Design and Fabrication of Private Parking Boom Barrier

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Abstract— *This abstract provides an overview of the final year project report on Private Parking Boom Barriers. The project investigates how these systems contribute to sustainable urban mobility by integrating convenience, efficiency, and environmental consciousness. It explores the working principles of private parking boom barriers, evaluates technological advancements, and analyzes their impact on personal mobility and urban infrastructure. Through literature review and survey analysis, the study identifies factors influencing their adoption, including cost, operational range, infrastructure requirements, and regulations. The project also assesses the environmental benefits of smart parking systems in reducing congestion compared to traditional barriers. The insights offer policy recommendations for integrating private parking boom barriers into modern transportation systems.*

Keywords — Private Parking, Boom Barriers Systems, Smart Parking, Sustainable Mobility, Urban Infrastructure, Security

1. INTRODUCTION

This project report delves into the study and application of Private Parking Boom Barriers, which are essential security and traffic management devices used in private and controlled-access parking spaces. Found in places like gated communities, corporate offices, shopping malls, and apartment complexes, these barriers help regulate the flow of vehicles, ensuring that only authorized users are granted entry or exit. They play a vital role in optimizing space utilization, preventing unauthorized parking, and enhancing overall security in both residential and commercial properties.

At the core of the system is a horizontal arm or "boom" that automatically lifts or lowers based on access authorization. Modern boom barriers are often integrated with technologies such as RFID card systems, license plate recognition (LPR), barcode scanners, remote controls, and sensor-based automation. These integrations reduce the need for manual monitoring and make the system suitable for high-traffic zones. Manual override options are also available to ensure continued functionality during power outages or system malfunctions, offering reliability and safety under all circumstances.

The main advantages of these barriers include enhanced security, operational efficiency, customization flexibility, and robust durability. The system can be tailored with different arm lengths, access control types, and connectivity to additional infrastructure like CCTV surveillance, visitor management systems, and payment kiosks. This integration creates a smart parking solution that improves vehicle flow, reduces congestion, and ensures only permitted vehicles use the space. With increasing urbanization and the demand for automated parking solutions, private parking boom barriers are becoming an indispensable part of sustainable and intelligent urban mobility systems.

2. LITERATURE SURVEY

[1] A Design Study of an Innovative Barrier System for Personal Parking Lots Hüseyin R. Börklü1, Sadık A. Kalyon1

The paper analyzes various barrier systems used in side-by-side parking lots, highlighting their strengths and weaknesses. While non-motorized barriers are affordable, they lack ease of use. Motorized options offer convenience but can be hard to detect and may damage vehicles on sloped surfaces. Chain and arm barriers are cost-effective and provide secure locking, but rely on single safety sensors, risking malfunction. Rising bollards offer high security but are expensive and unsuitable for multi-floor use. The study suggests future barrier systems should be solar-powered, cost-efficient, require minimal maintenance, and operate independently to avoid interference. A next-generation barrier should merge the advantages of current models while addressing their limitations.

[2] Advanced Smart Parking Barriers: Design, Implementation, and Impact on Urban Infrastructure – Rama Rao Lachanna S

This paper discusses the design and implementation of an intelligent parking barrier system in Malaysia, featuring wireless control and advanced sensors. With a 95% detection success rate and minimal delay, the system supports Malaysia's smart city goals by reducing emissions and improving parking efficiency. It also aligns with global sustainability initiatives and is scalable for broader urban deployment.

[3] RFID-Enabled Intelligent Parking – Sanskriti Gautam, Sanskriti Verma, Sakshi Priya, Syed Ibraheem Ali

This study evaluates the current smart parking landscape in India, highlighting existing solutions and challenges. It proposes improvements through digital tools like online car parking apps and optimized infrastructure. The goal is to enhance government-led initiatives for efficient and sustainable parking systems across the country.

[4] Smart Parking Systems: Reviewing the Literature, Architecture and Ways Forward – Can Biyik et al. This comprehensive review explores smart parking technologies, focusing on how rising vehicle ownership increases urban challenges. It categorizes vehicle detection methods and communication technologies, emphasizing their role in reducing emissions and improving urban life. The paper offers future directions for the evolution of smart parking systems.

[5] Implementation of RFID-Based Automated Parking Management System: A Feasibility Study – Win Lester S. Dichoso et al.

Focusing on Victory Mall in Tanauan City, this paper assesses the feasibility of an RFID-based parking system. The proposed system offers contactless, cashless, and paperless operations. With promising financial projections, including a three-year payback on a PHP 15 million investment, the system is found viable for practical deployment.

[6] Study On Parking System And Its Analysis – Sneha Raju, Joyal Joseph, Tinu Joseph, Midhun M.

This study analyzes global urban parking problems driven by rapid car ownership and poor policy coordination. It stresses the need for structured planning, understanding parking behavior, and demand analysis to develop effective and integrated traffic and parking management systems.

[7]An Intelligent Parking Management System using RFID Technology based on User Preferences – Amir Shimi, Mohammad Reza Ebrahimi Dishabi, Mohammad Abdollahi Azgomi

The paper presents a smart multi-storey parking system using RFID and a user-preference-based algorithm (MODM-RPCP). It aims to reduce booking and server response times significantly compared to traditional methods. Simulation results show notable efficiency improvements, making it suitable for modern urban settings.

[8]Automated Barrier Gate System By Using Rfid – Suriya Morthi A/L Manivelu

Designed For A Malaysian School Campus, This System Uses Rfid To Automate Vehicle Entry And Exit For Students And Staff. It Records Essential User Data And Enhances Security By Limiting Access To Authorized Individuals. However, Some Locations Still Rely On Manual Gate Operation.

3. DESIGN INSPIRATION

A private parking boom barrier is a crucial access control device used to regulate vehicle entry in areas like residential complexes, offices, malls, and private lots. It features a horizontal arm—typically made of aluminum or steel—that lifts and lowers to allow or block access. These barriers come in manual, semi-automatic, and fully automated forms, often using technologies like RFID cards, remote controls, LPR (License Plate Recognition), or keypad entry for automation. The Software used for the design of private parking boom barrier body is AutoCAD Fusion 360.

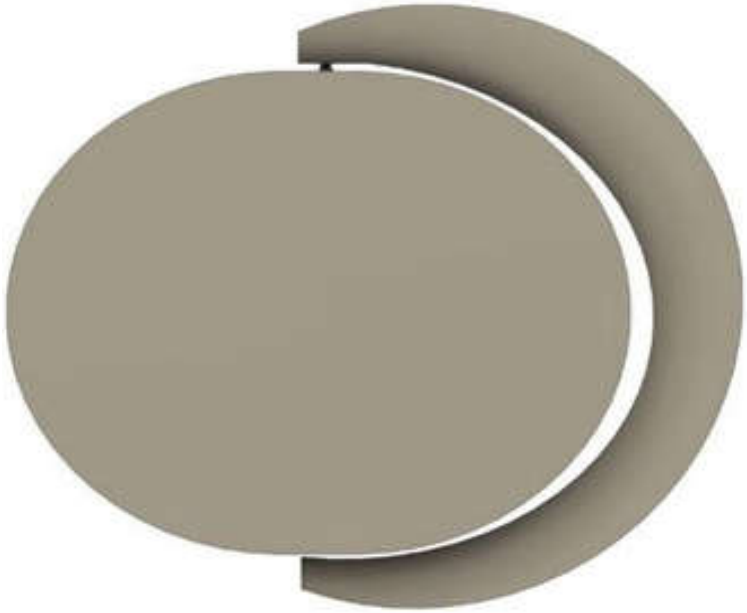
Advanced systems may include sensors for touchless entry, safety mechanisms like reflective strips and anti-crush sensors, and emergency manual overrides. In commercial settings, boom barriers can integrate with ticketing or payment systems. Built to withstand outdoor conditions, these barriers ensure security, smooth traffic management, and efficient vehicle access control.

4. FINAL DESIGN

The finalized design of our private parking boom barrier system integrates an ESP32 microcontroller as the central processing unit. The barrier includes an ultrasonic sensor for vehicle detection and an RFID module for identity verification. Upon vehicle detection, the system activates a buzzer and scans for an authorized RFID tag. If a registered RFID tag is detected, the buzzer stops, and a servo motor lowers the boom arm to allow entry.

The RFID information is sent via Wi-Fi to a MySQL database hosted on XAMPP. The system fetches the corresponding user details—such as name, RFID number, car name, and car number—from the database. These details are then sent via Twilio SMS to a registered mobile number for security notification.

The chassis is constructed from durable materials to ensure strength and stability, and the servo-powered arm operates reliably under various conditions. The boom barrier also includes a 30-second timer that manages vehicle entry and exit before automatically raising the arm and reactivating the buzzer if no vehicle is detected. This integrated, IoT-based design provides a secure, automated, and efficient parking management solution.



Key design considerations include:

Structural Integrity & Precision Engineering**:**

The frame and chassis were designed with a strong focus on durability and accurate alignment tensure reliable long-term operation.

Material Selection – Mild Steel:
Aluminum was chosen for its high strength, offering both durability and rigidity. This enhances system efficiency and ease of installation.

Hybrid Fastening System:
A combination of clamps, screws and bearings ensures a secure and vibration-resistant assembly capable of withstanding mechanical stress from repeated operations.

Lightweight Construction:
With a total frame weight of approximately 20kg, the design is lightweight yet sturdy, supporting fast actuation and minimal wear on moving parts.

Environmental Resistance:
Components are designed to operate reliably in outdoor conditions, with material and construction choices accounting for exposure to heat, moisture, and dust.
Sensor and Control Integration:

Compact sensor housing and strategic placement ensure accurate ultrasonic detection and smooth RFID scanning without interfering with structural elements.

Maintenance and Accessibility:
The design allows easy access to electronic modules and mechanical parts for regular maintenance, ensuring longevity and system uptime.

V. SIMULATIONS

In the pursuit of ensuring structural robustness and reliability, our private parking boom barrier's frame design underwent comprehensive simulation testing, aimed at validating its performance under real-world operating conditions.

1. Structural Integrity:
The results of the load testing revealed that the frame successfully withstood the applied load, showcasing its inherent robustness and resilience. This outcome underscores the frame's ability to endure demanding operational environments and challenging tasks with confidence.

2. Simulation Validation:
The simulation results closely mirrored real-world testing outcomes, confirming the accuracy of our modeling techniques. This validation strengthens the credibility of our simulations as reliable tools for forecasting performance and informing design optimizations.

3.Reliability Assurance:
The boom barrier’s capacity to endure operational loads with negligible deformation confirms its robustness and dependability. This assurance underscores its suitability for continuous deployment in high-traffic private parking environments, maintaining consistent functionality over time.

VI. PROTOTYPING

A. Components of the Prototype

The prototyping of our private parking boom barrier system involves the integration of several key components that collectively deliver intelligent access control, automated movement, and real-time communication capabilities.

ESP32 Microcontroller:
The ESP32 acts as the central control unit of the system, orchestrating all sensor readings, RFID scans, motor movements, and communication tasks. Its dual-core processing capability, built-in Wi-Fi, and Bluetooth modules make it ideal for real-time data handling and seamless server connectivity with the MySQL database via XAMPP.

RC522 RFID Reader:
The RC522 RFID reader module is responsible for reading the unique IDs of RFID tags. When a vehicle arrives, the system scans the RFID tag to verify access rights by matching the UID against entries in the MySQL database. Its fast response time and compatibility with 13.56 MHz tags make it ideal for secure and efficient identification.

HC-SR04 Ultrasonic Sensor:
The HC-SR04 sensor monitors the presence of a vehicle in close proximity. Upon detecting an approaching vehicle, the sensor triggers the buzzer and activates scanning routines. This sensor enhances the system’s automation by enabling motion-triggered operations without manual input.

SG90 Servo Motor:
The servo motor is used to actuate the boom arm by rotating it upward or downward. Controlled via PWM signals from the ESP32, the servo ensures smooth and precise barrier movement during access authorization and vehicle departure.

Twilio SMS API:
Twilio's SMS service is used to send real-time SMS notifications with RFID tag details, owner name, car name, car number, and timestamps. This feature ensures remote monitoring and alerting, providing both security and transparency.

Buzzer Module:
An active buzzer is deployed to indicate system alerts such as unauthorized access, successful verification, or vehicle removal. It adds an auditory cue to the system for added awareness.

XAMPP and MySQL Database:
The local XAMPP server hosts the MySQL database, storing all registered RFID details. Upon scanning a tag, the ESP32 queries this database and retrieves associated information for SMS dispatch and verification.

B. Connections

All hardware components are interfaced with the ESP32 microcontroller. The RC522 RFID reader is connected via SPI protocol, while the ultrasonic sensor is interfaced using digital I/O pins. The SG90 servo receives PWM signals through a dedicated GPIO pin. The ESP32 communicates with the XAMPP server over Wi-Fi using HTTP requests to insert and retrieve data from the MySQL database. Upon successful verification, Twilio’s API is triggered through an HTTP POST request from the ESP32 to send SMS notifications.

C. Fabrication & Assembly

The mechanical and electronic subsystems of the boom barrier are carefully designed and assembled to ensure optimal functionality, durability, and a professional finish.

1. **Laser Cutting:**
   Mild Steel sheets were precision-cut using laser technology to create the base, chassis, and mounting plates for sensors and the boom arm mechanism. This method allowed high accuracy and reduced fabrication time.
2. **Welding:**
   Arc welding techniques were used to assemble the Mild Steel Body and frame components, ensuring structural integrity and robustness to withstand repeated actuation cycles.
3. **CNC Bending:**
   Structural elements like the boom arm bracket and mounting flanges were shaped using CNC bending machines to ensure consistency and clean geometries for sensor alignment and motor mounting.
4. **Powder Coating:**
   The fabricated aluminum parts were powder-coated with a weather-resistant matte finish, ensuring durability and a professional look suitable for outdoor installations.
5. **Assembly:**
   The final assembly involved mounting the servo motor, wiring the sensors and microcontroller, attaching the RFID module, and routing all connections within a protected casing. The boom arm was balanced and calibrated for smooth up/down motion. The system was then powered by a 5V regulated source for logic components and tested with multiple RFID tags for functionality.

D. Working

The boom barrier system operates as an automated access control solution integrated with sensor, RFID, and communication technologies. When a vehicle approaches, the ultrasonic sensor detects its presence and activates a buzzer. The user must scan a valid RFID card, which is read by the RFID module and verified against a MySQL database hosted via XAMPP. If the RFID matches a registered user, the system retrieves the associated details (owner name, car number, etc.) and sends an SMS notification using the Twilio API. Simultaneously, the buzzer stops, and a servo motor lowers the boom arm to allow vehicle entry. Once the vehicle is parked, RFID scanning continues in the background. When the vehicle departs, the last scanned RFID details are sent via SMS, the buzzer activates again, and after a 30-second delay, the boom arm rises and the buzzer stops, resetting the system for the next vehicle. This ensures secure, efficient, and contactless control of private parking access.

VIII. CONCLUSION

In conclusion, the private parking boom barrier system developed in this project embodies a seamless fusion of mechanical engineering and smart automation. Designed with lightweight yet durable aluminum construction, it ensures long-term structural integrity and operational efficiency. The integration of advanced components— including RFID authentication, ultrasonic sensing, and GSM-based SMS notification via Twilio—enhances security, user convenience, and system responsiveness. With precise motion control through servo actuation and real-time database verification via XAMPP and MySQL, the system offers a robust, scalable solution for access management in residential, commercial, and industrial settings. Rigorous testing and simulation validate its reliability, making it a forward-thinking innovation tailored for modern urban mobility challenges.

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