployment in small to medium-scale parking areas such as educational institutions, residential complexes, and commercial spaces. Furthermore, the system provides a strong foundation for future enhancements, including IoT integration and smart city applications. Overall, this research contributes to the development of efficient, affordable, and intelligent parking management solutions.

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REFERENCES

[1] K. Tribelhorn and Z. Dodds (2007) *Evaluating the Roomba: A low-cost platform for robotics research, IEEE Conference*This study analyses the working and efficiency of the Roomba robot. It focuses on autonomous navigation, obstacle detection, and coverage algorithms. The main purpose is to demonstrate low-cost robotic automation using simple sensor-based techniques.

[2] K. M. Hasan et al. (2016) *Automated Floor Cleaning Robot, American Journal of Engineering Research*This research presents a

microcontroller-based cleaning robot using sensors for automation. It highlights real-time control and efficiency improvement. The purpose is to show how embedded systems can automate repetitive tasks.

[3] H. Choset (2001) *Coverage Algorithms for Robotics, Annals of Mathematics*This paper explains coverage path planning methods used in robotics. It introduces systematic movement strategies like area division and path optimization. The purpose is to improve efficiency in automated systems.

[4] Arduino Documentation (Arduino.cc) *Official Arduino Technical Documentation*This source provides complete details about Arduino hardware and programming. It explains sensor interfacing and real-time data processing. The purpose is to support embedded system development and control applications.

[5] J. Jones research *Smart Parking Systems and Applications, IEEE Robotics Magazine*This research discusses modern smart parking technologies and their benefits. It focuses on automation, real-time monitoring, and traffic reduction. The purpose is to improve parking efficiency using intelligent systems.

[6] Embedded Systems Design (McGraw Hill) *Embedded Systems Design Book*This book explains the integration of hardware and software in automated systems. It covers sensor interfacing, control logic, and system design. The purpose is to develop reliable embedded applications.