Tsinghua University

Tsinghua University

Service Research & Innovation Institute

Tsinghua University

Certificate Program on

“Innovation & Entrepreneurship for Digital Economy”

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Group Project:

Transportation AI

Project Topic:

Smart Parking Solutions with AI

Team members:

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MOUNA MOHAMADI	8/10
JUMA MDELELE	8/10
VEONICA CUPPAH	10/10
RIAD HAJAR	9/10
LUONG THI LINH	9/10
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Introduction

The Fourth Industrial Revolution (FIR) is transforming transportation by integrating digital, physical, and biological technologies. Advancements in AI, robotics, quantum computing, IoT, and 5G wireless technologies are revolutionizing parking management. AI-powered solutions optimize space allocation, perform predictive maintenance, save costs, and enhance security and safety. These systems use real-time data from sensors, cameras, and mobile apps to provide dynamic parking solutions, reduce emissions, and improve maintenance. Smart vehicles equipped with advanced technologies like automatic emergency calling and adaptive speed signs can be connected to other vehicles and infrastructure. Traffic management systems, like the ALPR System, use AI technology to optimize parking experiences, efficiency, and convenience. However, challenges such as data privacy, security, integration with existing systems, scalability, accuracy of AI models, and user acceptance can affect performance. Despite these challenges, AI can transform parking management, increasing sustainability, efficiency, and convenience.

Research Background

Smart parking systems are revolutionizing urban mobility and parking management in advanced countries like New York, London, Tokyo, and Singapore. These systems use advanced technologies like AI, IoT, and data analytics to detect parking availability in real-time, reducing traffic congestion and stress. They are integrated with other smart city initiatives, such as intelligent transportation systems and urban planning strategies. The economic benefits of smart parking systems include increased revenue for municipalities and parking operators, cost savings, and improved resource allocation. However, challenges such as privacy concerns, interoperability issues, and regulatory barriers persist.

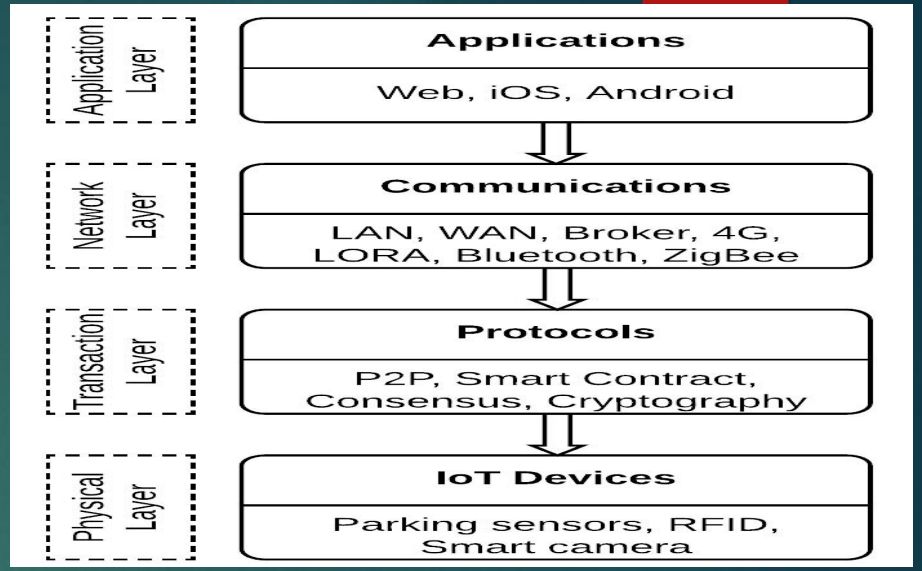
Emerging countries are adopting smart parking systems to address rapid urbanization, inadequate infrastructure, and increasing vehicular congestion. These systems provide real-time parking availability information, improving traffic flow and enhancing urban life. However, challenges persist in implementing smart parking systems, including limited financial resources, regulatory barriers, and technological constraints. Collaboration among government agencies, industry stakeholders, and community organizations is needed to ensure equitable and sustainable deployment of smart parking solutions across diverse urban contexts.

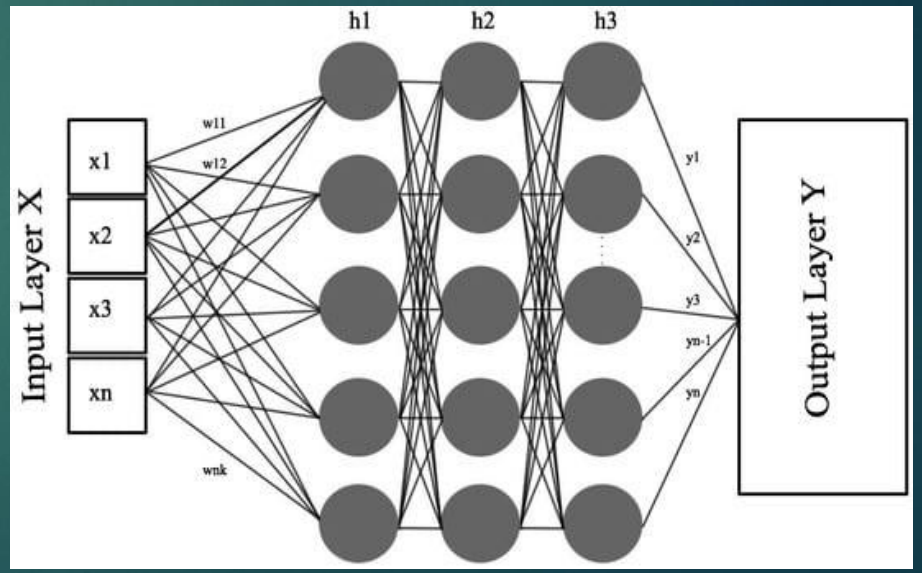
The global smart parking system market is growing due to urbanization, vehicle ownership, and the need for efficient parking management solutions. Key players include Parkmobile, Siemens AG, Streetline, IPS Group, and Park Assist. The market is expected to reach USD 7.8 billion by 2027, driven by factors such as increasing urbanization, rising vehicle ownership, and the need for efficient parking management in congested areas.

Methodology

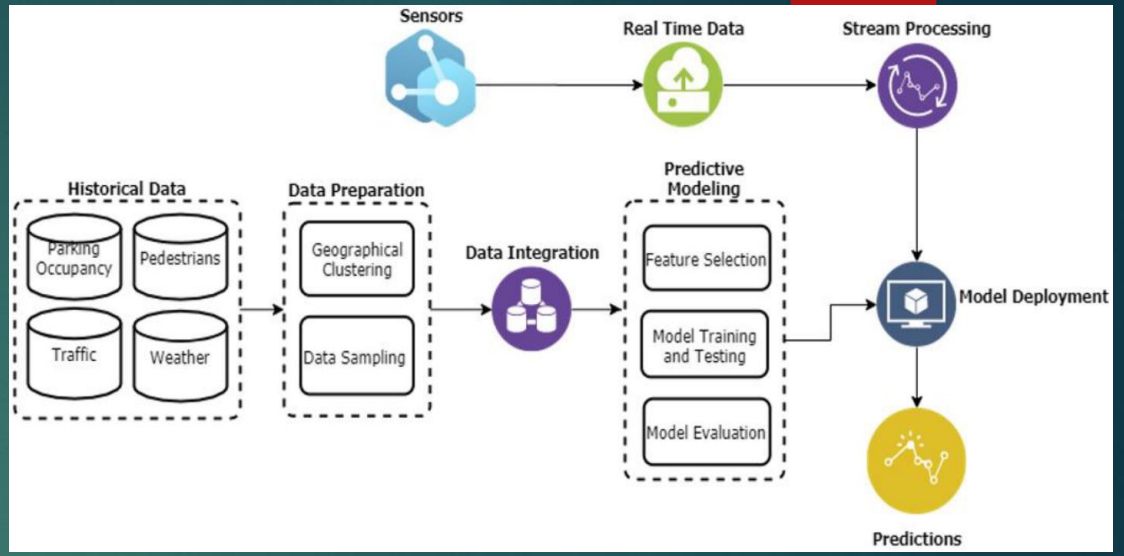
Intelligent parking systems are gaining popularity for their ability to improve urban efficiency and foster smart cities. These systems simplify parking systems, reduce traffic, and enhance customer satisfaction. Two trends in parking designs are IoT-based and visual-algorithm-based techniques. The proposed intelligent parking system uses security camera footage, big data, predictive analytics, behavioral analytics, and optimization algorithms to optimize parking systems. A blockchain-based integrated vehicle parking system involves a parking service provider, blockchain network, and user, with transactions taking place through parking sensors and smart contracts. Transactions are verified using a consensus process, updating local blocks and ensuring secure and efficient parking.

The proposed blockchain-based integrated intelligent parking system uses a layered architecture with four levels: application, network, transaction, and physical. It focuses on big data collection, including license plate numbers, vehicle size, parking duration, payment information, real-time occupancy, environmental data, and user feedback. Data analysis and machine learning can predict parking availability, forecast demand, and implement dynamic pricing models. Challenges include data privacy, security, and data accuracy. Implementing big data solutions requires infrastructure, data processing tools, and AI models. Techniques include data mining, predictive analytics, machine learning, neural networks, GIS, time series analysis, cluster analysis, and anomaly detection.

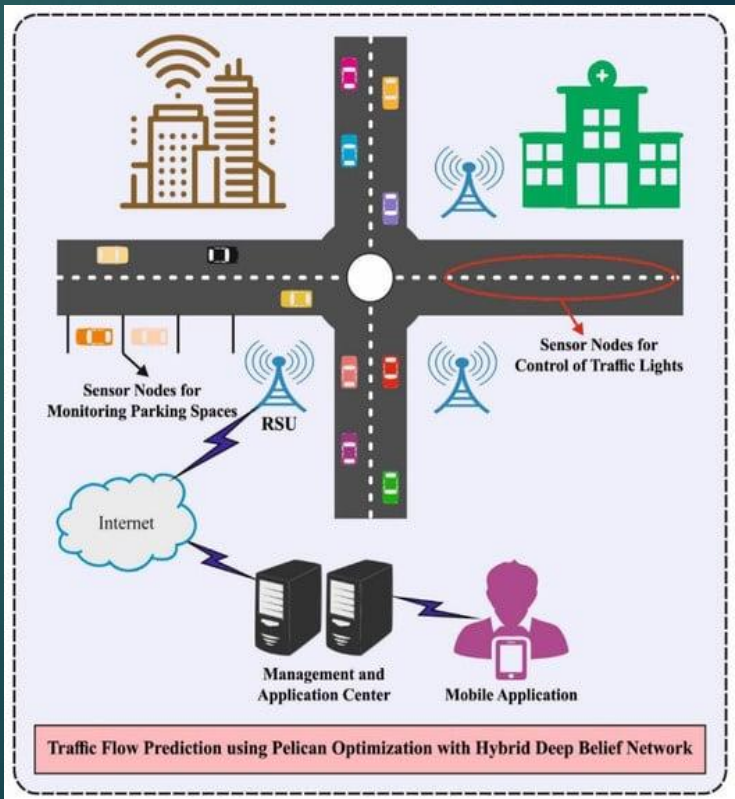


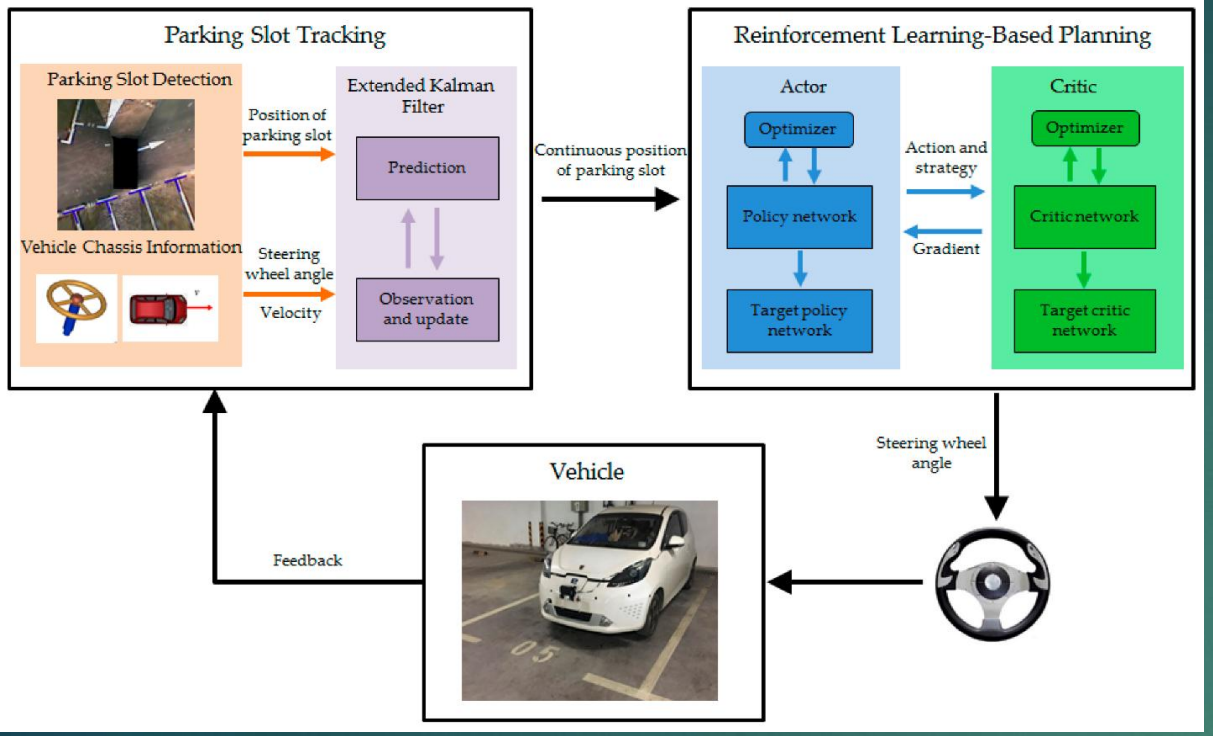


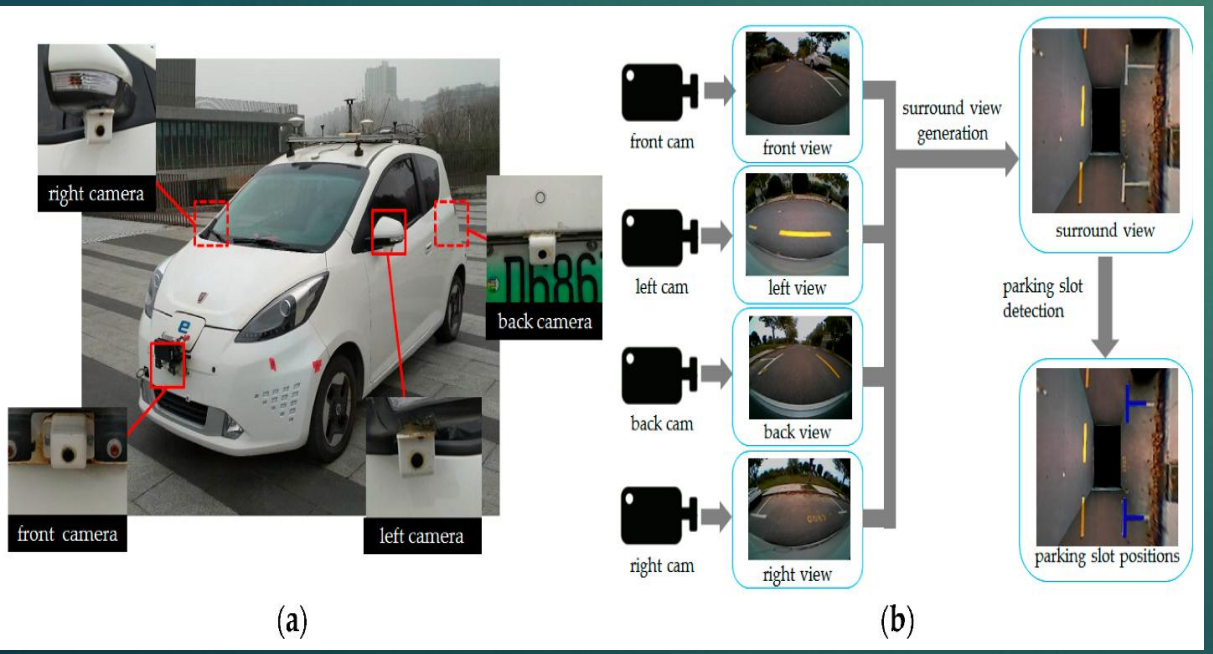
Data Type	Source	Purpose
License Plate Number	License Plate Recognition (LPR) Cameras	Identify and track vehicles for parking availability and violation detection.
Vehicle Size	LPR Cameras / Manual Input	Optimize parking space allocation based on vehicle size.
Parking Duration	Entry and Exit Timestamps	Analyze parking patterns and adjust pricing or availability accordingly.
Payment Information	Mobile App / Payment Kiosks	Simplify the payment process and integrate it with digital wallets.
Real-time Occupancy	Sensor Data / Camera Footage	Provide users and management with real-time parking availability.
Historical Occupancy	Database Records	Predict future parking demand using historical data.
Environmental Data	Weather Stations	Adjust parking recommendations based on weather conditions.
User Feedback	Mobile App / Website	Improve service quality by addressing user-reported issues and suggestions.



Melbourne City uses sensors to analyze parking events, enabling predictive analysis, automated enforcement, and improved compliance rates. License plate recognition technology detects violations and alerts security. Big data platforms like Apache Hadoop and Google BigQuery streamline data processing. AI is revolutionizing parking management systems, improving user experience, and enabling autonomous driving and fraud detection.

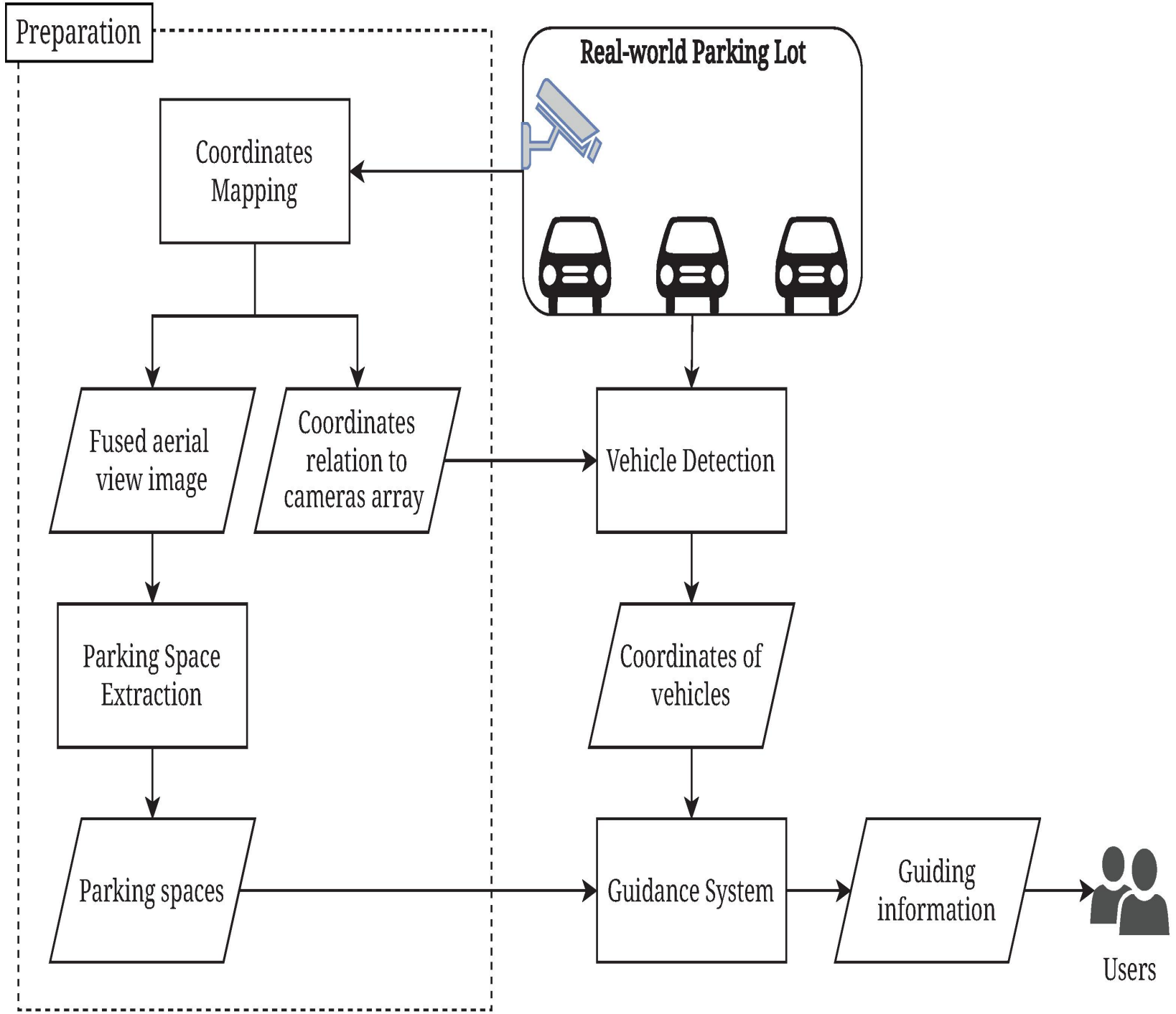


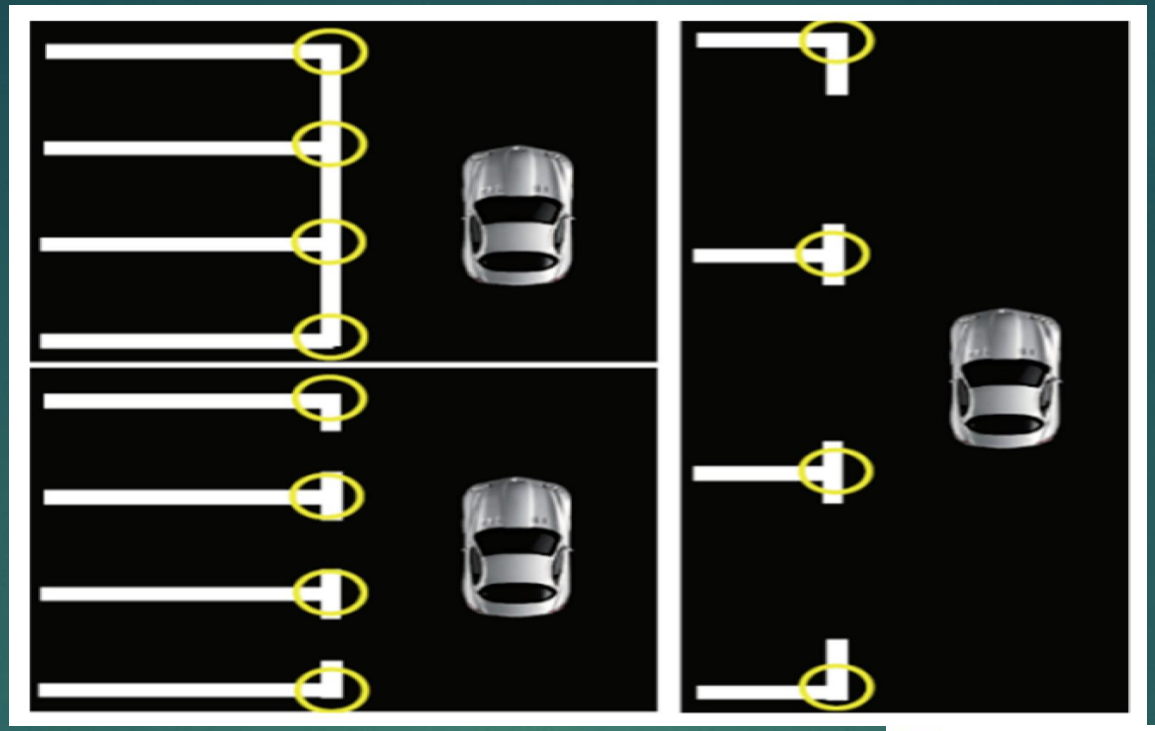


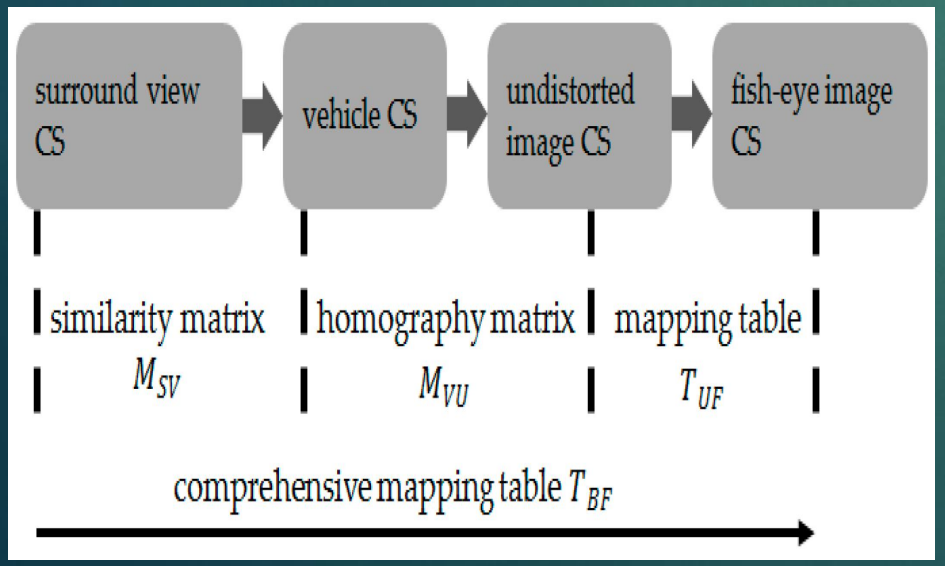


Artificial intelligence (AI) has revolutionized urban parking management by enabling real-time monitoring and efficient management of spaces. It uses image recognition and sensor technology to accurately identify space utilization, reducing time and resource waste. AI can also perform intelligent payment functions, such as license plate recognition and mobile payment, eliminating manual operations. It can predict parking needs, schedule resources in advance, and optimize allocation, reducing traffic congestion and safety hazards. AI also promotes sustainable urban development, reduces vehicle emissions, and promotes green transportation. It can also increase parking lot revenue and reduce management costs, making its application prospects in smart parking increasingly broader.

Model Architecture



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fish-eye image CS
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homography matrix
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mapping table
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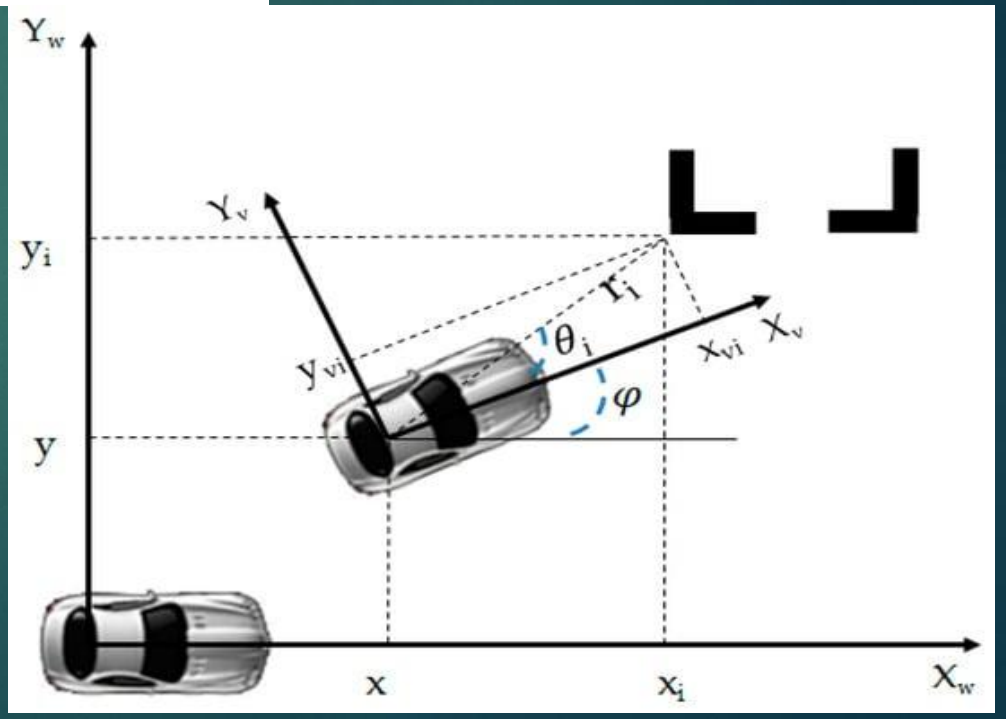
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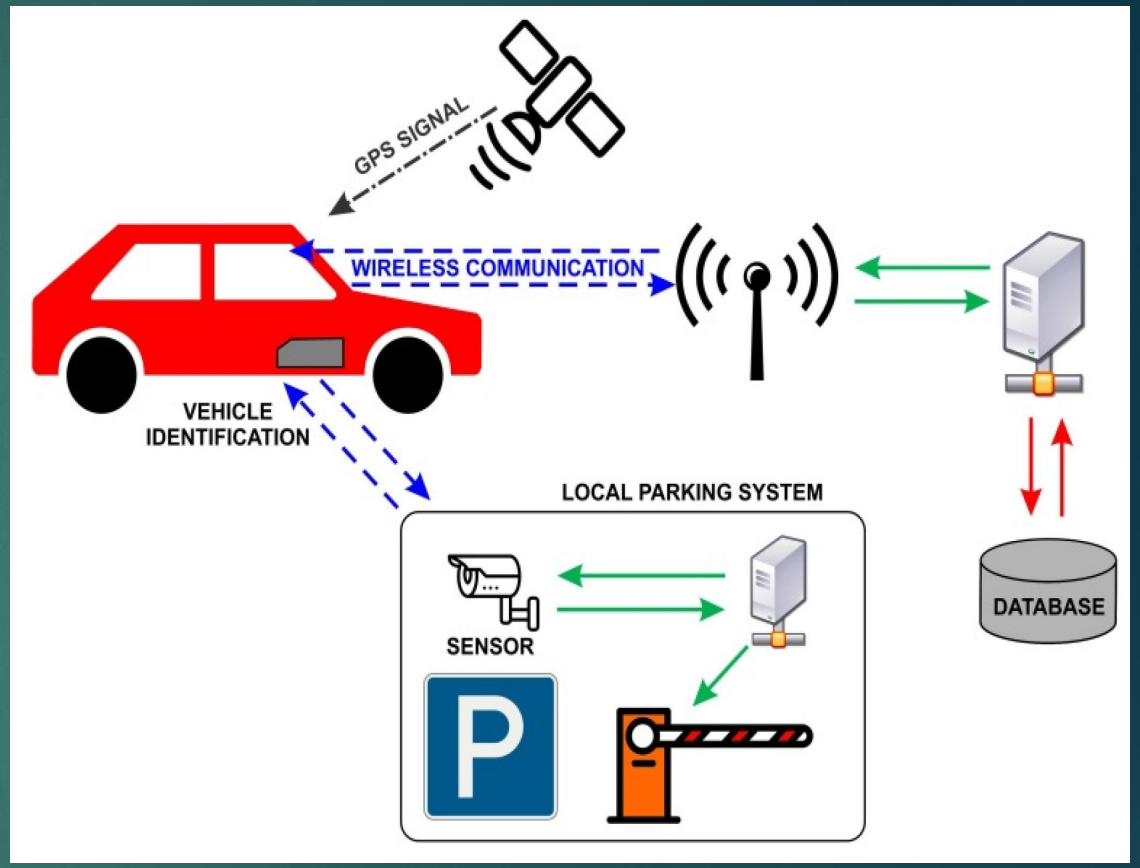
Artificial intelligence (AI) is crucial in solving smart parking problems by utilizing deep learning, image recognition, and big data analysis. These technologies help in efficient management and optimal utilization of parking spaces. AI can monitor usage in real-time, identify vacant spaces, and predict traffic flow and parking demand. It can also automate payment and management, ensuring safety and convenience. However, without Standard Positioning Service (SPS), the accuracy of positioning information can drop, leading to inaccurate parking space identification and navigation route deviations. Without SPS, the performance and effectiveness of smart parking systems may be severely affected. Therefore, AI is essential for the efficient operation and accuracy of smart parking systems.



The Challenges and Opportunities of SPS

Smart Parking Solutions (SPS) are a technology that aims to improve traffic flow, safety, and efficiency in transportation. However, challenges include design, implementation, operation, costs, heterogeneity among devices, meta-data collection, storage, transfer, recall, and analysis, security of information, preservation of city environment and resources, population growth, and transportation system failure recovery mechanisms in case of natural disasters. Opportunities for SPS include integrating IoT technology, mobile apps, AI, machine learning algorithms, sustainability, seamless integration with other smart city initiatives, and social and community engagement. To overcome these challenges, careful planning, robust testing, and collaboration between stakeholders are needed. AI can help tackle pressing challenges in developing countries, such as the scarcity of skilled professionals capable of harnessing AI's power. Developed countries should support each other in areas such as AI and SPS, promoting free trade and ensuring security and safety in development.

Conclusion

This study explores smart parking systems (SPS) in urban areas due to reduced parking spaces and increased traffic congestion. The research identifies twelve main SPS approaches and their advantages and disadvantages. The study also discusses various smart parking sensors and their usage in different situations. The research suggests multi-approach SPS will be predominant in smart cities, with a smartphone app as the user interface. Sensors will be chosen based on ease of installation, privacy, sensing technique, and sensor coverage area. Wireless communication protocols will be prioritized for data security. The study provides a platform for users to address potential issues and provide solutions, ensuring convenience and convenience for those struggling with daily routines.

Recommendation Recommendation

Smart parking systems are designed to improve efficiency in finding and managing parking spaces. One such system is U-Park, a user-centric system for Electric Shared Micromobility Services (ESMS), which uses historical mobility data, trip trajectory, and parking space availability to provide personalized recommendations. The system can predict a user's destination with high accuracy and recommend the best parking station based on predicted spaces. It also incorporates a blockchain-empowered module for safety and transparency in transactions.

IoT solutions, which combine sensors and software, can help drivers find parking spots quickly and manage compliance. They can be applied in various industries to improve efficiency, productivity, and decision-making processes. IoT solutions are pivotal in enabling smart cities, homes, and industries by connecting physical objects to the internet.

Parking planning is a critical component of urban development and transportation infrastructure, involving strategic design and management of parking spaces to ensure efficient use and accommodate the needs of an area. Effective parking planning can lead to improved urban mobility, reduced congestion, and enhanced safety for drivers and pedestrians.

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