

Puzzle Parking System: An Space-Efficient Vehicle Management Solution

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Abstract - The increasing number of vehicles in modern urban areas has created significant challenges in parking management, leading to congestion, inefficient land use, and increased fuel consumption. This paper presents a Puzzle Parking System, an automated parking solution designed to maximize space utilization using vertical and horizontal vehicle arrangement. The system integrates microcontrollers, sensors, motors, and mechanical platforms to enable automated parking and retrieval operations. detect vehicle presence and send signals to the controller, which manages platform movement using motor drivers and relays. The proposed system reduces human effort, minimizes parking time, and enhances safety by eliminating manual parking in congested areas. Experimental results demonstrate that the system efficiently accommodates more vehicles within limited space compared to traditional parking methods. Additionally, the system contributes to reduced traffic congestion and environmental impact by minimizing idle vehicle movement. This study confirms that puzzle-based parking systems are a practical and scalable solution for smart city infrastructure.

Key Words: Puzzle Parking, Automation, Smart Parking, Microcontrolle, Space Optimization.

1. INTRODUCTION

With rapid urbanization and increasing vehicle ownership, parking has become a major issue in cities worldwide. Traditional parking systems require large amounts of space and involve manual management, leading to inefficient space utilization, high fuel consumption due to idle searching, and severe traffic congestion.

The Puzzle Parking System is an advanced automated solution that arranges vehicles in a compact, multi-level structure using coordinated vertical and horizontal movement. It employs components such as microcontrollers, motors, relays, and mechanical platforms to automate the entire parking process without human intervention.

This system reduces space requirements by up to 40%, improves operational efficiency, and provides a smart solution for modern urban parking problems. Unlike conventional parking, it minimizes human intervention and optimizes the use of available land area, making it highly suitable for dense commercial and residential zones.

2. BODY OF PAPER

2.1 Traditional Parking System

Traditional parking systems consist of fixed parking slots arranged in rows and columns across a flat or multi-storey structure. Vehicles are parked manually by drivers, requiring wide driving lanes for maneuvering, which significantly reduces the net vehicle capacity of any given land area.

Advantages:

- Simple and easy to use with no specialized equipment
- Low initial installation and maintenance cost

Disadvantages:

- Requires large land area for lanes and turning radii
- Inefficient space utilization — typically 30–40% wasted
- Causes traffic congestion at entry and exit points
- High operational time due to manual searching for slots

2.2 Puzzle Parking System

The puzzle parking system is an automated system where vehicles are placed on individually movable platforms arranged in a grid matrix. These platforms shift horizontally and vertically in a coordinated sequence — similar to a sliding tile puzzle — to create the necessary space for parking or retrieval of any specific vehicle.

Key Features:

- Compact multi-level structure with minimal footprint
- Fully automated operation with no driver skill required
- Efficient space utilization — increases capacity by 40–60%
- Enhanced safety by eliminating pedestrian–vehicle conflict

Working Principle:

vehicle presence → Microcontroller processes signals → Shortest-path algorithm computes move sequence → Motor driver activates platform motors → Vehicle is automatically parked or retrieved.

2.3 Proposed System Overview

The proposed prototype implements a 3×2 grid (six slots, five vehicles, one puzzle gap) sliding platform mechanism where vehicles are dynamically rearranged to service parking and retrieval requests. The key hardware components are:

- Arduino UNO microcontroller (control unit)

- L298N motor driver module (actuation control)
- Gear motors with mechanical structure (platform movement)
- BC547 transistors and relay modules (switching)
- Switched-Mode Power Supply — SMPS (power management)

The system continuously monitors slot occupancy via IR sensors. On receiving a park or retrieve request, the Arduino computes an optimized movement sequence and drives the L298N motor driver to shift the platforms, placing the empty gap adjacent to the target slot.

2.4 Block Diagram Description

The overall control architecture of the Puzzle Parking System is organized into the functional blocks described below:

- User Input — Initiates a park or retrieve request via push button or keypad
- Microcontroller (Arduino UNO) — Processes sensor data and determines platform movement sequence
- Control Unit / Logic — Decides optimal movement sequence to minimize platform shifts
- Motor Driver (L298N) — Amplifies microcontroller signals to drive DC gear motors
- Mechanical Structure — Horizontal rail and vertical lift mechanism moves the platforms
- Parking Slots — Six-slot 3×2 grid stores up to five vehicles simultaneously

Table -1: Component Functions

Component	Function
Arduino UNO	Central controller — processes sensor inputs and computes movement sequence
L298N Motor Driver	Drives horizontal and vertical gear motors for platform movement
Gear Motors	Mechanically shift platforms horizontally and lift them vertically
BC547 Transistors	Switching elements for relay and indicator control circuits
Relay Modules	High-current switching for motor power supply control
SMPS Unit	Regulated power supply for all system components

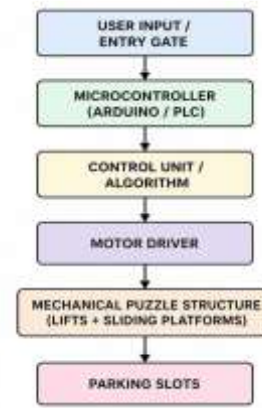


Fig -1: System Block Diagram

3. CONCLUSIONS

The Puzzle Parking System provides an efficient, fully automated solution to modern urban parking challenges. The prototype successfully demonstrates that a 3×2 puzzle grid can house five vehicles within the footprint otherwise required for two to three conventionally parked vehicles, validating the core hypothesis of compact space utilization.

The system substantially reduces human effort, minimizes parking and retrieval time, and enhances safety by eliminating the need for drivers to maneuver in congested bays. The Arduino-based control logic, combined with the L298N motor driver feedback, provides reliable and repeatable automated operation.

Beyond space efficiency, the system contributes to environmental sustainability by reducing fuel consumption from idle vehicle movement and lowering carbon emissions in parking zones. Its modular architecture makes it inherently scalable from small residential installations to large commercial facilities. Future enhancements include IoT-enabled remote monitoring, AI-based slot allocation, solar power integration, and RFID/app-based user interfaces, positioning puzzle parking as a cornerstone of smart city infrastructure.

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