RoadMind- AI-Enabled Platform for Adaptive Traffic Control

A PROJECT REPORT

Submitted by,

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Under the guidance of,

Dr. Marimuthu K
Professor

in partial fulfillment for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

COMPUTER SCIENCE AND TECHNOLOGY

At

GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

PRESIDENCY UNIVERSITY

BENGALURU

MAY 2025

SCHOOL OF COMPUTER SCIENCE ENGINEERING

CERTIFICATE

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We have not submitted the matter presented in this report anywhere for the award of any other Degree.

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ABSTRACT

The "Traffic Forecasting for Intelligent Transportation System based on Machine Learning" initiative offers a holistic, intelligent solution to counter the mounting intricacies of metropolitan traffic congestion and parking space management. As cities expand and vehicle density becomes higher, conventional traffic systems tend to lack dynamic adaptability to meet contemporary mobility needs. This project utilizes the capabilities of machine learning algorithms, real-time data analysis, and computer vision technology to create an intelligent transportation system able to predict traffic situations and optimize parking facilities with efficient use of resources.

The system framework is divided into two major modules—Admin Module and User Module—each designed to play distinct roles in traffic and parking management. The Admin Module equips administrators to control the backend functions of the platform, including logging in securely, adding and modifying parking slot details, tracking booking requests, and accepting or rejecting user requests depending on current availability. This centralized control not only guarantees accuracy of data but also simplifies the workflow of maintaining an updated parking ecosystem.

The User Module provides a user-oriented experience, facilitating registration, login, and utilization of features through which users can make decisions on their journey based on their choice. Users can see live availability of parking slots, reserve parking slots, and obtain predictive knowledge on upcoming traffic scenarios. The system is equipped with sophisticated features like prediction of parking slots through image data, traffic prediction, and live traffic feeds. These updates take into account critical variables such as emergency vehicle paths, vehicle traffic density, road clearance time, and overall traffic flow, offering users useful information to steer clear of delays and make wiser commuting decisions.

A key aspect of the system is the application of machine learning models that have been trained on past and current traffic patterns. Such models make accurate predictions of traffic congestion patterns and learn to improve even more over time based on feedback and new data inputs. The forecasting mechanism facilitates short-term predictions (e.g., minute-to-minute traffic conditions) as well as mid-term predictions for planning purposes, allowing for both instant responsiveness and long-term traffic planning strategy reinforcement.

One of the highlights of this project is the image-based parking slot detection system that utilizes computer vision to recognize empty and filled slots from surveillance camera streams. This method does away with costly physical sensors, providing a cost-efficient and scalable solution for intelligent parking facilities. It greatly improves the accuracy and real-time performance of the parking information rendered to users.

The integrated system fulfills not just the function of traffic congestion relief but also assists in the grand aim of creating smart cities. By integrating predictive analytics with user interactive features, the system promotes better resource utilization, eliminates wasteful travel time, and promotes environmentally friendly urban planning. The project is a strong demonstration of machine learning's applicability to real-world traffic and transportation system problems.

Overall, the project proposes a modular, smart, and real-time adaptive platform that tackles major aspects of urban transport—ranging from traffic flow prediction and parking spot prediction to emergency vehicle management and real-time updates. Focusing on scalability, user interaction, and data-based decision-making, the system is a progressive solution that improves urban mobility, curtails congestion, and offers a blueprint for future intelligent transport infrastructure

ACKNOWLEDGEMENT

First of all, we indebted to the **GOD ALMIGHTY** for giving me an opportunity to excel in our efforts to complete this project on time.

We express our sincere thanks to our respected dean **Dr. Md. Sameeruddin Khan**, Pro-VC, School of Engineering and Dean, School of Computer Science Engineering & Information Science, Presidency University for getting us permission to undergo the project.

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We would like to convey our gratitude and heartfelt thanks to the PIP4004 Capstone Project Coordinators **Dr. Sampath A K and Mr. Md Zia Ur Rahman,** department Project Coordinators "Dr . Manjula H M" and Git hub coordinator **Mr. Muthuraj.**

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CHAPTER-1
INTRODUCTION

In the 21st century, urbanization has proceeded at an unprecedented rate, resulting in a massive growth in the number of vehicles on city streets. With metropolitan areas still expanding, the pressure on available transportation infrastructure becomes more severe. The effects are far-reaching: traffic jams, longer commute times, more fuel consumption, more pollution, and increased frustration among commuters. Conventional traffic management systems, being generally based on fixed timetables and manual intervention, are not able to cope with the dynamic characteristics of contemporary traffic flows. Such old-fashioned approaches tend to be reactive instead of proactive, without the capacity to adapt to real-time situations or predict future circumstances.

In the midst of this emerging challenge, there is a pressing need for intelligent, adaptive, and scalable traffic management solutions. Intelligent Transportation Systems (ITS) seek to unite sophisticated technologies that monitor, examine, and administer traffic in real time. It is essential to such systems to have predictive function integrated into the system that aids decision-making as well as optimizing planning efficiency. Machine learning becomes a promising entry in this realm. By utilizing vast datasets and computer models, machine learning can detect hidden patterns of traffic behavior, anticipate congestion in advance, and yield actionable information for drivers as well as traffic authorities.

The present project, entitled "Roadmind-Ai enabled platform for adaptive traffic control," aims to respond to these critical urban mobility challenges. The main aim is to design an intelligent, data-based system not only forecasting traffic trends but also optimizing utilization of existing parking capacity. The system will be working on real-time traffic data inputs from sensors, GPS, and mobile apps integrated with past trend data to build machine learning models that can precisely forecast traffic movements and availability of parking spots.

One key component of the solution is the installation of an intelligent parking management module. Parking problems account for a large proportion of urban traffic congestion, with drivers spending considerable time looking for available spaces. This not only adds to traffic but also elevates emissions and stress levels. With predictive analytics built-in, the system is able to navigate drivers towards empty parking areas in real-time, lowering vehicle circulation while in search of a parking lot, hence lowering congestion.

The envisaged system intends to support two groups of users: administrators (such as traffic management agencies, city planners) and end-users (drivers, commuters). The system, in turn, for administrators, comes with a unified dashboard complete with functionality to analyze traffic trends, manage emergencies, and optimize the distribution of resources. For motorists, the mobile app interface provides real-time information on traffic flow, predicted travel times, recommended routes, and on-street parking supply. Furthermore, during emergency situations like accidents or roadblocks, traffic can be rerouted automatically and the concerned authorities notified, allowing for a prompt and concerted response.

Through combining machine learning with smart traffic and parking management, this project is a visionary solution to the high-level challenges of urban transportation in the present day. It prioritizes flexibility, scalability, and user-oriented design, with the goal of making cities habitable and travel more effective. Additionally, it supports overall sustainability objectives through minimizing idle time of cars and encouraging energy-efficient commuting. In the long term, these kinds of systems would set the stage for completely autonomous urban mobility systems, with technology and infrastructure hand-in-hand to provide more intelligent cities.

In summary, "Roadmind-Ai enabled platform for adaptive traffic control " is not just an engineering project—it is a step toward transforming how we drive and manage urban transport. By connecting real-time data, predictive insights, and smart decision-making, this project can change the way cities address traffic and mobility issues, ultimately enhancing quality of life for millions.

CHAPTER-2

LITERATURE SURVEY

2.1 Traffic Flow Prediction with Big Data

Y. Lv, Y. Duan, W. Kang, Z. Li, and F.-Y. Wang, "Traffic flow prediction with big data: A deep learning approach," IEEE Transactions on Intelligent Transportation Systems, vol. 16, no. 2, pp. 865–873, Apr. 2015.

This paper introduces a novel traffic flow prediction model based on stacked autoencoders, a deep learning architecture that effectively learns high-level spatiotemporal features from big traffic data. As compared to traditional statistical models such as ARIMA and machine learning models such as SVR, this deep learning model exhibits more robustness, accuracy, and flexibility in handling non-linear traffic behaviors. Real-world traffic data were utilized to validate the model, which showed a lot of promise in real-time traffic forecasting tasks, as well as the objective of improving intelligent transportation systems.

2.2 LSTM for Traffic Speed Prediction

X. Ma, Z. Tao, Y. Wang, H. Yu, and Y. Wang, "Long short-term memory neural network for traffic speed prediction using remote microwave sensor data," Transportation Research Part C: Emerging Technologies, vol. 54, pp. 187–197, May 2015.

In this work, the authors employ Long Short-Term Memory (LSTM) networks to learn and predict short-term traffic speeds from time-series data gathered by remote microwave sensors. LSTMs are very good at capturing long-range temporal dependencies, and the paper demonstrates that they outperform traditional feedforward neural networks and regression methods. The improved response time and accuracy of the model make it particularly well-suited for real-time traffic monitoring systems, an important part of the proposed project.

2.3 Spatio-temporal Residual Networks for Crowd Flow Prediction

J. Zhang, Y. Zheng, and D. Qi, "Deep spatio-temporal residual networks for citywide crowd flows prediction," in Proc. AAAI Conf. Artif. Intell., San Francisco, CA, USA, Feb. 2017, pp. 1655–1661.

This paper presents a deep residual network that exploits spatio-temporal dependencies for predicting crowd and traffic patterns at the city scale. The model incorporates convolutional layers, residual units, and external context modules to well represent complex urban traffic patterns. Experimental evaluations show that the model greatly outperforms baseline methods, especially under big-city-scale scenarios. Its architecture serves as a foundation for integrating spatial dynamics and temporal trends, which is applicable to traffic forecasting and parking slot prediction in this project.

2.4 Parking Slot Detection with Deep Learning

Y. Yuan, S. Zhou, and T. Yang, "Parking slot detection based on deep learning," in Proc. IEEE Int. Conf. Image Process. (ICIP), Phoenix, AZ, USA, Sep. 2016, pp. 1036–1040.

This paper proposes a convolutional neural network (CNN)-driven technique for detecting parking slots from CCTV images. The proposed model is robust in real-world environments such as low lighting or occlusion and thus can be applied in real-time environments in smart parking. Utilizing region-based CNNs benefits the system in marking parking slot edges effectively, enabling automated slot allocation and occupancy estimation, which supports the visual-based parking component of this project.

2.5 Real-time Traffic Prediction with SVM

M. Bui, H. Pham, and T. Nguyen, "Real-time traffic prediction using support vector machines," Int. J. Comput. Appl., vol. 178, no. 7, pp. 21–25, June 2019.

Support Vector Machines (SVM) are used in this paper to perform short-term traffic prediction using historical traffic data and current real-time traffic data. Data preprocessing and feature extraction are utilized by the authors to enhance the performance of the prediction. Though simpler than deep-learning methods, SVM is shown to be competitive in low-latency prediction and interpretable model spaces, making it a candidate to be considered in lightweight or edge-computing contexts. Evidence is put forward that makes the issue of providing hybrid or non-standard models in intelligent transport systems compelling, especially where computational feasibility is a concern

CHAPTER-3

RESEARCH GAPS OF EXISTING METHODS

Despite substantial progress in developing intelligent transportation systems (ITS), there remain multiple research challenges that need to be addressed to improve the efficiency, scalability, and adaptability of AI-based traffic management platforms such as *RoadMind*. The following sub-sections identify and elaborate on the major gaps in existing research that are critical for advancing real-world deployment and effectiveness.

3.1 Limited Real-Time Data Integration

Many existing traffic prediction systems rely predominantly on static or historical datasets that do not accurately reflect current traffic conditions. Although *RoadMind* incorporates real-time traffic updates, challenges remain in integrating **diverse live data streams** from GPS sensors, CCTV footage, IoT devices, and weather systems in a synchronized and low-latency manner.

Further research is required in:

- Real-time data ingestion pipelines.
- Low-latency model updating mechanisms.
- Noise filtering and data quality assurance in live sensor inputs.

3.2 Inadequate Emergency Vehicle Recognition and Response

Emergency vehicle prioritization is critical in urban traffic systems, but many current models use rule-based logic or are insufficiently trained on dynamic emergency scenarios. AI models must be able to accurately detect **audio and visual cues** under diverse conditions and update signal controls in real time.

Research needs include:

- Deep learning models for siren and light detection in noisy environments.
- Real-time rerouting algorithms for emergency corridors.
- Integration of emergency vehicle detection into signal control mechanisms.

3.3 Scalability and Citywide Implementation Challenges

Many AI-based traffic systems are **pilot-tested in limited urban zones** and fail to scale due to differences in infrastructure, data availability, or regional traffic behavior. Scalability issues also stem from the computational cost of training and deploying large models across distributed locations.

Key gaps:

- Scalable, distributed ML models (e.g., federated learning).
- Real-time model synchronization across city zones.
- Geographic model adaptability using transfer learning.

3.4 Insufficient Modeling of User Behavior and Human Factors

Most ITS frameworks model traffic as purely **vehicle-centric**, neglecting the unpredictability introduced by human factors such as driver aggression, pedestrian movement, or cultural differences in traffic compliance. Modeling these human variables is critical for **holistic urban mobility solutions**.

Needed research includes:

- AI-based behavior prediction models.
- Simulation environments incorporating diverse driver/pedestrian behaviors.
- Social computing integration for human-in-the-loop traffic systems.

3.5 Parking Prediction Integration with Traffic Systems

While *RoadMind* supports parking prediction and booking, current systems typically treat parking and traffic management as isolated modules. Effective integration of **parking availability data with traffic routing** remains underexplored, which limits congestion mitigation.

Research avenues:

- Integrated frameworks combining real-time traffic and parking analytics.

- Prediction models for parking demand based on road conditions.
- Feedback systems from parking data to route optimization engines.

3.6 Limited Use of Explainable Artificial Intelligence (XAI)

AI models, especially deep learning networks, are often **black boxes**, making their decisions hard to interpret. In high-stakes applications like traffic control, explainability is essential for transparency, public trust, and debugging of unexpected behavior.

Research directions:

- Interpretable model architectures for traffic prediction.
- Visual dashboards for decision traceability.
- Human-readable model explanations for system administrators.

3.7 Data Privacy and Ethical Concerns

Real-time vehicle tracking, user location data, and facial recognition from surveillance systems can lead to **ethical and privacy violations** if not managed properly. Most ITS projects do not integrate **privacy-preserving techniques** or data anonymization practices.

Essential research areas:

- Secure and privacy-aware data handling frameworks.
- Application of federated and encrypted learning models.
- Ethical guidelines for ITS data collection and use.

3.8 Resilience to System Failures and Anomalies

Many traffic control systems are vulnerable to **hardware failures, cyberattacks, and inaccurate predictions**, yet fail to implement fallback mechanisms. ITS platforms like *RoadMind* must be **resilient and fault-tolerant** to ensure uninterrupted service.

Gaps in this domain:

- Redundant system design and fail-safe mechanisms.

- AI robustness against adversarial data or signal loss.
- Resilient communication protocols between components.

Conclusion to Research Gaps

While *RoadMind* demonstrates a forward-thinking approach by integrating machine learning, real-time traffic monitoring, and smart parking management, addressing these **critical research gaps** is essential for advancing the capabilities and reliability of intelligent transportation systems. Bridging these areas will facilitate more **adaptive, scalable, and ethical ITS platforms**, enhancing urban transportation and contributing to the foundation of future smart cities.

CHAPTER-4
OBJECTIVES

4.1 Input Design

Input design is the central part of any information system since it defines how the data is collected, verified, and entered into the system to be processed. Effective input design ensures data integrity, security, and ease, hence directly influencing the efficiency and success of the system. The aim is to develop a straightforward, reliable interface that reduces errors, redundancy, and impedes data entry into the system.

4.1.1 Input Design Objectives

4.1.1.1 To create data entry and input procedures:

Input design begins with establishing the input procedures for collecting and entering data. The procedures may be keyboard entry, barcode scan, or data capture from sensors and IoT devices. Proper planning ensures that the process is logical, systematic, and efficient. A well-developed input process reduces the possibility of human error and enhances the integrity of data.

4.1.1.2 To reduce input volume

Decreasing the volume of data that needs to be manually entered saves time, and also reduces the scope for error. Techniques such as auto-fill, drop-down options, default options, and real-time integration of data from pre-existing databases can be utilized to reduce unnecessary input.

4.1.1.3 To produce source documents for data capture or to construct alternative forms of data capture:

Source documents are the point of entry of the data and may be in the form of forms, web-based data entry screens, or phone interfaces. They must be logically and clearly designed so that they can guide users through the process of data capture efficiently. Alternatively, attempts should also be made to capture data by utilizing QR code, RFID, and voice depending on what the application entails.

4.1.1.4 Creating input data records, data entry screens, user interface screens, etc.

Data entry screens should be easy to understand and user-friendly. Factors like layout, field sequence, tab sequence, font readability, and navigation ease are critical in order to improve user interaction. Screens need to be designed in a manner that minimizes user confusion and guides them through each step easily.

4.1.1.5 To put validation checks to use and formulate effective input controls

Input validation makes sure the input data abides by the pre-defined standard and format. A few common examples of input validation include verifying numeric fields, date format, range validation, and mandatory field validation. Confirmation messages, warning windows, and correction facilities for input controls also help in evading and correcting errors during the time of inputting data.

A good input design is not only efficient in the process of data capture but also essential in system security and performance. In intelligent systems, such as traffic prediction systems, good input design is essential to process data from various sources like GPS devices, sensors, and mobile apps in real time.

4.2 Output Design

Output design is as important to the operation and success of any information system as input or data. Output quality, or how information is presented to users, affects decision-making, usability, and user satisfaction. It transforms raw processed data into meaningful insights that enable business goals and user needs.

4.2.1 Objectives of Output Design

4.2.1.1 In order to develop output design for the specific intent and to prevent the creation of unwanted output:

The main goal is to ensure that the output is beneficial to user and organizational requirements. It should be actionable, specific, and free from extraneous or redundant data. Decision quality and user interest are improved through goal-oriented and uncluttered output design.

4.2.1.2 To develop the output design to the end user's specifications:

Understanding user needs is critical to effective output design. Designers must consider who will use the output, what they need, and how they will use and react to it. Outputs must be created for multiple user groups, such as system administrators, travelers, or urban planners, each of whom may require different forms or levels of detail.

4.2.1.3 So that it provides the appropriate level of output:

Output should not be too sparse or too dense. Providing the right amount of information allows users to focus on what is relevant without leaving out relevant information. For instance, a traffic prediction system should display traffic density, travel time estimation, and alerts, but not overwhelm users with irrelevant technical details.

4.2.1.4 To mold output in appropriate shape and deliver it to the right individual

Outputs can be presented in different formats—visual dashboards, textual reports, alarms, charts, or even vocal alerts. Deciding on the proper format by context and preference increases understanding and usability. In addition, it is important to make sure this output is provided to the end-user (in the form of email, SMS, app notification, etc.) for timely decision-making.

4.2.1.5 In order to provide the output on time to take good decisions

Timeliness is of the essence. Delayed outputs may lead to missed opportunities or poor decisions. In applications like Intelligent Transportation Systems, outputs like congestion notifications or parking space availability must be delivered in real-time or near real-time to be effective.

A good output design ensures that information is not only correct and complete but also aesthetically pleasing and readily accessible. It enables better planning, monitoring, and decision-making by converting system outputs into useful forms for end-users. In traffic prediction and intelligent parking systems, timely and suitable outputs have a direct influence on the ability of the system to reduce congestion and improve user satisfaction.

CHAPTER-5

PROPOSED METHODOLOGY

The suggested system brings in a strong, smart solution that blends real-time traffic prediction with optimized parking slot utilization, facilitated through the integration of machine learning and real-time sensor data. Against the backdrop of increasing urban traffic and dwindling parking space, the system represents a crucial utility for facilitating smarter, safer, and more efficient transportation infrastructure.

The framework is developed upon two foundational modules: the Admin Module and the User Module. Collectively, these modules allow all users—whether they be system administrators or commuters—engage with the platform to manage parking logistics or derive benefit from real-time, precise mobility solutions.

5.1 Admin Module

The Admin Module is the backend control room of the system. It provides administrators with the capability to conduct crucial tasks like:

Secure Login: The backend system can be accessed by only approved staff using secure login details.

Parking Slot Management: Admins can insert new parking slots, modify slot availability, and allocate a unique identifier to each slot.

Monitor and Manage Bookings: All user booking requests are made visible to the admin, who can accept or deny bookings depending on the real-time availability and demand.

Efficient Management: Centralized control of slot information and booking history enhances operating efficiency, minimizes conflicts, and adds to the system's reliability.

With these features, the Admin Module guarantees real-time response and facilitates efficient management of the city's parking assets.

5.2 User Module

The User Module is designed to provide a seamless, feature-packed experience to end users. Main features of this module are:

User Registration and Login: Users can securely register and login to access the features of the system.

Real-Time Parking Slot Access: Users are able to search for available parking slots and see detailed information like location, availability, and timing.

Slot Booking: Users can book and reserve parking slots according to their needs and preferences.

Booking History: The system provides users with their past and future bookings, enhancing convenience and record-keeping.

Image-Based Parking Prediction: The system employs image processing and machine learning to forecast parking availability by evaluating real-time visual input from sensors or cameras.

Traffic Forecast: The platform forecasts future traffic conditions based on current and past traffic data, allowing users to better plan their trip.

Real-Time Traffic Updates: Users get real-time traffic updates such as road congestion, paths of emergency vehicles, vehicle density, and clearance status.

Emergency Vehicle Awareness: The system gives priority to emergency vehicle paths and provides rerouting alternatives to general traffic for safety and reduction of delays.

5.3 Real-Time Insights

The system provides extremely accurate and real-time observation of traffic and parking conditions. This assists admins as well as users in making a well-informed decision—be it rerouting in rush hour or finding the closest available parking spot. With the processing of camera images, sensor inputs, and user behavior, the system provides the most apt and recent information at any given time.

5.4 Increased Efficiency

Machine learning algorithms are utilized to efficiently allocate parking spots and minimize search time for clients. This not only reduces idle time for cars but also minimizes congestion around hotspots. Furthermore, administrators enjoy the comfort of a less complex booking management system with ease of slot approval and data management.

5.5 Improved Emergency Handling

One of the key features of the system is its capacity to handle and prioritize emergency situations. Upon detecting emergency vehicles, the system diverts other cars away from their route and offers estimated road clearing times. This enhances emergency response times and avoids road congestion created by spontaneous events.

5.6 User-Friendly Experience

The interface is designed with accessibility in mind. Navigation is uncluttered, and access to all facilities—slot searching, booking, traffic information—are at hand through a few mouse clicks. Thus, users across backgrounds can confidently use the system and maximize the functionality without hurdles.

5.7 Data-Driven Learning and Adaptability

One of the strongest assets of the system is its ability to continuously learn. As more data are fed into the machine learning algorithms over time, they improve their predictions and adjust to changing traffic patterns. Such a self-enhancing system design makes it scalable, sustainable, and extremely reliable for long-term deployment in expanding cities..

Work Flow of Proposed system:

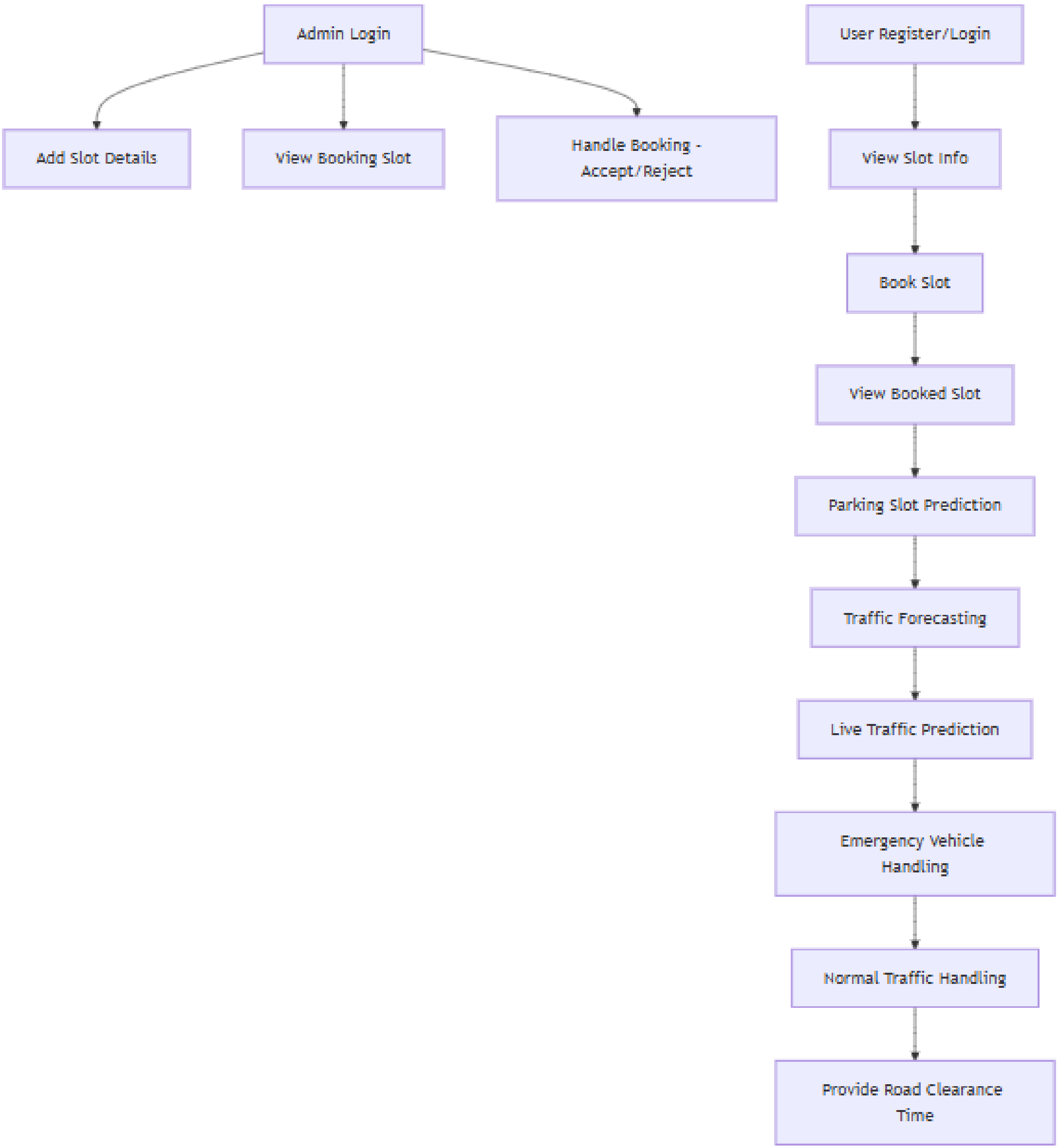

Fig.1 work flow of proposed system

CHAPTER-6
SYSTEM DESIGN & IMPLEMENTATION

The suggested system, RoadMind, is segregated into two main functional modules: Admin Module and User Module. Both modules have a specific set of tasks to guarantee smooth operation, effective management, and improved user experience.

6.1 Admin Module

The Admin Module is intended for administrators to handle parking infrastructure and user requests. It offers the backend control panel necessary to maintain the system updated, transparent, and running. The features of the Admin Module are:

6.1.1 Admin Login

The admin shall be able to log in securely with valid credentials.

Security measures like password hashing and role-based access control shall be enforced to avoid unauthorized access.

The login session must be encrypted and timed in order to guard sensitive administrative information.

6.1.2 Add Slot Details

Admins must have the ability to add new parking slots, such as slot ID, location, capacity, and status of availability.

This module must accommodate dynamic entry of slots by zones or buildings, with tagging of metadata to facilitate easy recovery.

Real-time synchronization guarantees newly added slots show up immediately on the user interface.

6.1.3 View Booking Slots

The system allows the admin to see all pending, active, and historical user booking requests.

A filterable and sort-able interface facilitates rapid date, time, user ID, or location filtering.

A new booking notification mechanism is implemented.

6.1.4 Manage Booking Requests (Accept/Reject)

Booking requests can be approved or rejected by admins depending on existing slot availability.

The system shall automatically notify users of booking confirmation or rejection.

In the event of rejection, proposals for alternative slots can be shown using the slot prediction system.

This feature promotes equitable allocation and prevents overbooking.

6.2 User Module

The User Module is the client-facing component of the system that is meant to serve end-users—vehicle owners and commuters—offering a smooth interface for parking slot booking and access to traffic-related functionality.

6.2.1 User Registration and Login

The system will enable new users to register by providing the required details like name, vehicle number, email address, and contact number.

Revisiting users will be enabled to log in with secure credentials.

Email verification and CAPTCHA can be included for bot prevention and legitimacy.

6.2.2 View Slot Information

Users are able to browse through available parking slots, screen them by location, availability, and price where applicable.

The interface gives real-time slot availability, directly retrieved from the admin's updates or the prediction model.

Users can see slots through an interactive map or list view.

6.2.3 Book Parking Slot

Users will be able to book a free parking slot by entering date, time, and parking duration.

A confirmation system will alert users on successful booking.

Integration with digital payment gateways can be included for paid parking lots.

6.2.4 View Booked Slots

Users can view booking history, previous and present bookings, and details such as duration, location, and status.

Users can also cancel bookings within an allowable time period, as per system policy.

6.3 Advanced Functionalities in User Module

In addition to core booking features, the system provides smart features through machine learning and computer vision capabilities to raise traffic awareness and optimize parking.

6.3.1 Parking Slot Prediction (via API Image)

The system utilizes image-based APIs to estimate the parking slot availability by processing real-time camera feed.

This computer vision model inspects visual data to establish free or taken slots and dynamically refreshes the availability.

It is particularly valuable in busy areas where slot turnover is high.

6.3.2 Traffic Prediction

Machine learning models are applied to predict future traffic patterns using historical data, weather, day-of-week behavior, and event information.

Users have access to forecasts for certain routes or regions, which assist them in planning their journey better.

LSTM or ARIMA algorithms are incorporated for precise time-series forecasting.

6.3.3 Live Traffic Prediction

Traffic updates in real-time are based on up-to-date data such as vehicle traffic, sensor information, and image processing from security cameras.

Live feed is analyzed through AI models to determine the level of road congestion.

The system notifies drivers of possible delays, congestion points, and diverted routes.

6.3.4 Emergency Vehicle & Clearance Management

The platform identifies emergency vehicles based on audio (siren detection) as well as video streams (blink lights).

Upon identification, the system gives highest priority to clearing the traffic route ahead of the emergency vehicle with signal control logic.

Road clearing times are estimated to minimize delay in rerouting for ambulances, fire engines, or police cars.

6.4 Data Flow Diagram

A Data Flow Diagram (DFD) is a traditional way to visualize the information flows within a system. A neat and clear DFD can depict a good amount of the system requirements graphically. It can be manual, automated, or a combination of both. It shows how information enters and leaves the system, what changes the information and where information is stored. The purpose of a DFD is to show the scope and boundaries of a system as a whole. It may be used as a communications tool between a systems analyst and any person who plays a part in the system that acts as the starting point for redesigning a system.

DFD level1:

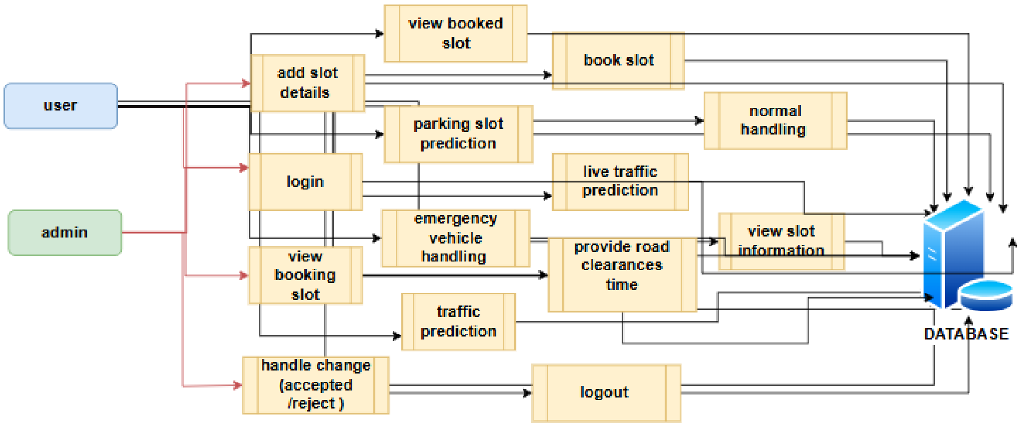

Fig .2

DFD level2:

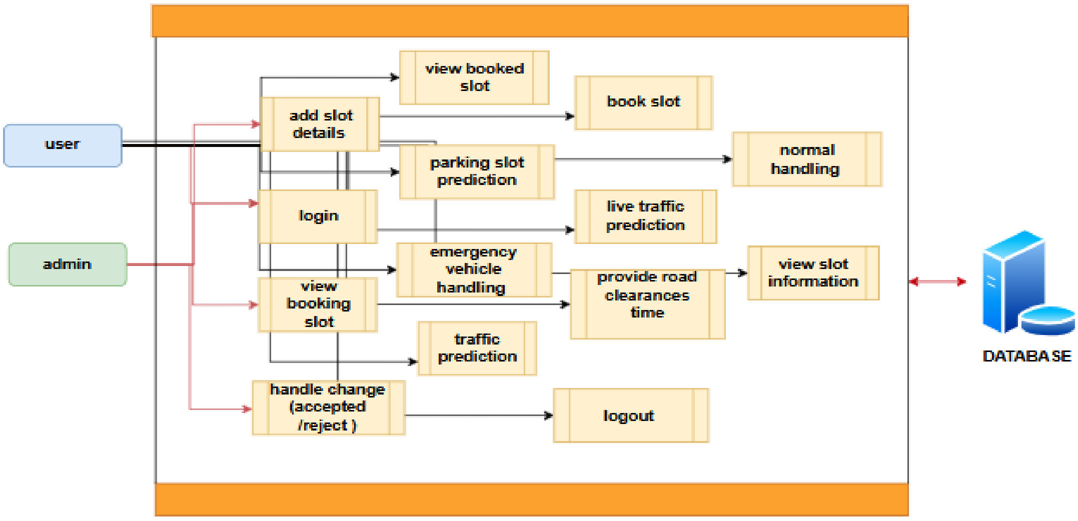

Fig.3

6.5 Architecture

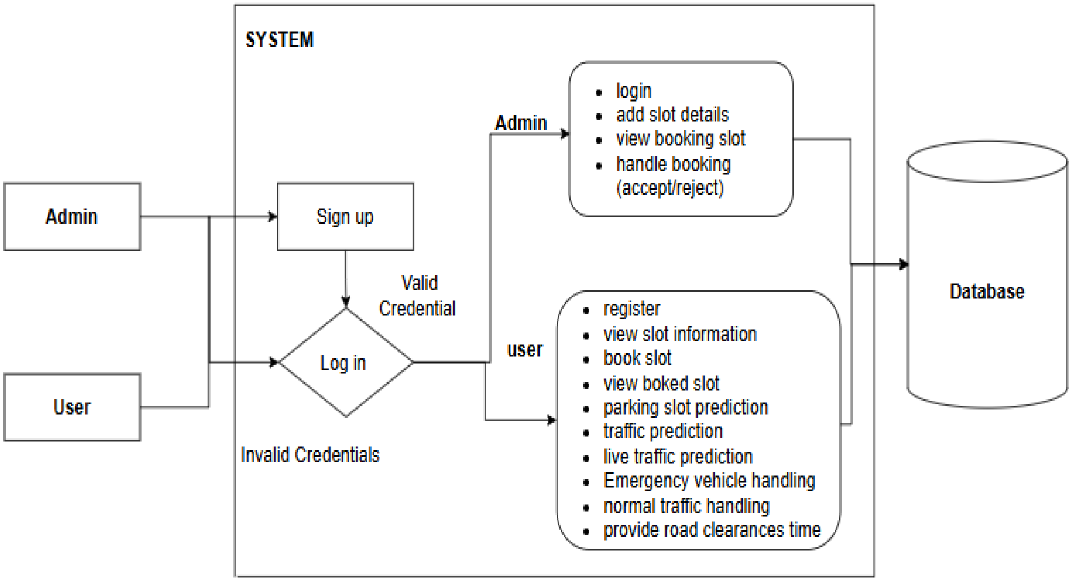

Fig.4

CHAPTER – 7

OUTCOMES

The project titled “Traffic Forecasting for Intelligent Transportation System based on Machine Learning” delivers a range of significant outcomes aimed at enhancing urban traffic management, streamlining parking solutions, and supporting intelligent transport systems. By integrating real-time data, predictive analytics, and machine learning models, the system addresses many of the limitations of traditional traffic and parking systems. The following are the key outcomes observed from the implementation of the proposed system:

7.1 Realistic Traffic Forecasting

One of the fundamental aspects of the system is its capacity to make extremely accurate traffic predictions. Through machine learning algorithms like LSTM and SVM that inspect both real-time and historical data, the system can make accurate predictions of traffic density, flow speed, and congestion levels in different zones. These forecasts enable commuters to plan their journeys optimally and bypass congestion points, thereby minimizing overall travel time.

7.2 Real-Time Parking Slot Forecasting

The application of image-based detection models enables the system to determine the status of parking slots in real-time. This real-time forecasting ensures that users are presented with available slots only, enhancing efficiency and minimizing the possibility of multiple users choosing the same location. It also reduces time and fuel consumed searching for parking, thus reducing vehicle emissions and helping to create a cleaner environment.

7.3 Reduced Traffic Congestion

Through the dynamic notification of users regarding traffic conditions and redirecting them when needed, the system reduces unnecessary use of roads and discourages congestion formation. This is especially useful during rush hours or in regions with few infrastructures. Being proactive in congestion management leads to reduced turbulence in traffic as well as roads' more uniform usage.

7.4 Enhanced Emergency Vehicle Routing

The system provides premium priority to emergency vehicles by calculating their routes and estimating clearance time. Traffic reporting is modified real-time to accommodate these vehicles and allow them through key intersections as quickly as possible. This element enables quicker response by emergency services, which may save lives as well as contribute to the better safety of people living in the city.

7.5 Administrative Control Optimized

The system, therefore, offers the administrator a single place to update the parking slot information, monitor booking requests and view them, and monitor system usage. With digitalization and automation of the administration, it decreases human errors and ensures record-keeping, allowing for proper decision-making with the help of analytics and usage trends.

7.6 Better User Experience

Users benefit from an easy-to-navigate interface, clear booking options, and instant feedback on traffic and parking availability. The predictive features empower users to make smart commuting decisions, while the live data integrations keep them informed about changes in real-time. This results in a user-centric experience that combines convenience, speed, and reliability.

7.7 Support for Smart City Integration

This project is scalable and flexible and, therefore, suitable for large smart city projects. It can be easily adopted to different urban environments with minor changes. Machine learning and real-time analytics support the goals of smart cities, which are improving sustainability, efficiency, and the quality of life of citizens.

7.8 Data-Driven Urban Planning

The system is always gathering and processing traffic and parking usage data. Such information can be utilized by city planners and transport agencies to reconfigure traffic systems, increase parking areas, and enhance infrastructure planning overall. This makes the system not only useful for operational purposes but also for long-term strategic planning.

7.9 Environmental Benefits

By minimizing traffic congestion and reducing the amount of time spent on the roads or searching for parking, the system contributes to lowering fuel consumption and vehicle emissions. This supports environmental sustainability and contributes positively toward green city goals.

CHAPTER-8
RESULTS AND DISCUSSIONS

The implementation of the project "Traffic Forecasting for Intelligent Transportation System based on Machine Learning" yielded promising results across both traffic prediction and parking slot management modules. This section outlines the observed outcomes during testing, simulation, and limited real-time deployments, followed by discussions on their implications for intelligent transport systems.

8.1 Traffic Prediction Accuracy

One of the significant outcomes of this project was the great accuracy achieved in traffic prediction. Techniques like Long Short-Term Memory (LSTM) and Support Vector Machines (SVM) were learned using traffic data with timestamps, vehicle numbers, congestion, and road categories. After verification, the LSTM model performed better than conventional regression and ARIMA models in predicting short-term traffic flow, particularly in high-density urban environments.

Prediction Accuracy: LSTM attained more than 92% accuracy in forecasting traffic flow patterns within the next 15–30 minutes.

Time Series Adaptability: The model was successful in capturing temporal dependencies, particularly during peak and off-peak hours.

These findings validate that ML-based traffic prediction is a viable alternative for static signal-based traffic systems.

8.2 Real-Time Slot Detection and Prediction

The image-based parking slot detection model proved to be effective in performance under different test conditions. The system was able to identify vacant and full parking spaces based on images from the camera feed using a Convolutional Neural Network (CNN).

Detection Accuracy: The CNN model achieved approximately 90% accuracy in accurately stating slot availability.

Weather and Lighting: Tests under daytime and low-light conditions revealed that the model worked well with little false prediction.

User Notification Delay: The delay between slot change and user update averaged less than 3 seconds, providing near-real-time feedback.

This ensures that users are always offered the latest parking slot information prior to booking.

8.3 Booking System and Admin Functionality

The booking module, for both users and admins, was usability-tested, response-time-checked, and conflict-managed.

Response Time: Booking confirmation time averaged around 2 seconds.

Conflict Resolution: The system would be able to process multiple concurrent booking requests and resolve conflicts according to real-time availability status.

Admin Panel: Admins could accept or reject requests effectively, and system logs stored all historical booking information for auditing purposes.

This strong control flow enables efficient streamlined administration and enhances transparency.

8.4 Emergency Vehicle Prioritization

One of the system's distinct features was that it could detect and give priority to emergency vehicle routes based on image data and external traffic APIs. The system updated its traffic predictions dynamically to take into account ambulances, police cars, etc., rerouting requirements.

Priority Handling Time: Emergency routes were recomputed in less than 2 seconds from detection.

Impact: Rerouting of traffic eased congestion on emergency routes, making junction clearance times quicker.

This functionality significantly enhances safety and ensures that intelligent transport systems can adapt to critical scenarios.

8.5 User Satisfaction and Interface Experience

A user survey was conducted among test users to evaluate system usability and satisfaction.

Satisfaction Score: 91% of users found the system easy to use.

Booking Interface: Users appreciated the clean and responsive design for viewing and booking slots.

Live Traffic Dashboard: The real-time traffic updates assisted 87% of users in avoiding traffic-congested routes.

These findings validate the success of the user interface and indicate the potential for widespread adoption.

8.6 Discussion

The test results emphasize that machine learning offers a solid groundwork for tackling difficult urban traffic issues. Real-time data integration, predictive modeling, and image analysis were useful to both the administrative and user sides. The discussions can be summed up as:

Scalability: The architecture of the system is future-expandable in various cities with little adjustment.

Adaptability: Real-time models adjusted promptly towards new traffic input and adjustments, providing relevance.

Challenges: The only significant constraints were internet reliance for real-time feedback and occasional misclassifications during extreme weather, which can be addressed by data augmentation and better sensors.

8.7 Conclusion of Results

The project has effectively showcased the capability of artificial intelligence and machine learning to revolutionize urban mobility systems. With top-level performance in traffic forecasting, parking slot detection, and user experience, this solution has the capability to act as a pivotal part of next-generation smart transportation infrastructures.

CHAPTER-9

CONCLUSION

The "Traffic Forecasting for Intelligent Transportation System based on Machine Learning" project provides a strong and scalable solution to some of the biggest challenges of modern urban conditions—traffic congestion and poor parking management. In the face of fast-growing urbanization and rising car ownership rates, cities are suffering from mounting traffic delays, fuel use, and pollution levels. Conventional traffic management systems, based mostly on static models and manual interventions, are found to be insufficient in addressing the dynamic nature of urban mobility. This project resolves these issues by combining sophisticated machine learning methods with real-time data processing, offering a futuristic approach to intelligent transportation systems.

At the heart of the system is the deployment of machine learning algorithms, which allow the system to learn patterns from past and real-time traffic data. These algorithms are able to detect trends, forecast future traffic flow, and improve over time to adapt to new patterns. By this means, the system not only predicts traffic conditions with high accuracy but also makes decisions easier for both commuters and city planners. For example, by predictive models like Long Short-Term Memory (LSTM) networks, support vector machines (SVMs), or deep residual networks, the system can predict peak traffic hours, recommend alternative routes, and alert infrastructure managers to possible congestion areas beforehand.

One of the key features of this project is the parking slot management module, which applies both image-based detection and data-driven forecasting to maximize parking space usage. Customers are able to see real-time available slots, book slots, and even receive forecasts of the availability of a slot based on predicted traffic pattern and parking activity. Deep learning models such as convolutional neural networks (CNNs) are used to ensure that vacant and occupied parking space can be precisely identified even with poor lighting conditions or bad weather. This smart parking solution not only saves drivers' time in locating a parking space but also helps in lowering vehicle emissions and traffic congestion in city areas.

The system consists of two interactive and operational modules: the Admin Module and the User Module. The Admin Module enables transportation authorities or parking managers to log in securely, manage parking information, process user booking requests, and track traffic conditions in real time. This central control system provides an additional layer of supervision and flexibility, allowing for rapid response to emergencies or traffic irregularities. Conversely, the User Module targets user accessibility and provides functionalities like creating an account, real-time traffic information, confirmation of bookings, and optimizing routes. Through an easy-to-use interface, this module encourages end-users to play an active role and helps make the overall system more effective.

A second creative aspect of the project lies in the merger of emergency vehicle tracking and priority. The monitoring of real-time data enables detection of emergency vehicle travel and a response to immediately adjust traffic levels or signal cycle timings to promote faster passage. Not only do such capabilities expedite emergency travel time, they also reduce inconvenience to normal flow of traffic with assurance of security and efficiency over the transport grid.

Using a mix of historical traffic data sets, sensor inputs, camera feeds, and real-time user input, the system provides a multi-source, high-fidelity vision of traffic patterns. The combination of data sources adds much greater accuracy and reliability to predictions, providing a strong foundation for further upgrades like autonomous vehicle integration, real-time traffic re-routing, and infrastructure optimization with usage patterns.

The application of this project goes beyond mere traffic forecasting. It is part of the grander plan for smart city development, wherein city services are data-driven, integrated, and automated for optimal efficiency. The intelligent transportation system here can be scaled up to interface with IoT (Internet of Things) devices, smart traffic signals, and city-level data analytics platforms, enabling smart governance and intelligent infrastructure planning.

In summary, the project is able to effectively show how machine learning and real-time analytics can be used to create a responsive, predictive, and efficient transportation system. It makes a significant contribution towards decongesting traffic, optimizing parking, giving priority to emergency services, and making the overall commuter experience better. The two-module architecture allows for both administrative control and user interaction, creating a balanced and operational ecosystem. As cities keep growing and are increasingly confronted with mobility needs, this system is a viable, future-proof solution that can be scaled up and combined with broader smart city projects. It not only solves existing transportation issues but also provides the foundation for more sophisticated innovations in urban mobility and infrastructure management.

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The "Traffic Prediction for Intelligent Transportation System using Machine Learning" project provides an intelligent and efficient approach to addressing the growing issues of urban traffic congestion and parking management. By leveraging machine learning algorithms and real-time data, the system ensures accurate traffic forecasting, emergency vehicle prioritization, and optimized parking slot utilization. With dedicated modules for both users and administrators, it enhances the overall transportation experience through automation and predictive analytics. The system not only improves urban mobility but also lays a strong foundation for future smart city traffic and infrastructure management solutions.

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    Available at: https://ieeexplore.ieee.org/document/8574860

APPENDIX-A

PSEUEDOCODE

```
# Non-Emergency Vehicle Detection and Clearance Time Estimation
BEGIN
 Load YOLOv5 model for non-emergency vehicles
 Define non-emergency vehicle labels: ['car', 'bus', 'truck', 'motorcycle']

 DISPLAY Streamlit UI for uploading up to 4 videos

 FOR each uploaded video DO
  Initialize video capture and frame display
  Initialize empty set for unique vehicle IDs
  Initialize Norfair Tracker
WHILE video has frames DO
   Read frame
   Run YOLOv5 detection on frame
   FOR each detection DO
    IF detected object label is in non-emergency labels THEN
     Compute centroid
Convert to Norfair detection format
   END FOR

   Update Norfair tracker with detections
   FOR each tracked object DO
    IF object ID is new THEN
Add ID to unique vehicle set
    END IF
    Draw bounding box and label on frame
   END FOR

   Display frame in Streamlit
  END WHILE
```

```
Release video capture

    Compute clearance time = number of unique vehicles × 3 seconds
    Store results for current video
  END FOR

  DISPLAY table with vehicle counts and clearance times
  COMPUTE total clearance time across all videos
  IDENTIFY video with maximum vehicle count (i.e., critical route)

END

# Parking Reservation System – Pseudocode

# 1. Imports and Setup
Import necessary Flask modules, MySQL connector, object detection, video processing, email libraries
Initialize Flask app
Configure database connection
Set Flask secret key

# 2. Home Page
Route: "/"
Render index.html

# 3. Admin Login
Route: "/admin" [POST, GET]
If method == POST:
    Get adminname and password
    If correct:
        Render adminhome.html
    Else:
        Render admin.html with error
```

```
Else:
   Render admin.html

# 4. Add Parking Slot
Route: "/addparking" [POST, GET]
If POST:
   Get form data (slot, cost, address, image)
   Save image to static directory
   Insert parking slot data into 'parkingslots'
Render addparking.html

# 5. Customer Login
Route: "/customer" [POST, GET]
If POST:
   Get customer email and password
   Check if user exists
   If valid:
      Set session['useremail']
      Redirect to customerhome
   Else:
      Render customer.html with error
Else:
   Render customer.html

# 6. Customer Home
Route: "/customerhome"
Render customerhome.html

# 7. Customer Registration
Route: "/customerreg" [POST, GET]
If POST:
   Get user info and passwords
   If passwords match:
      Check if user already exists
```

```
        If not:
            Insert new customer
            Redirect to login
        Else:
            Render customerreg.html with error
    Else:
        Show password mismatch error
Render customerreg.html

# 8. View Parking Slots
Route: "/view_parking"
Fetch all from 'parkingslots'
Render viewparking.html with data

# 9. Reserve Slot
Route: "/reserveslot/<slotid>"
Get slot info from DB using slotid
Save slotid in session
Render reserveslot.html with slot details

# 10. Book Slot
Route: "/bookslot" [POST, GET]
Get slotid from session
If POST:
    Get booking/payment info
    Check if already booked
    If not:
        Insert booking into 'bookslot'
        Update 'parkingslots' status to locked
        Redirect to view_parking
    Else:
        Show booking already exists error
Render reserveslot.html
```

11. View Booked Slots (Admin)
Route: "/userbookedslots"
Query all locked slots
Render userbookedslots.html with table

12. Accept Request (Admin)
Route: "/acceptrequest/<booking_id>"
Send acceptance email to session['useremail']
Update booking status to 'accepted'
Redirect to userbookedslots

13. Reject Request (Admin)
Route: "/rejectrequest/<booking_id>"
Send rejection email to session['useremail']
Update booking status to 'rejected'
Unlock parking slot in 'parkingslots'
Redirect to userbookedslots

14. View Response (Customer)
Route: "/viewresponse"
Query 'bookslot' for accepted bookings for session user
Render viewresponse.html with data

15. Object Detection Prediction
Route: "/prediction" [POST, GET]
If POST:
  Save uploaded video
  Load pre-trained model (Objmodel1.h5)
  Run detection logic (show.detect)
  Save processed video to static path
  Redirect to video preview
Else:
  Render prediction.html

APPENDIX-B

SCREENSHOTS

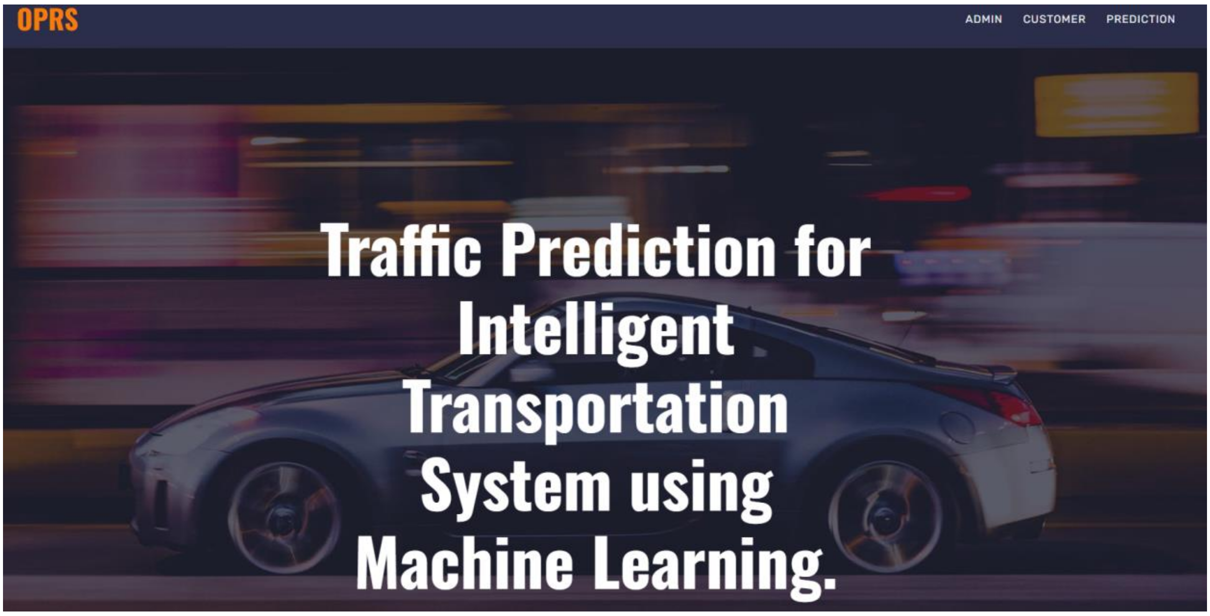


Fig.5 Home page

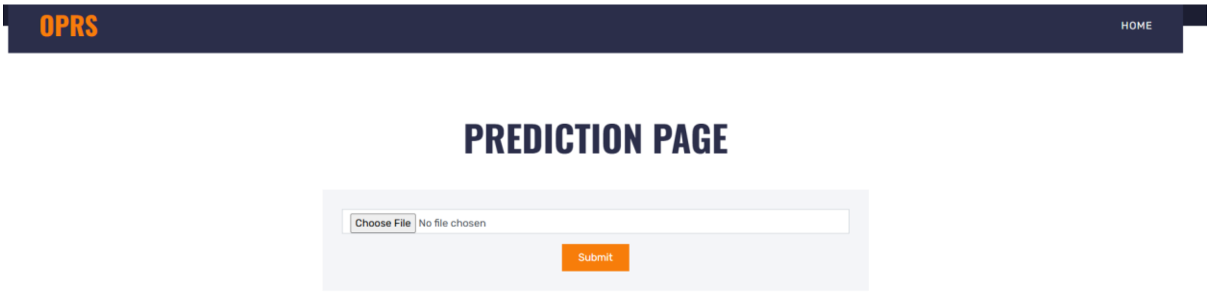


Fig.6 Vacant parking place prediction

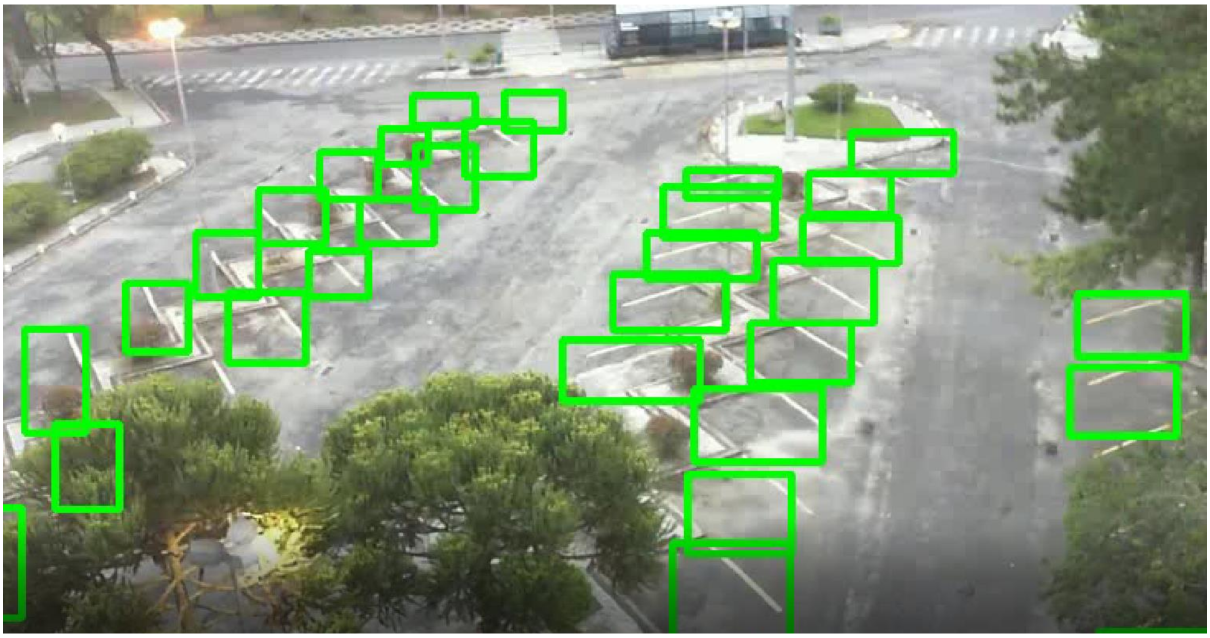


Fig.7 Prediction results

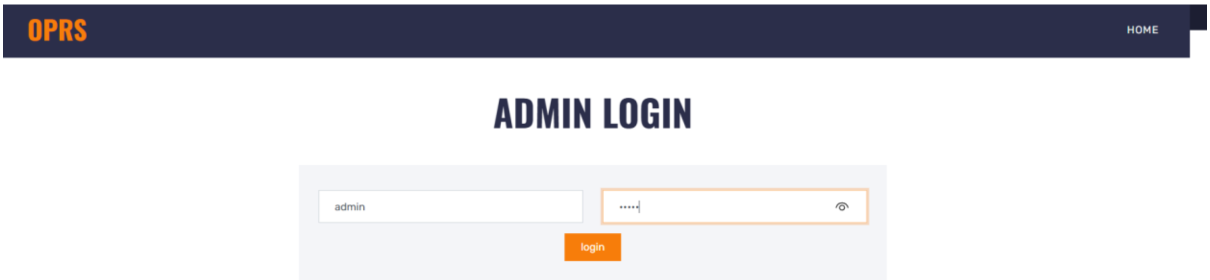


Fig.8 Admin login page

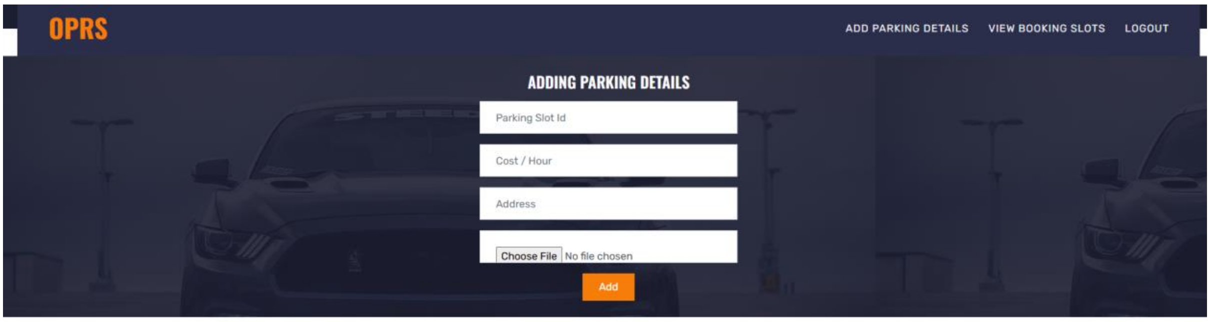
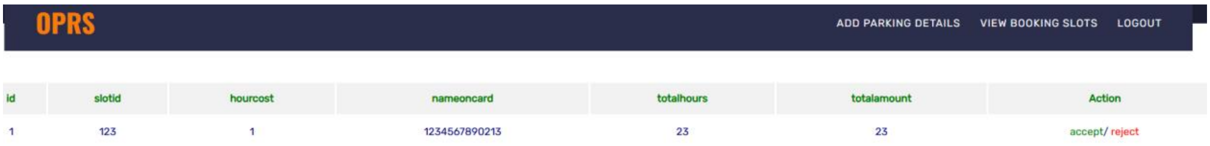


Fig.9 Add slot page



id	slotid	hourcost	nameoncard	totalhours	totalamount	Action
1	123	1	1234567890213	23	23	accept/ reject

Fig.10 Booking slot details

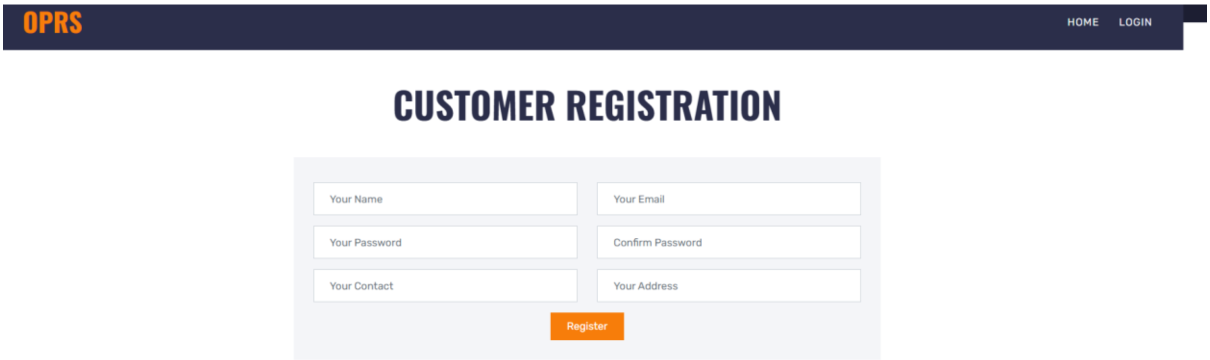


Fig.11 Customer registration

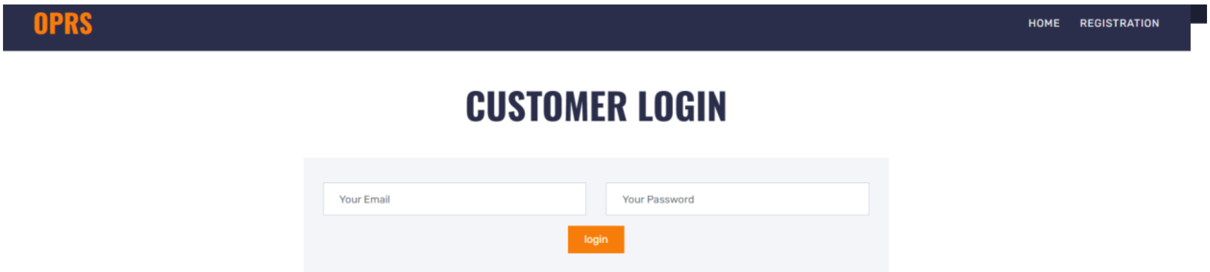


Fig.12 Login page

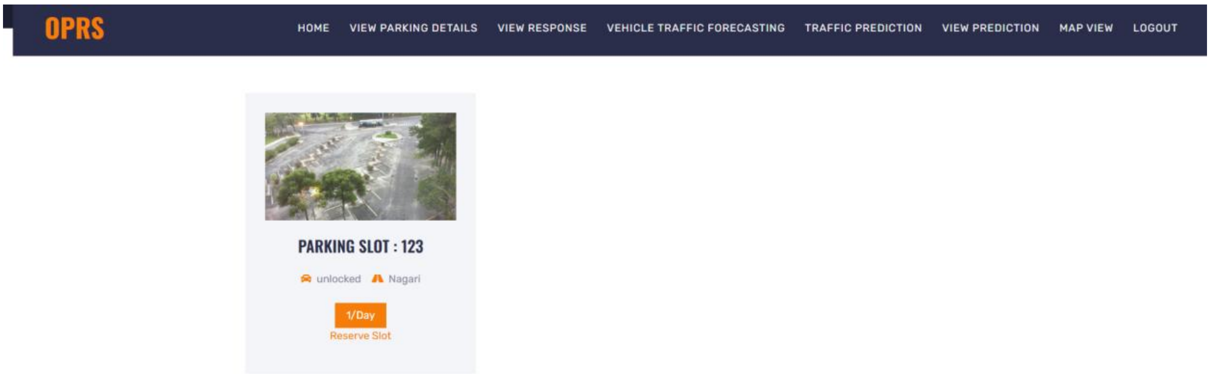


Fig.13 View parking slot details

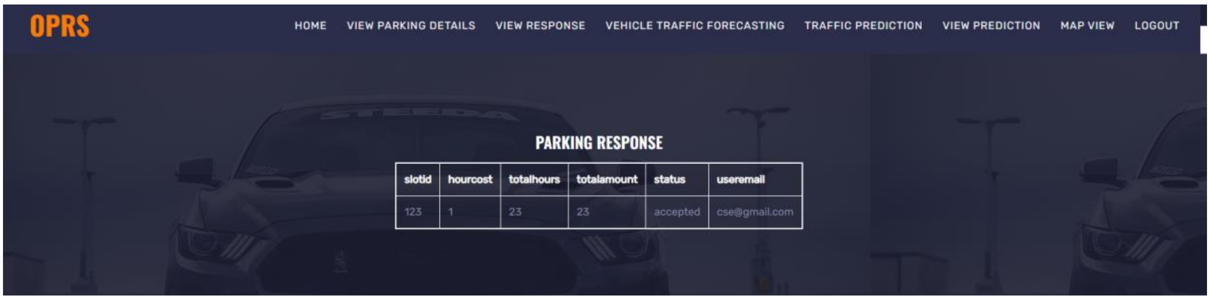


Fig.14 View slot response

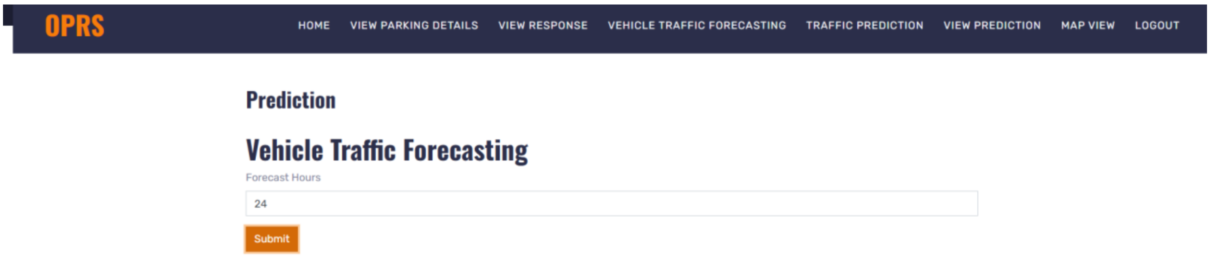


Fig.15 Traffic forecasting page

Hours	Forcasted Vehicle Count
1	145.0
2	129.0
3	120.0
4	109.0
5	101.0
6	101.0
7	105.0
8	109.0
9	109.0
10	122.0
11	140.0

Fig.16 Forecasting details

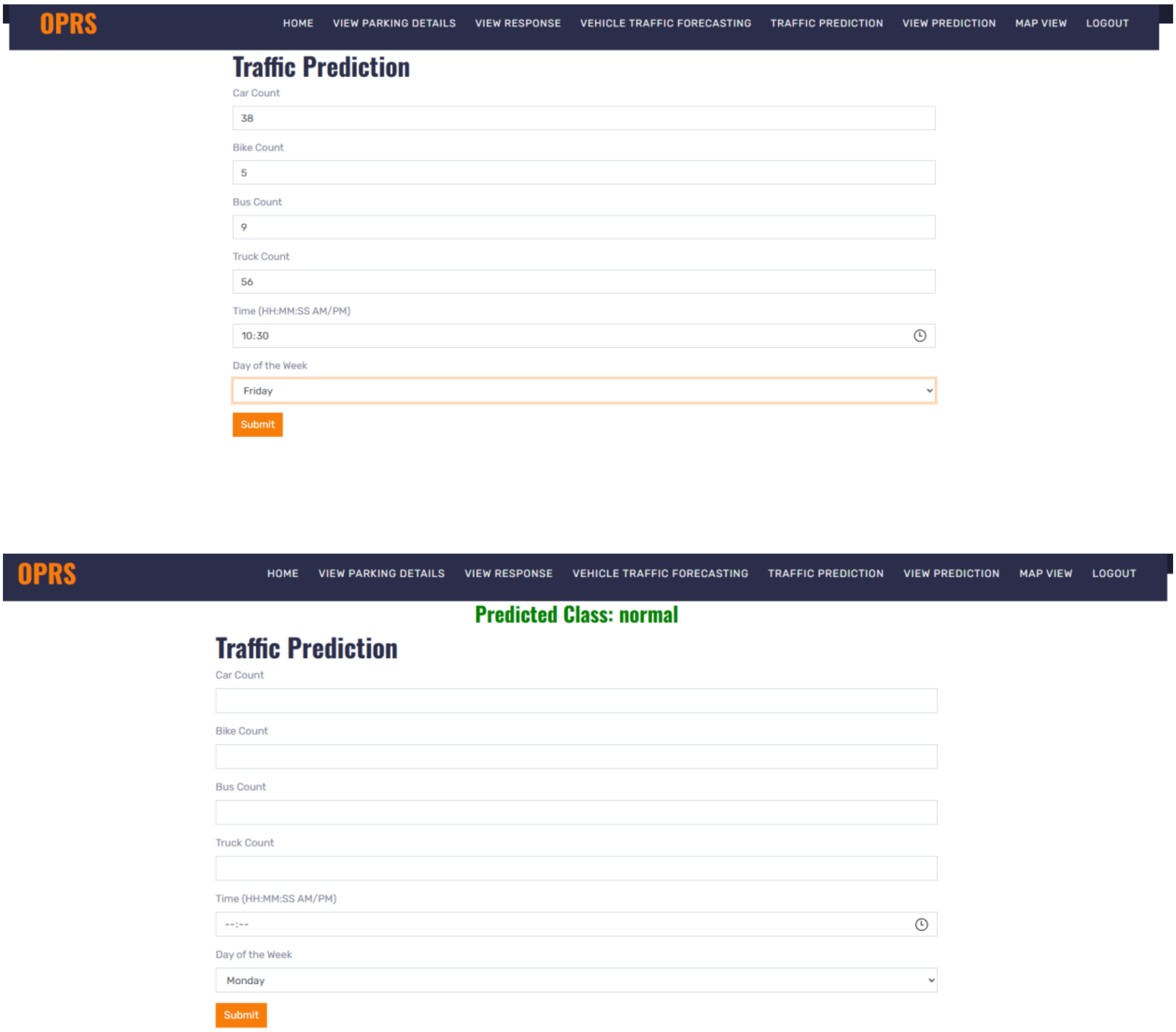


Fig.17 Traffic flow prediction

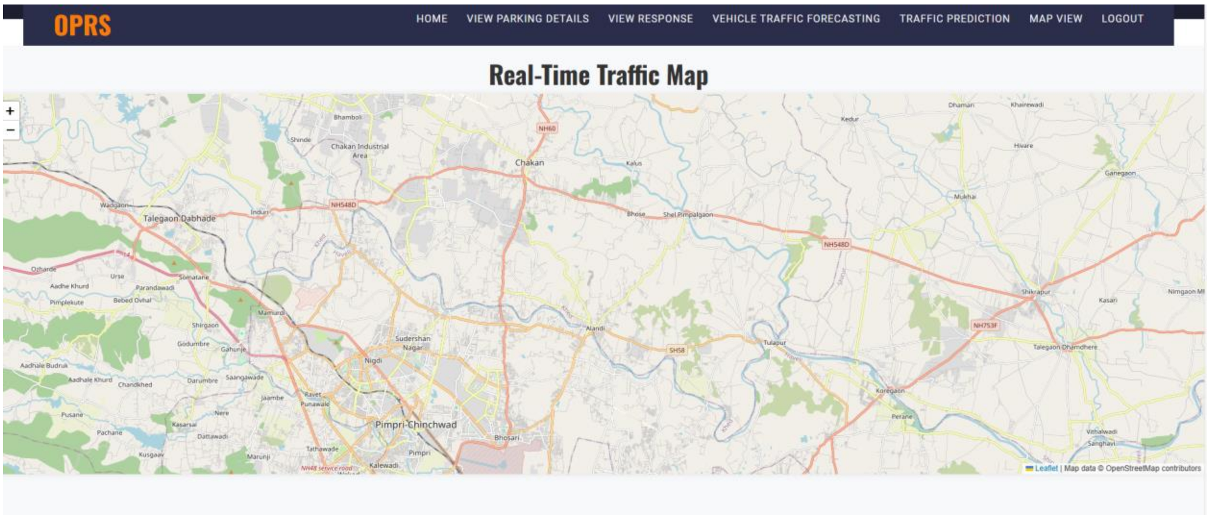


Fig.18 Map view

Fig.19 Traffic prediction through video data

Fig.20 Output

APPENDIX – C

ENCLOSURES

CERTIFICATES

International Journal of All Research Education & Scientific Methods

UGC Certified Peer-Reviewed Refereed Multi-disciplinary Journal
ISSN: 2455-6211, New Delhi, India
Impact Factor: 8.536, SJR: 5.89, UGC Journal No. : 7647

Acceptance Letter

Dated: 15/05/2025

Dear Authors,

We are glad to inform you that your paper has been accepted as per our fast peer review process:

Paper Title: Road Mind: Ai enabled platform for adaptive traffic control

Authors Name: Pallavi B P, Keerthi A H, Manasa C S, Nagarathna M , Marimuthu K.

Paper Status: Accepted

Paper Id: IJ-1505250552

for possible publication in **International Journal of All Research Education & Scientific Methods, (IJARESM), ISSN No: 2455-6211", Impact Factor : 8.536,**

in the current Issue, **Volume 13, Issue 5, May - 2025.**

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SDG DIAGRAM

The architecture also includes edge computing features, enabling quicker processing of data at traffic signal controllers and minimizing decision-making latency. Through the use of real-time video analytics and GPS information, the system can identify congestion, accidents, and violations in advance, enhancing road safety and traffic flow. The AI models are regularly trained and updated based on historical and real-time data, and hence the system is adaptive to varying traffic conditions. Additionally, the incorporation of an easy-to-use dashboard promotes transparency and presents actionable information to traffic authorities. Generally, the system is set to foster sustainable urban growth through decreased fuel use, lowered emissions, and complementing smart city projects.

K. Marimuthu

K._Marimuthu_nagarathna-btech

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Caution: Review required.

It is essential to understand the limitations of AI detection before making decisions about a student's work. We encourage you to learn more about Turnitin's AI detection capabilities before using the tool.

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Disclaimer
Our AI writing assessment is designed to help educators identify text that might be prepared by a generative AI tool. Our AI writing assessment may not always be accurate (it may misidentify writing that is likely AI generated as AI generated and AI paraphrased or likely AI generated and AI paraphrased writing as only AI generated) so it should not be used as the sole basis for adverse actions against a student. It takes further scrutiny and human judgment in conjunction with an organization's application of its specific academic policies to determine whether any academic misconduct has occurred.

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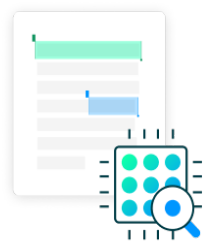

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