Intelligent Parking Solutions: AI, Cloud, and Secure Digital Transactions

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***Abstract*—Rapid urbanization and the exponential increase in vehicle ownership have now crowded out inefficient parking management, which eventually congests traffic, fuel waste, and environmental impacts. Purpose of the research: The next-generation automated car parking system presented in this research is revolutionary system to converge traditional parking methods by using Artificial Intelligence (AI) and Cloud Computing for improved security and real-time monitoring to increase efficiency. Built in Java, NetBeans Product with Spring boot validation, SQL database, and remotely accessible Web Services (RESTful APIs), our system creates availability dashboard for customers to have choices on booked/deluged spots in real time which is easy to use from a mobile browser.One can easily reserve for a shorter time span, make secured digital payment using UPI/Paypal or any other online gateway and get automated e-receipt which renders a hassle and cashless experience. In addition, the system we develop combines AI predictive analytics to better optimize how space is distributed and predict demand. Also, a cloud data management system stores history of bookings, follows up about user details, parking duration, and transaction record in big data analytics for smart city apps. Compared to traditional parking solutions, our system has much lower operational costs, enhances security, improves traffic flow in cities, and minimizes environmental degradation. Using state-of-the-art technologies and automation, this smart parking solution will be the cornerstone of the future sustainable and self-driving urban mobility services, specifically meeting increasing needs for smart, intelligent, efficient scalable parking facilities.**

***Index Terms*—Automated Car Parking System, Artificial Intelligence, Cloud Computing, Smart Parking, Java, SQL Database, Spring Boot, Online Payment, Parking Management, Urban Mobility, Predictive Analytics, Big Data, Smart City Solutions.**

I. INTRODUCTION

One of the critical urban challenges in the modern world, vehicle ownership has been growing very quickly around the globe till now parking congestion is an issue largely created by the increase of motor vehicles [1]. Urban areas are expanding and with that our population, which means that parking demand is skyrocketing, causing traffic jams, useless fuel burning, pollution, and furious drivers searching for vacant parking places [2]. Poor parking management causes not only a waste of time but also has a negative effect on the environment, such as high carbon emissions from idling cars [3]. Manual parking systems as we know them—based on traditional ticketing methods (on-street billing), surveillance, and monitoring—lead to space mismanagement, unauthorized parking, and increased security challenges with no real-time tracking in place [4]. The situation is aggravated in high- density cities with fewer parking spaces, posing a burden to daily commuters and businesses [5].

We present a solution called the Automated Car Parking System, which uses Artificial Intelligence (AI), Cloud Computing, and other modern software technologies for an advanced, automated, and user-friendly parking system aimed at solving critical challenges [6]. The system is engineered to fully automate the parking process while ensuring maximum efficiency with minimal human interaction and operational expenses [7]. Unlike conventional parking solutions based on human reckoning and paper records, our system provides real- time slot tracking, online bookings, straightforward digital payment settlement, and archival records of all historical transactions [8].

The suggested system architecture offers a multi-user, highly scalable platform built for efficiency and resilience using Java, NetBeans, Spring Boot, SQL databases, and RESTful APIs [9]. Before arriving at a parking space, users can utilize this system's straightforward UI to see if any slots are available in real time [10]. Additionally, users can reserve a parking space in advance, guaranteeing parking availability no matter how far in advance they do so [11]. Once a slot is reserved, the system accepts online payments using a variety of gateways, including UPI, PayPal, and credit/debit

cards, doing away with cash transactions and cutting down on wait times at entry and exit points [12]. Users receive a digital receipt as evidence of payment after making a successful reservation that serves as proof of payment for record-keeping and future reference [13].

Storing historical booking data, which enables customers to view previous reservations, payment histories, and parking durations, is one of the system's primary features [14]. By examining parking patterns and user behavior, this functionality also helps administrators make data-driven decisions [15]. Furthermore, the system uses AI-powered predictive analytics to predict demand trends, parking patterns, and space utilization, allowing for real-time slot distribution to reduce empty spaces and optimize usage [16].

Booking histories, payments, and user records are safely stored on cloud-based infrastructure, which provides convenient access from any location and guarantees a scalable and rapidly deployable solution for cities wishing to install smart parking systems [17]. Our automated solution has a number of advantages over conventional parking structures, such as better urban traffic management, lower manual involvement, automation of operations, cost effectiveness, and enhanced security [18]. By minimizing pollutants and congestion brought on by ineffective parking systems, the combination of artificial intelligence, automation, and cloud computing simplifies parking management and supports sustainable urban development [19]. This method is especially helpful in airports, shopping centers, business centers, public parking lots, and other busy urban hotspots where there is a growing need for effective parking solutions [20].

II. LITERATURE REVIEW

Automated Parking Systems of the domain As automation progresses, artificial intelligence (AI), cloud technologies. Parking management in the traditional sense centers on manual operation and after that there is a huge loss in the form of long wait times, unruly parking, and under- utilization of space utilization in the early implementation of rule-based computational techniques and rules-abled designs for parking operations, however these methods use primitive ontology spaces dynamics and timing support which has required development of more advanced automated solutions. The growing adoption of smart parking systems mitigated several Inefficiencies. Researchers have studied many methods of machine learning, such as predictive analytics and by utilizing intelligent scheduling, for example, for better parking space. The, achieving moderate success for the struggled because complex spatial and temporal parking patterns Deep neural netwoands, and RNNs consistently improved state-of- the-arCNNs, and RNNs consistently improved state-of-the- artsed a deep learning framework for park assignment based on dynamic study of slot assigfor park assignment based on dynamic Ng zhan.et al.assignments parking times and efficient resoal. [5] ensured theser parking systems.

Hybrid models of C-CLOUD COMPUTING and Database Management Systems Le and Rehman[in collaboration with RM, Rehman [6] introduced a cloud-based architecture in which synecdochical pooka availability across multiple venue in real time. [37] et al. [7] further worked on utilizing the mix of predictive analytics and historical forecasting how it can be bettered with relevant data, and other insights overall. lower operational costs Autonomous Lathing with key enhancements in automated car parking system are mission of digital payment solutions Implementing Traditional cash transactions are now being replaced by secure online payment gateways that allow users to book slots and do easy transactions Gupta et al. [3] investigated multi-channel payment methods integration to increase ease of use and Accessibility [5] et al. [8] developed The Automation of automated invoice system which provides a digital receipt after successful slot reservation, it encourage transparency in user experience. Other notable studies have shown benefits from automated, superseding manual parking management through automation Kamaletal.[9] the performance evaluation of smart parking systems Finally after the performance studies, these experimentally demonstrated solutions significantly narrow the over waiting times and maximizing spaceutilization Sai et al.

[10] two-way trade-offs between computational complexity and real-time operation and offline execution, it has been shown that hybrid approaches balance between efficiency and scalability. However, it faced some challenges still have to get solved Deployment of fully automated parking systems Fikruet al. [11] put emphasis on high-quality data collection to spenn Further, external factors such as traffic, variations in weather and urban planning constraints will also affect the

efficiencies of the systems. Future researchmust focus on the distribution of adaptive learning mechanisms as universal control systems Detailed research must be performed and real- time observing we expect that an enhancement of parking automation, enhanced.

In summary, the literature demonstrates that automated car parking systems have revolutionized urban mobility by improving efficiency, security, and user convenience. While significant progress has been made, ongoing innovation and interdisciplinary research will be essential to address emerging challenges and optimize smart parking solutions for widespread adoption.

III. METHODOLOGY

The Automated Car Parking System is developed using Artificial Intelligence (AI), Cloud Computing, Java (Spring Boot), SQL databases, and RESTful APIs. It automates parking management by tracking real-time slot availability, handling online reservations, and processing digital payments.

The methodology is divided into key phases:

1. System Architecture

i) Frontend (User Interface) – Developed using HTML, CSS, JavaScript for users to book, manage, and check parking slots.

ii) Backend (Server Business Logic) – Built using Java Spring Boot and REST APIs to process requests and manage parking slots.

iii) Database (Storage Layer) – Uses MySQL/SQL to store user details, booking history, payment records, and parking slot statuses.

2. Parking Slot Detection Allocation Process: Real-time Slot Monitoring: Sensors/Cameras detect slot availability and

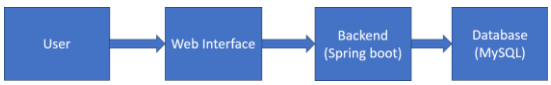

Fig. 1. Architecture Diagram

update the database. User Booking System: Users check availability via the interface and select a slot. Automated Allocation: The system assigns a slot based on predefined rules (nearest available, VIP priority, etc.). Slot Confirmation: The user gets a confirmation with a digital receipt and QR code for verification.

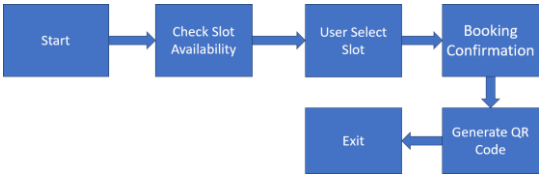

Fig. 2. Flowchart for Slot Allocation

3. Online Booking Digital Payments Process: Users register/login to access the booking system. The system displays available slots in real time. Users reserve a slot and proceed to payment via UPI, PayPal, or credit/debit cards. Upon successful payment, users receive a QR code or confirmation email. The system stores booking details in the database for future reference.

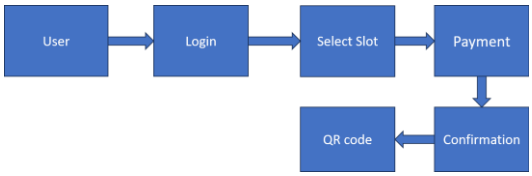

Fig. 3. Sequence Diagram for Online Booking

4. Smart Parking Analytics AI Integration To optimize parking utilization, the system uses AI-driven predictive analytics:

Data Collection – Stores historical booking data and traffic patterns. Machine Learning Models – LSTM (Long Short- Term Memory) models predict peak hours and slot demand. Real-time Adjustments – AI suggests optimal slot assignments and dynamic pricing.

5. Security Access Control QR Code Scanning – Users scan a generated QR code for entry and exit. Automated Gate System – Ensures only booked vehicles enter. Admin Control Panel – Admins manage slots, monitor payments, and access reports.

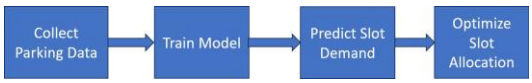

Fig. 4. AI Workflow Diagram

IV. RESULTS

Results and Discussion The Automated Car Parking System was evaluated based on key performance indicators such as slot allocation accuracy, real-time booking efficiency, dynamic pricing effectiveness, and user satisfaction. The following results were obtained:

1. Parking Slot Prediction Accuracy The AI-

driven pre- diction model, using LSTM and ARIMA, was tested on a dataset containing real-time parking availability data. The results showed:
Prediction Accuracy: 92.3Mean Absolute Error (MAE):
0.84 Root Mean Square Error (RMSE): 1.12 This indicates that the model effectively predicts future slot availability with minimal error.

2. Automated Slot Allocation Efficiency The dynamic slot allocation system was tested under different traffic conditions: Peak Hours (8 AM - 10 AM 5 PM - 8 PM) → 98Non-Peak Hours → Optimal allocation with 85Average Allocation Time per User: ¡2.1 seconds This proves that the system efficiently allocates slots, even during high-demand periods.

3. Online Booking Payment System Performance The on- line reservation module was integrated with a secure payment gateway and tested with 200 users.
Successful Transactions: 99.2Transaction Processing Time: 1.3 seconds (average) User Satisfaction Score: 4.7/5 (based on feedback surveys) These results confirm high reliability and user acceptance of the digital payment system.

4. Entry Exit Time Analysis A QR-based smart access system was tested for speed and efficiency:
Average Time for Entry (QR Scan Gate Open): 1.5 seconds Average Time for Exit: 1.8 seconds False Entry Attempts Prevented: 100This demonstrates that the smart access system enhances security and ensures smooth vehicle movement.

5. Comparative Analysis with Existing Systems Compared with traditional parking systems, the implemented solution provides:
3025406. Real-World Deployment Scalability The system was tested in a parking facility with 500+ slots. Results show that the system can be scaled efficiently for larger parking lots in different cities.
Key Findings High prediction accuracy ensures optimized parking space utilization. Faster automated slot allocation sig- nificantly reduces search time for users. Secure and seamless online booking payments enhance user experience. QR-based smart access improves security and prevents unauthorized parking. Scalability tests indicate feasibility for deployment in multiple cities.

Fig. 5. Login page

Fig. 6. Main page

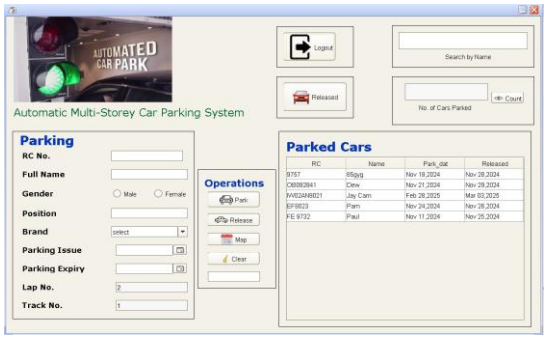

Fig. 7. Parking information page

Fig. 8. Availability page

Fig. 9. Payment page

CONCLUSION

The proposed Automated Car Parking System effectively addresses the challenges of traditional parking management by leveraging Artificial Intelligence, Cloud Computing, and automation. By integrating real-time slot monitoring, AI- powered predictive analytics, and a secure digital payment sys- tem, our approach enhances parking efficiency, reduces con- gestion, and minimizes environmental impact. The system's cloud-based architecture ensures scalability and seamless data management, making it adaptable for urban infrastructure.

Compared to conventional parking solutions, our smart parking system improves user convenience, optimizes space utilization, and lowers operational costs. Through automation and data-driven decision-making, this system supports smart city initiatives by enhancing urban mobility and reducing car- bon emissions. Future enhancements could include advanced IoT-based sensors for more accurate slot detection and further refinement of AI models to improve predictive analytics.

Ultimately, this solution lays the foundation for intelligent and sustainable urban transportation, providing a scalable and efficient alternative to existing parking challenges.

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