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## ORIGINAL CONTRIBUTION

# An AI and IoT-Driven Framework for Intelligent Parking Management and Optimization

<sup>1</sup>Avijit Biswas, <sup>1</sup>Archisman Kundu, <sup>1</sup>Bikram Paul, <sup>1</sup>Abhijit Maity, <sup>2</sup>Dibyendu Chowdhury

<sup>1</sup>UG student, Dept. of Electronics and Communication Engineering, Haldia Institute of Technology, Haldia, Purba Medinipur, West Bengal

<sup>2</sup>Department of Electronics and Communication Engineering, Haldia Institute of Technology, Haldia, Purba Medinipur, West Bengal

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## ABSTRACT

This research explores an advanced approach to addressing parking challenges in urban areas through the integration of Artificial Intelligence (AI) and Internet of Things (IoT) technologies. Traditional parking systems often suffer from inefficiencies like manual vehicle identification, lack of real-time updates, and delays in slot allocation. The proposed system introduces automated processes such as License Plate Recognition (LPR), real-time slot monitoring, and contactless payment integration, significantly enhancing parking management. Additionally, a mobile application supports features like pre-booking and nearest slot identification. This scalable and reliable solution demonstrates potential applications in public lots, event venues, and smart cities, addressing modern parking inefficiencies while paving the way for future enhancements like dynamic pricing and green energy integration.

**KEYWORDS:** *Smart Parking, Artificial Intelligence, Internet of Things, Edge Computing, Real time monitoring, LPR.*

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## 1. INTRODUCTION

With the rapid pace of urbanization and increasing vehicle density, parking management has become a significant challenge in urban spaces [1, 2]. Conventional systems rely heavily on manual operations [3], leading to inefficiencies such as long search times for parking slots [4], inaccurate fee calculations [5], and congestion during peak hours [6]. These limitations often result in poor user experiences and reduced operational efficiency [7, 8]. The proposed AI and IoT-based Smart Parking System addresses these challenges by leveraging cutting-edge technologies to automate processes [9], optimize resource utilization [10], and improve overall parking management. This paper explores the design and implementation of this innovative system, which integrates AI for License Plate Recognition and IoT for real-time parking slot tracking, ensuring seamless operations and enhanced user convenience.

## 2. SYSTEM DESCRIPTION

The AI and IoT-based Smart Parking System is a comprehensive solution designed to revolutionize traditional parking management. It combines advanced technologies such as Artificial Intelligence (AI) for automated decision-making and Internet of Things (IoT) for real-time monitoring, ensuring efficient and user-friendly parking operations. Fig.1 shows the flowchart of the smart parking management and describe the key points.

- *AI-Driven License Plate Recognition (LPR):* The system employs AI algorithms to detect and recognize vehicle license plates, automating the process of vehicle identification at entry and exit points. This eliminates the need for manual checks, significantly reducing wait times and errors.

○ *Real-Time Slot Monitoring with IoT Sensors:* IoT-enabled sensors are strategically deployed across the parking facility to continuously track the availability of parking slots. This data is transmitted in real time to a central system, ensuring accurate monitoring and instant updates for efficient slot management.

○ *Closest Slot Finder Algorithm:* An intelligent allocation algorithm processes the real-time data from sensors to guide drivers to the nearest available parking space. This feature minimizes the time spent searching for a slot, enhances user satisfaction, and optimizes the use of available resources.

○ *Automated Contactless Payment System:* Parking fees are calculated automatically based on the duration of the stay. Payments are processed digitally through integrated mobile applications, offering a seamless, contactless experience. This system reduces human intervention and enhances operational efficiency.

○ *Mobile and Web Application Integration:* The system is complemented by a user-friendly mobile and web application that provides functionalities such as real-time slot availability updates, pre-booking options, and instant payment confirmations. The application serves as an interface for users to interact with the parking system effortlessly.

○ *Pre-Booking Chatbot:* The system includes an AI-powered chatbot that enables users to pre-book parking slots through simple conversational interactions. It recommends slots, checks availability, and confirms payments, making the process highly intuitive and convenient.

○ *Scalable and Reliable Architecture:* Designed for scalability, the system is adaptable to various parking environments, including public lots, shopping malls, airports, and smart cities. The use of edge computing ensures reliable performance even in areas with limited network connectivity, making it suitable for a wide range of applications.

This integrated system addresses key challenges in traditional parking management, offering a future-ready solution that enhances efficiency, reduces congestion, and improves user experience.

### 3. INNOVATION AND UNIQUENESS

The proposed system stands out due to its innovative features and adaptability. The integration of AI and IoT enables seamless automation, which reduces reliance on human intervention. The closest slot allocation feature minimizes parking search time, enhancing both efficiency and user satisfaction. Another unique aspect is the use of edge computing, which allows the system to function effectively even in areas with limited connectivity. Additionally, the system is highly scalable, making it suitable for various environments such as commercial lots, residential complexes, and smart cities. The inclusion of a chatbot for pre-booking and secure payment integration further enhances its usability, making the system a comprehensive solution for modern parking needs.

### 4. APPLICATIONS

The AI and IoT-based Smart Parking System has a wide range of applications across different environments. In public parking lots, such as those in malls, airports, and offices, the system optimizes space usage and reduces congestion. For smart cities, it seamlessly integrates with urban planning systems to support efficient parking management and resource allocation. At event venues, the system handles high traffic volumes by guiding users to available slots quickly, reducing wait times and enhancing the overall event experience. These diverse applications highlight the system's versatility and potential to address parking challenges in various scenarios.

### 5. FUTURE SCOPE

The future development of this system offers numerous possibilities for enhancing functionality and sustainability. Dynamic pricing based on real-time demand and slot availability can improve space utilization and generate

additional revenue. Integration with electric vehicle (EV) charging stations can further increase the system's utility, providing real-time updates on charging slot availability. The system can also direct users to nearby parking lots if the primary lot is full, ensuring a hassle-free experience even during peak hours. Finally, adopting green energy solutions, such as solar-powered IoT sensors and charging stations, will reduce the system's carbon footprint and support eco-friendly practices.

## 6. CONCLUSION

The AI and IoT-based Smart Parking System represents a transformative solution to modern parking challenges. By automating critical processes and integrating advanced technologies, the system addresses inefficiencies in traditional parking management, enhancing operational efficiency and user satisfaction. With its scalability and potential for future enhancements, the system is well-positioned to contribute to the development of smart cities and sustainable urban environments.

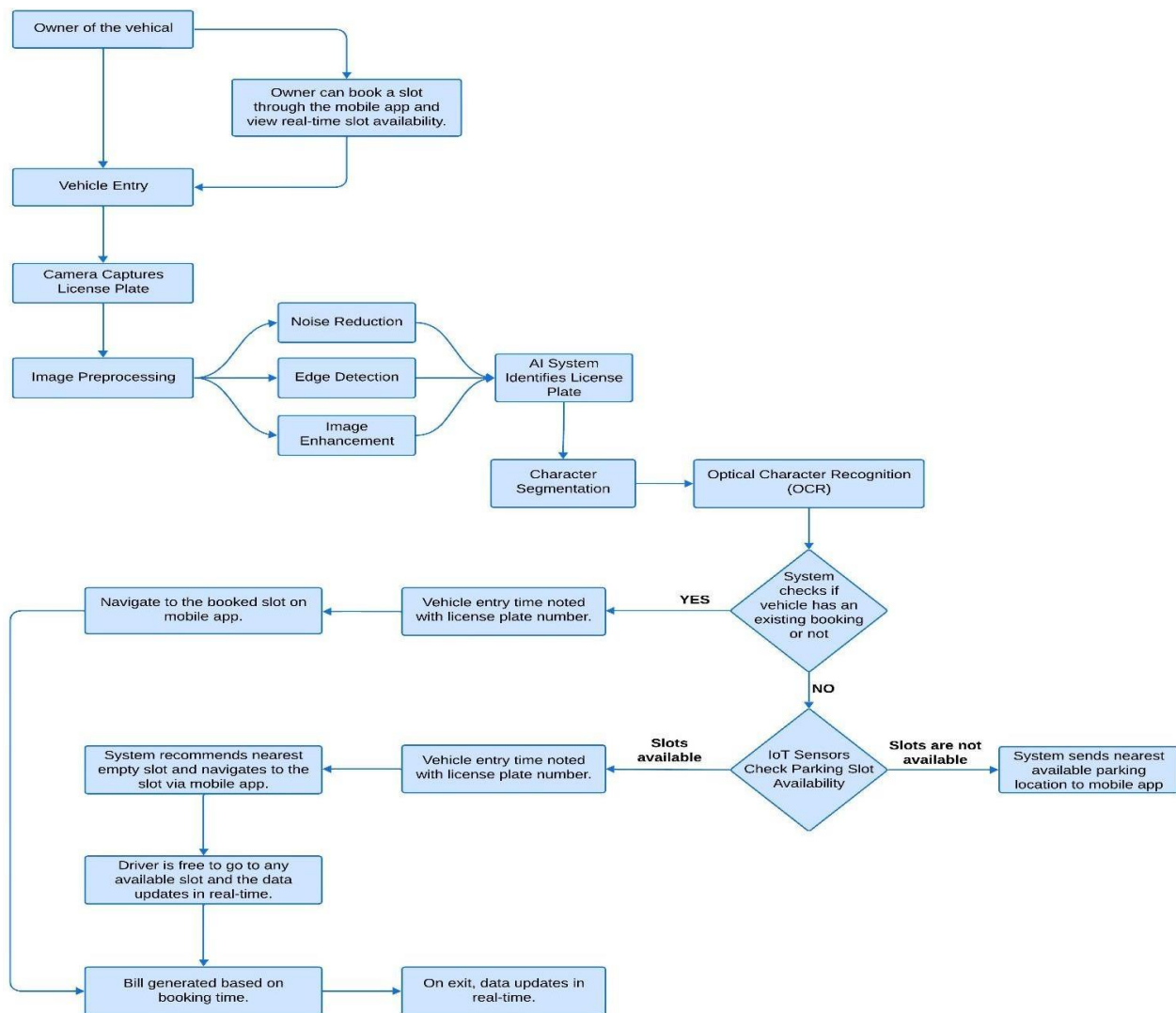


Figure 1. Flowchart of the Smart Parking Management

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