Problem Statement

“PS-13 Vehicle Movement Analysis and Insight Generation in a College Campus using Edge AI”

This problem statement addresses the complex challenge of efficiently managing vehicle traffic and parking within a college campus environment using advanced Edge AI technologies. The core objectives are to enhance campus security, optimize parking resource utilization, and generate actionable insights for facility management. The solution aims to leverage edge computing infrastructure to process data near the source, reducing latency and enabling real-time analysis and decision-making at the campus level.

The system utilizes state-of-the-art computer vision and image processing techniques to capture and analyze vehicle images and license plates. This involves implementing robust image recognition algorithms capable of operating in various lighting and weather conditions. The solution must handle continuous streams of image data from multiple entry points, processing this information in real-time to make instant decisions on vehicle authentication and parking allocation. Advanced machine learning models are required to identify and analyze vehicle movement patterns, predict peak times, and optimize parking allocations based on historical and real-time data.

Unique Idea Brief (Solution)

Leveraging Edge AI technologies, this innovative system optimizes vehicle traffic and parking management within college campuses. By processing data in real-time at the edge, the system enhances campus security, maximizes parking resource utilization, and provides actionable insights for facility management.

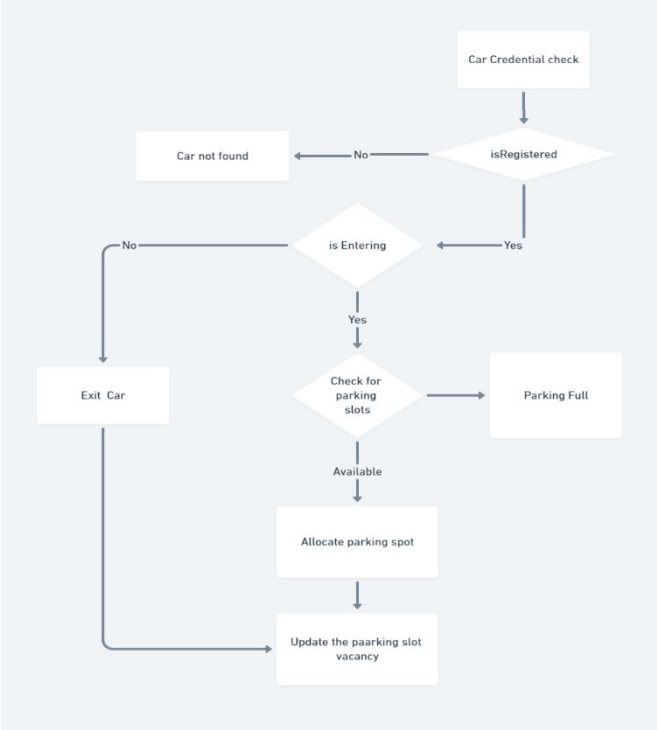
- Computer vision and image processing for vehicle image and license plate analysis
- Robust image recognition algorithms for accurate authentication in varying conditions
- Real-time processing of image data from multiple entry points for instant decisions
- Advanced machine learning models for predicting peak times and optimizing parking allocations based on historical and real-time data.

This cutting-edge solution transforms campus parking management, making it more efficient, secure, and data-driven.

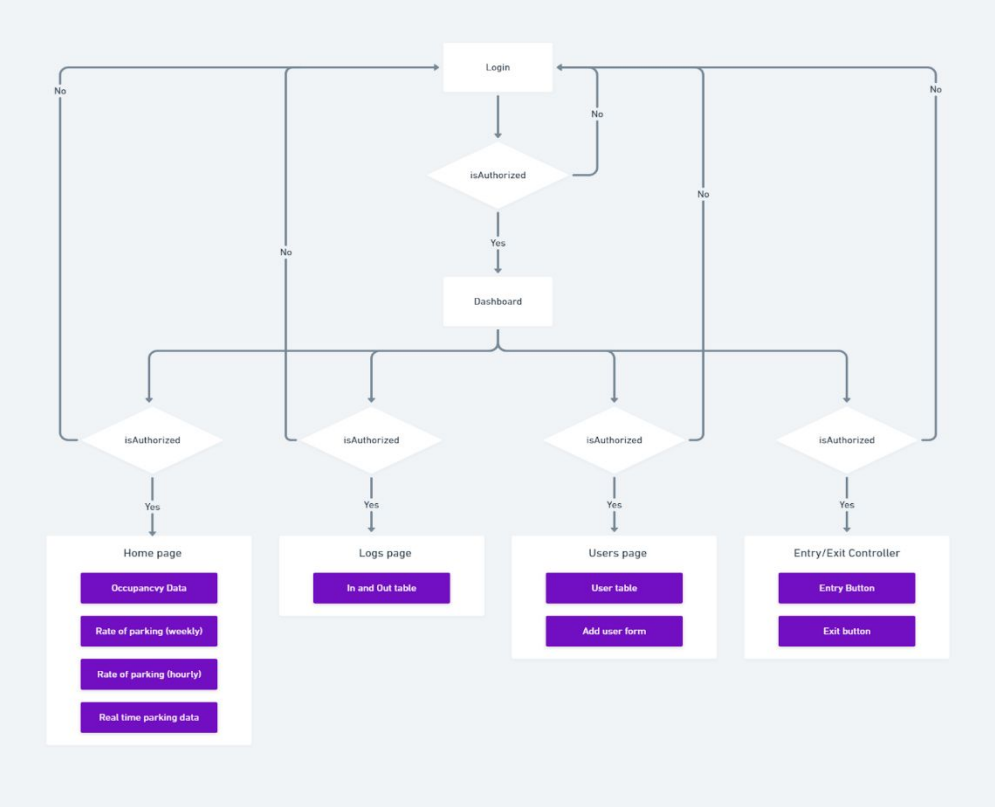
Features Offered

- Efficient Parking Space Allocation: Optimizes parking space usage to reduce congestion and improve user experience.
- Multi-Level User Authorization: Implements a secure authorization system to control access to the parking area.
- Real-Time Verification Process: Verifies user credentials in real-time to ensure secure parking transactions.
- Real-Time Data Analysis: Provides instant insights into parking space usage and availability.
- Historical Data Analysis: Offers in-depth analysis of past parking trends and patterns to inform decision-making.

Process flow



Architecture Diagram



Technologies used

The Vehicle Management System is a comprehensive solution that leverages a combination of cutting-edge technologies to provide real-time parking information and analytics.

- Database MongoDB serves as the primary database, storing vehicle information, parking records, and user details. Its flexible document-based structure enables efficient storage and retrieval of complex data.
- Backend Express.js acts as the backend framework, facilitating communication between the frontend and Node.js server. It handles routing, middleware integration, and API endpoints. Node.js functions as the server-side runtime environment, managing data transmission, processing queries, and backend logic.
- Frontend React.js powers the dynamic and responsive user interface, providing real-time parking information, analytics, and content to users and administrators.
- AI and Analytics Python is utilized for interfacing with the AI model, processing image data, and performing real-time analysis of parking slot occupancy. The AI model, built using scikit-learn, is a machine learning classifier that predicts parking spot status in real-time. Scikit-learn's comprehensive tools enable data preprocessing, model selection, and evaluation, allowing for experimentation with different classification algorithms.

Team members and contribution:

Project Team Members

Ishita Jain: Team Lead
Shreedhar Joshi: Team Member
Harsh Jajal: Team Member
Nishit Shetty: Team Member

Contribution:
Ishita Jain: Led research efforts on dataset selection and curation, and designed and developed the Graphical User Interface (GUI) for the software application.
Shreedhar Joshi: Implemented core business logic and handled server-side development tasks, successfully integrating the machine learning model with the server infrastructure.
Harsh Jajal: Conducted in-depth research on the machine learning model, exploring and testing various requirements to ensure project feasibility and success.
Nishit Shetty: Focused on developing the logic for generating actionable insights and was responsible for maintaining comprehensive project documentation, ensuring transparency and knowledge sharing among team members.

Conclusion

This project successfully developed a comprehensive system for vehicle movement analysis, parking occupancy monitoring, and vehicle matching using Edge AI and the MERN stack. The system provides real-time insights that improve traffic management, optimize parking space utilization, and enhance campus security. The results demonstrate the effectiveness of using Edge AI for real-time data processing and analysis, highlighting its potential for broader applications. The project lays the foundation for future enhancements, offering a scalable and adaptable solution for various environments.