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Smart Parking System Using Arduino Uno

Prof. S. M. Todkari[1], Saee Deshmukh[2], Prajakta Gaikwad[3], Laxman Bhadke[4]
Professor, Electronics Engineering Department[1]
Students, Electronics Engineering Department[234]
M.S. Bidve Engineering College, Latur, Maharashtra, India
D.R. Babasaheb Ambedkar Technological University, Lonere.
deshmukhsaee50@gmail.com

Abstract : *The increasing number of vehicles in urban and institutional areas has intensified the difficulty of locating vacant parking spaces. Conventional parking arrangements often depend on manual observation, resulting in unnecessary search time, inefficient space utilization and additional human supervision. This paper presents the design of a low-cost Smart Parking System using an Arduino UNO microcontroller and infrared (IR) sensors. The proposed prototype is designed for four parking slots. Four IR sensors monitor individual slot occupancy, while additional IR sensors at the entry and exit detect vehicle movement. The Arduino UNO processes the sensor signals, determines the number of vacant spaces and updates a 16×2 LCD display. When a vehicle is detected at the entrance, the controller checks slot availability and operates an SG90 servo motor to open the barrier only if at least one space is vacant. When all four slots are occupied, the barrier remains closed and the display indicates "PARKING FULL". LED indicators and a buzzer provide additional status information. The paper describes the system architecture, hardware components, control logic and proposed validation procedure. As the prototype is under development, no measured performance results are claimed. The design provides a practical foundation for a compact automated parking demonstrator and can be extended with IoT-based monitoring in future work.*

Keywords: Smart parking, Arduino UNO, infrared sensor, parking occupancy detection, automatic barrier, servo motor, LCD, embedded system.

1. INTRODUCTION

Parking availability is an important concern in areas where the number of vehicles is increasing while available parking space remains limited. Drivers may spend considerable time searching for vacant spaces, particularly in colleges, hospitals, shopping centres, offices and other public facilities. This search can contribute to internal traffic movement, delay and avoidable fuel consumption. In conventional parking arrangements, availability may be monitored manually or may not be displayed to drivers in a convenient way.

A smart parking system uses sensing and control technologies to monitor parking occupancy and communicate the current status to users. In this work, each of four parking slots is monitored by an IR sensor. The sensor output is read by an Arduino UNO, which acts as the central controller. The controller calculates the vacant-slot count and displays the result on an LCD. Entry access is controlled through a servo-operated barrier based on the availability of at least one slot.

The proposed design focuses on a small, low-cost prototype rather than a city-scale parking platform. Its contribution is the integration of slot-level detection, entry/exit event detection, availability display and automatic barrier control in one Arduino-based system. The UNO R3 is based on the ATmega328P and provides 14 digital input/output pins and six analog inputs [1].

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II. PROBLEM STATEMENT AND OBJECTIVES

Manual parking arrangements do not always provide immediate information about the number of vacant spaces. Drivers may approach a parking area without knowing whether space is available, while an operator may need to monitor occupancy and control entry manually. The proposed system addresses this problem by automatically sensing four parking slots, calculating available capacity and controlling the entrance barrier according to detected occupancy.

The objectives are to: detect occupied and vacant conditions in four individual parking slots; calculate and display available spaces; detect vehicle movement at the entrance and exit; open the barrier only when space is available; prevent entry when all slots are occupied; and demonstrate a compact embedded-system solution.[2]

III. LITERATURE REVIEW

Smart-parking research has explored infrared and ultrasonic sensors, cameras, wireless sensor networks and Internet of Things (IoT) platforms. Barriga et al. review smart-parking technologies and discuss sensor, communication and software choices, highlighting that sensor selection should consider the deployment environment and system requirements .

Tennyson et al. describe an Arduino UNO-based parking approach combining IR sensors, a servo motor and an LCD to detect parking availability and automate gate operation. Kotekar and Khan similarly discuss an Arduino-based arrangement using IR sensors, an LCD and servo-controlled access . These studies illustrate the relevance of low-cost microcontroller platforms for small parking prototypes.

Sahraei presents a parking design using ultrasonic sensors, Arduino and additional network hardware, with a display and servo-operated gate . Although its sensing arrangement differs from the present IR-based design, it demonstrates the value of integrating occupancy detection and access control. The proposed project uses a compact local-control architecture: four IR sensors monitor individual slots, while separate entry and exit sensors detect vehicle movement. No performance superiority over previous systems is claimed.[2]

IV. PROPOSED SYSTEM

The proposed system consists of four slot IR sensors, entry and exit IR sensors, an Arduino UNO controller, a 16×2 LCD with I2C module, an SG90 servo motor with a physical barrier, and LED/buzzer indicators. Each slot sensor provides a digital indication of whether a vehicle is present in its detection area. The Arduino reads the four slot states and computes the number of vacant spaces.

The entrance sensor detects an approaching vehicle. The controller checks the current vacant-slot count. If the count is greater than zero, it commands the servo motor to raise the barrier. The barrier returns to its closed position after the vehicle has passed, using a sensor-clear condition or a safe control delay. If the vacant-slot count is zero, the controller keeps the barrier closed, displays “PARKING FULL” and activates the warning indication. The exit sensor detects a departing vehicle; the slot sensors are then read again so that the displayed count reflects actual occupancy.[3]

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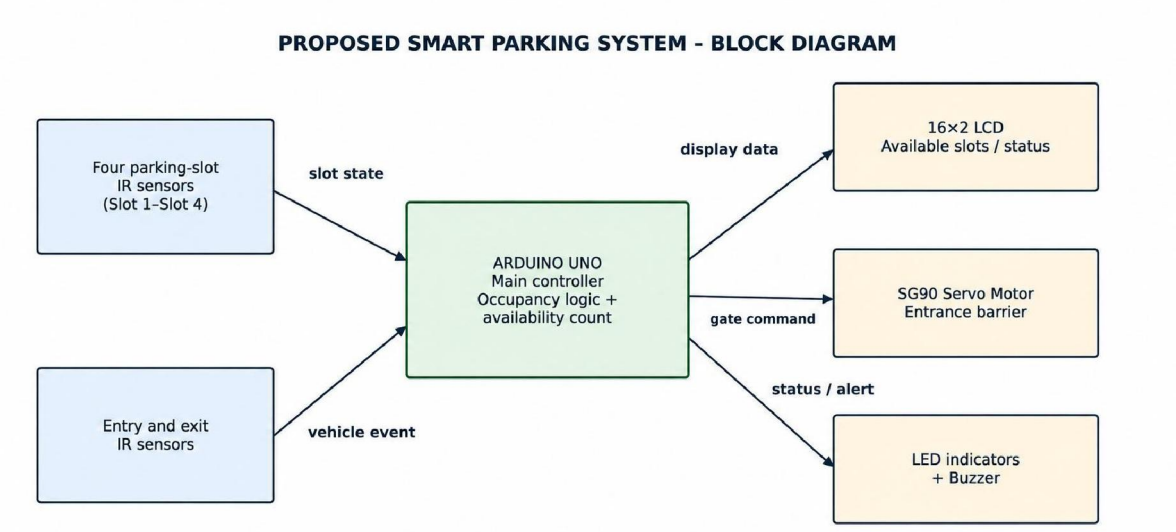


Fig. 1. Functional block diagram of the proposed four-slot smart parking system.

V. WORKING PRINCIPLE

At start-up, the Arduino configures sensor pins as inputs, initializes the LCD and attaches the servo motor control. The controller repeatedly reads the four slot sensors. The number of vacant spaces is obtained by counting the sensors that indicate an empty slot. The display is refreshed with the available-space count and overall status.

When a vehicle approaches the entrance, the entry IR sensor changes its digital state. The Arduino checks the current slot count before opening the barrier. The barrier remains closed if all four slots are occupied. When a vehicle exits, the exit sensor registers the event and the slot sensors provide the updated occupancy state. Direct slot readings are used as the primary source of occupancy information, rather than relying only on a running vehicle counter.[3]

VI. HARDWARE COMPONENTS

Sr.	Component	Qty.	Function
1	Arduino UNO	1	Reads sensors, calculates availability and controls outputs.
2	IR sensor modules	6 planned	Four slot sensors, one entry sensor and one exit sensor.
3	SG90 servo motor	1	Raises and lowers the entrance barrier.
4	16×2 LCD with I2C	1	Displays available spaces and PARKING FULL message.
5	Red and green LEDs	As required	Indicate full/denied and available states.
6	Buzzer	1	Audible warning when entry is denied.
7	220 Ω resistors	As required	Limit LED current.
8	Breadboard and jumper wires	1 set	Prototype assembly and connections.
9	5 V supply / USB	As required	Powers controller and modules; servo supply must be adequate.

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Sensor-count note: Six IR modules are inferred from the confirmed arrangement of four slot sensors plus one entry and one exit sensor. The synopsis originally listed IR and HC-SR04 ultrasonic sensors as alternatives; this paper uses IR sensors because that choice was confirmed by the project team.[4]

A. Arduino UNO

The Arduino UNO is the central processing unit. The UNO R3 uses the ATmega328P and provides 14 digital input/output pins, six analog inputs and a 16 MHz clock [1]. Digital inputs read the IR sensors; output pins control the servo, LEDs and buzzer. The LCD communicates through I2C when the selected LCD module supports that interface.[4]

B. Infrared Sensors

An IR obstacle-detection module generally contains an infrared emitter and receiver. When an object is present within the configured range, reflected infrared energy changes the receiver output and the module produces a digital state. One sensor is assigned to each parking slot, with additional sensors at entry and exit. Sensitivity and detection range must be adjusted for the physical model. Firmware must account for whether the selected module is active-LOW or active-HIGH.[4]

C. Servo Motor, LCD and Indicators

The SG90 servo provides controlled angular movement for the barrier. The open and closed angles must be calibrated to the mechanical model. The servo should use a suitable power supply if the board supply cannot provide its current demand; the grounds of the Arduino and external supply must be connected. The LCD presents the vacant-slot count and system messages. Green and red LEDs indicate availability and full status, while the buzzer provides an audible alert.[4]

VII. SYSTEM DESIGN AND METHODOLOGY

Let O_i be 1 when slot i is occupied and 0 when vacant. The total occupied count is $O = O_1 + O_2 + O_3 + O_4$. The available-space count is $A = 4 - O$, so A ranges from zero to four. This simple calculation is performed repeatedly from the four slot sensor readings.

The proposed smart parking system is designed to provide an efficient and automated solution for vehicle parking management. The four IR sensors are placed in individual parking slots to detect the presence or absence of vehicles. The sensor signals are continuously monitored by the Arduino UNO, which processes the data and updates the parking availability count. The LCD displays the current parking status, helping drivers identify available spaces easily. Based on the availability of parking slots, the Arduino controls the servo motor to open or close the entrance barrier automatically. This approach reduces manual effort, saves time, and improves parking-space management.

Proposed algorithm: (1) initialize Arduino pins, LCD and servo; (2) read the four slot sensors; (3) convert sensor outputs into occupied/vacant states; (4) calculate $A = 4 - O$; (5) update LCD and LEDs; (6) check the entrance sensor; (7) if a vehicle is detected and A is greater than zero, open the barrier, allow passage and close it safely; (8) if A equals zero, keep the barrier closed, display “PARKING FULL” and activate the buzzer; (9) monitor exit events and repeat the slot-reading cycle.[4]

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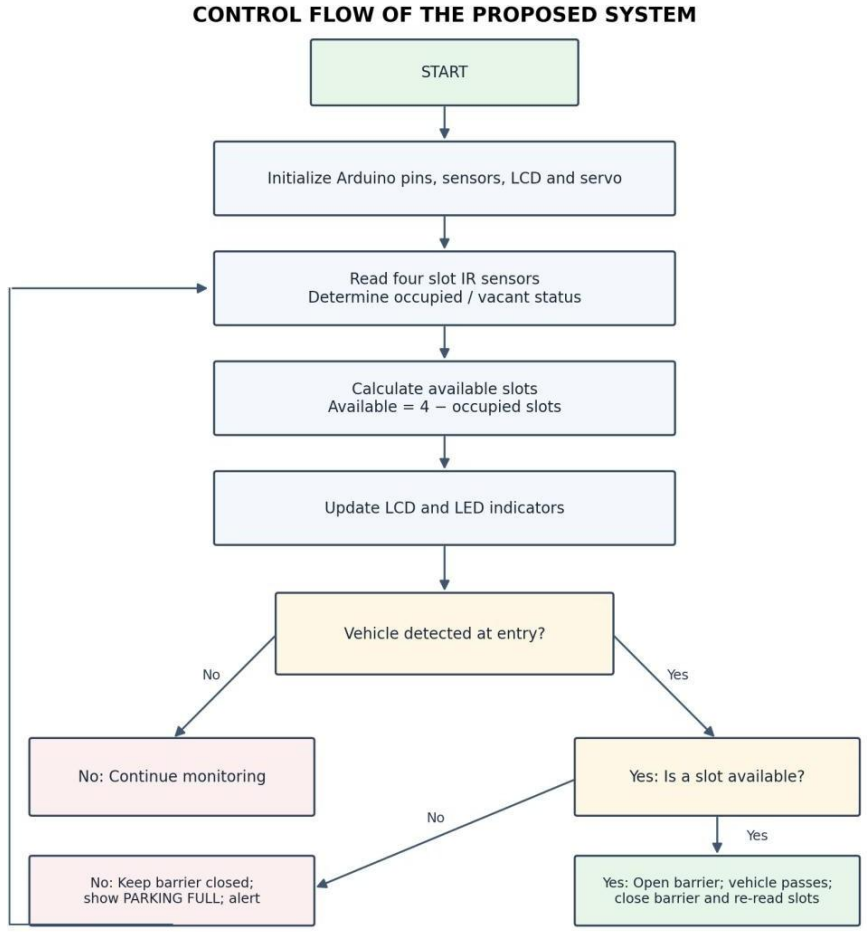


Fig. 2. Proposed control flow for vehicle detection, availability checking and barrier operation.

VIII. PROPOSED PIN ASSIGNMENT

The following pin plan is illustrative and must be checked against the final circuit. It is not a confirmed wiring record.

Arduino pin	Proposed connection	Purpose
D2–D5	Slot IR sensors 1–4	Read occupancy of four slots.
D6	Entry IR sensor	Detect approaching vehicle.
D7	Exit IR sensor	Detect departing vehicle.
D9	Servo signal	Control barrier.
D10	Buzzer	Audible warning.
D11 / D12	Green / red LEDs	Availability / full indication.
A4 / A5	I2C SDA / SCL	LCD communication.

Electrical consideration: The servo should be powered from a suitable regulated supply if required, with a common ground to the Arduino. Sensor output voltage must be compatible with the Arduino input voltage. Verify all connections before powering the complete circuit.[5]

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IX. PROTOTYPE LAYOUT AND OPERATING STATES

Each of the four parking spaces is assigned one IR sensor, mounted so that a vehicle in the corresponding slot can be detected. Entry and exit sensors are installed along the vehicle path.

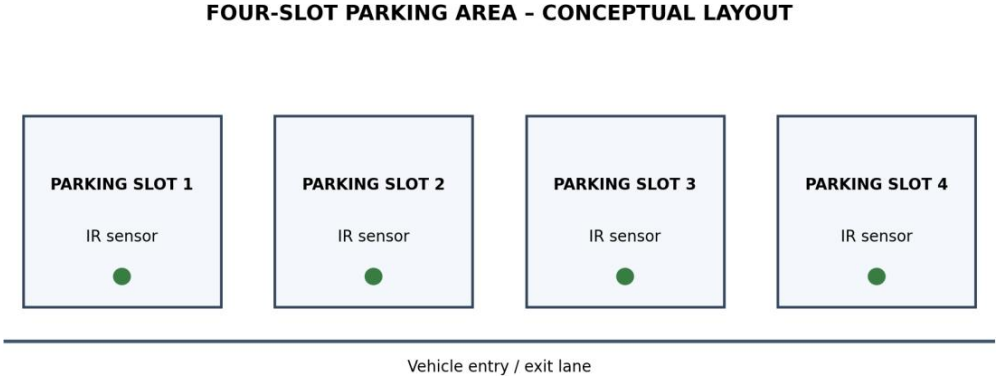


Fig. 3. Conceptual four-slot parking layout showing one IR sensor per slot.

Condition	Slot state	Expected response
All vacant	0 occupied; 4 available	LCD shows 4 available; entry can be permitted.
Partially occupied	1–3 occupied	LCD shows remaining spaces; entry permitted if A > 0.
All occupied	4 occupied; 0 available	PARKING FULL; red LED/buzzer; barrier remains closed.
Vehicle exits	One or more slots become vacant	Slot states are refreshed and available count increases.

X. RESULTS AND DISCUSSION

The project is under development and no physical test results, photographs or measured performance data have been supplied. Therefore, this section describes expected behaviour derived from the proposed design and does not present fabricated experimental values. The expected outcome is that each of the four IR sensors identifies the occupancy state of its assigned slot; the Arduino calculates a vacant-space count between zero and four and displays it on the LCD; the barrier opens only when an approaching vehicle is detected and at least one space is vacant; and the barrier remains closed when all four spaces are occupied. When a vehicle leaves, the slot sensors are read again and the count is refreshed.

Actual performance will depend on sensor alignment, ambient light, surface reflectivity, detection distance, model dimensions, servo response and power-supply stability. These factors must be evaluated during prototype testing.

A. Proposed Validation Plan

Test	Test case	Expected result
T1	Power on with all slots empty	LCD initializes and shows four available spaces.
T2	Place a model vehicle in Slot 1	Slot 1 becomes occupied; count becomes three.
T3	Occupy all four slots	Available count becomes zero; PARKING FULL appears.
T4	Trigger entry sensor when full	Barrier remains closed and warning activates.
T5	Trigger entry sensor when a slot is free	Barrier opens, then closes after vehicle passage.
T6	Remove vehicle / detect exit	Slot state refreshes and available count increases.
T7	Repeat sensor transitions	Display and gate control remain consistent.

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Measurements to record after implementation: correct and incorrect slot detections over repeated trials; time between sensor activation and LCD update; barrier actuation time; and false detections under different lighting conditions. These measurements can support a quantitative results section in a later revision.[6]

XI. ADVANTAGES

The proposed system provides visible parking-capacity information, monitors four spaces independently, automates entrance control, reduces the need for continuous manual observation in a small parking area and uses commonly available embedded-system components. It can be extended with additional sensing and connectivity.[7]

XII. LIMITATIONS AND DESIGN CONSIDERATIONS

The current prototype is limited to four spaces and does not include cloud connectivity, mobile booking, payment processing or vehicle identification. IR sensors may be affected by ambient infrared light, alignment, reflective surfaces and detection distance. Sensor thresholds and mounting positions require calibration. A single entrance sensor may not prove that a vehicle has completely cleared the barrier; the gate-closing logic must be checked to avoid lowering the barrier while a vehicle is passing. The servo also requires a stable power supply.[7]

XIII. APPLICATIONS AND FUTURE SCOPE

Potential applications include college campuses, hospitals, offices, residential societies, hotels, shopping areas and other small facilities. Future improvements may include IoT connectivity, a mobile or web dashboard, RFID-based identification, online reservation, individual slot indicators, data logging and support for more spaces. Larger deployments may require a controller with additional I/O capacity or sensor-expansion hardware.[8]

XIV. CONCLUSION

This paper presented the design of a four-slot Smart Parking System using an Arduino UNO and IR sensors. The proposed architecture combines individual slot monitoring, entry and exit detection, vacant-space calculation, LCD status display, LED and buzzer indications, and servo-based entrance-barrier control. The barrier is permitted to open when at least one slot is vacant and remains closed when all four slots are occupied. The design provides a practical, low-cost demonstration of embedded automation for small parking areas. Since the prototype is still under development, this paper reports the proposed methodology and expected operation rather than measured results. Physical implementation and systematic testing are required to verify sensor reliability, gate timing and overall performance.[8]

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