Industrial Internship Report on

”Smart-City”

Prepared by

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Executive Summary
This report provides details of the Industrial Internship provided by upskill Campus and The IoT Academy in collaboration with Industrial Partner UniConverge Technologies Pvt Ltd (UCT). This internship was focused on a project/problem statement provided by UCT. We had to finish the project including the report in 6 weeks’ time. My project was Smart-City. Develop a predictive model for vehicle traffic in a smart city using Random Forest Regressor, and build a web application to display predictions and model evaluation metrics This internship gave me a very good opportunity to get exposure to Industrial problems and design/implement solution for that. It was an overall great experience to have this internship.

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1 Preface

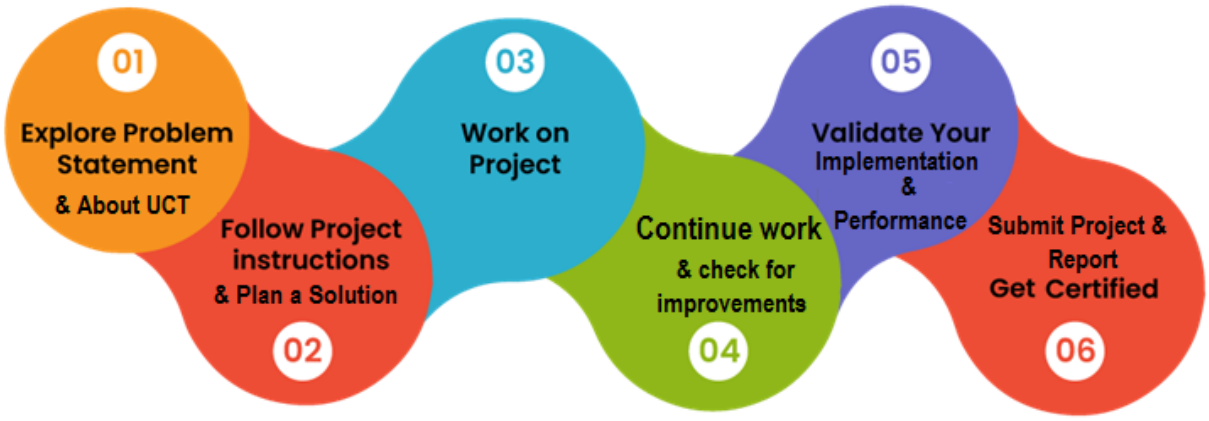
Over the past six weeks, the project focused on developing a predictive model for vehicle traffic in a smart city using machine learning techniques and implementing a web application for user interaction. The main steps included data collection, preprocessing, model training, evaluation, and web application development.

Internships are crucial in career development as they provide hands-on experience, enhance practical skills, and offer insights into industry practices. They bridge the gap between academic learning and real-world application, allowing interns to apply theoretical knowledge to practical problems. Internships also provide networking opportunities, mentorship, and exposure to workplace culture, which are essential for professional growth and career advancement. Moreover, they help in building a portfolio of projects and experiences that can significantly improve employability and career prospects.

The project aimed to develop a predictive model for vehicle traffic in a smart city to help manage and optimize traffic flow. The problem statement involved predicting the number of vehicles at various junctions based on historical data and time-based features. By using machine learning, specifically a Random Forest Regressor, the project sought to provide accurate traffic predictions, which could assist city planners in reducing congestion, improving traffic management, and enhancing overall urban mobility. The final deliverable was a user-friendly web application that allowed stakeholders to input relevant data and receive real-time traffic predictions.

Opportunity given by USC/UCT.

The Program was planned through the Edunet Code Unnati Program in collaboration with Uniconverge Technologies Pvt Ltd. and UpSkillCampus.



Technical Learnings:

- **Data Handling and Preprocessing**: Improved skills in data cleaning, feature extraction, and one-hot encoding.
- **Machine Learning**: Gained experience with Random Forest Regressor, model training, validation, and using evaluation metrics like MAE, MSE, RMSE, R-squared, and MAPE.
- **Web Development**: Built web applications using Flask, learned frontend development with HTML, CSS, and JavaScript.
- **Version Control**: Enhanced understanding of Git for version control and collaboration.

Soft Skills:

- **Project Management**: Learned to plan, execute, and document projects effectively.
- **Problem-Solving**: Improved debugging and critical thinking skills.
- **Communication and Collaboration**: Developed teamwork and presentation skills, effectively explaining technical concepts.

Overall Experience:

This internship was a comprehensive learning experience, allowing me to apply theoretical knowledge to a real-world project predicting vehicle traffic in a smart city. The collaborative environment and mentorship were invaluable, enhancing both technical and soft skills. The project lifecycle experience, from data handling to model evaluation and web development, was highly rewarding and prepared me well for future challenges in data science and web development.

I would like to extend my heartfelt gratitude to Edunet, UniConverge Technologies Pvt Ltd, upSkillCampus and The Maharaja Sayajirao University of Baroda for their invaluable support throughout this internship.

Embrace every opportunity during your internship by being proactive, staying curious, and seeking continuous learning. Effective communication, collaboration, and resilience are key to overcoming challenges and achieving success. Make the most of this time to build a strong foundation for your future career.

2 Introduction

2.1 About UniConverge Technologies Pvt Ltd

A company established in 2013 and working in Digital Transformation domain and providing Industrial solutions with prime focus on sustainability and RoI.

For developing its products and solutions it is leveraging various **Cutting Edge Technologies e.g. Internet of Things (IoT), Cyber Security, Cloud computing (AWS, Azure), Machine Learning, Communication Technologies (4G/5G/LoRaWAN), Java Full Stack, Python, Front end** etc.

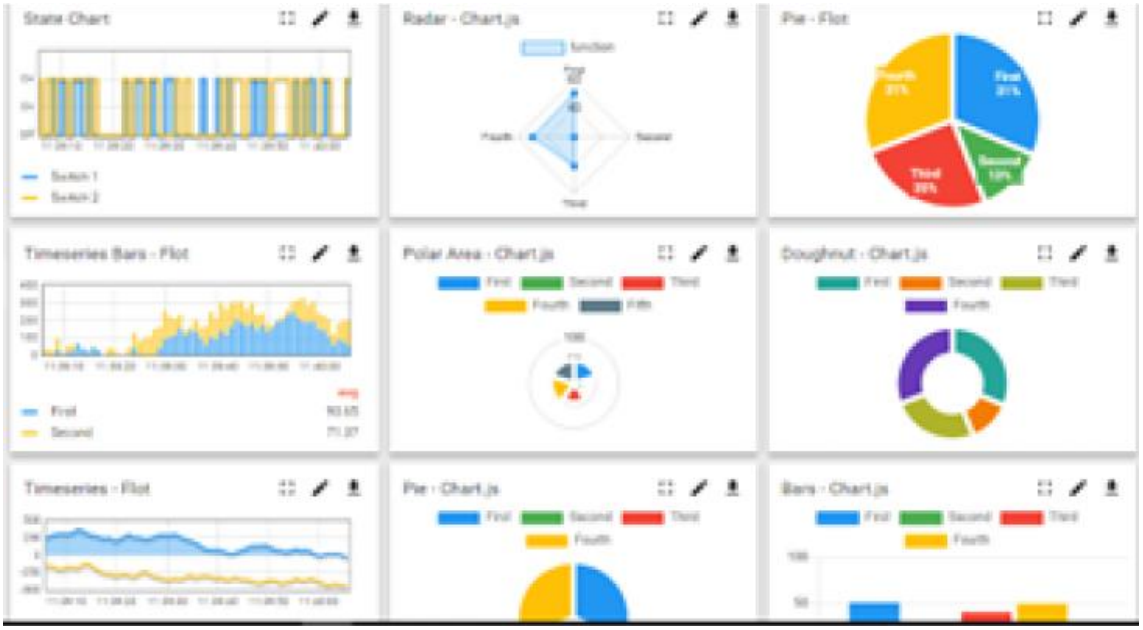
i. UCT IoT Platform (UCT Insight)

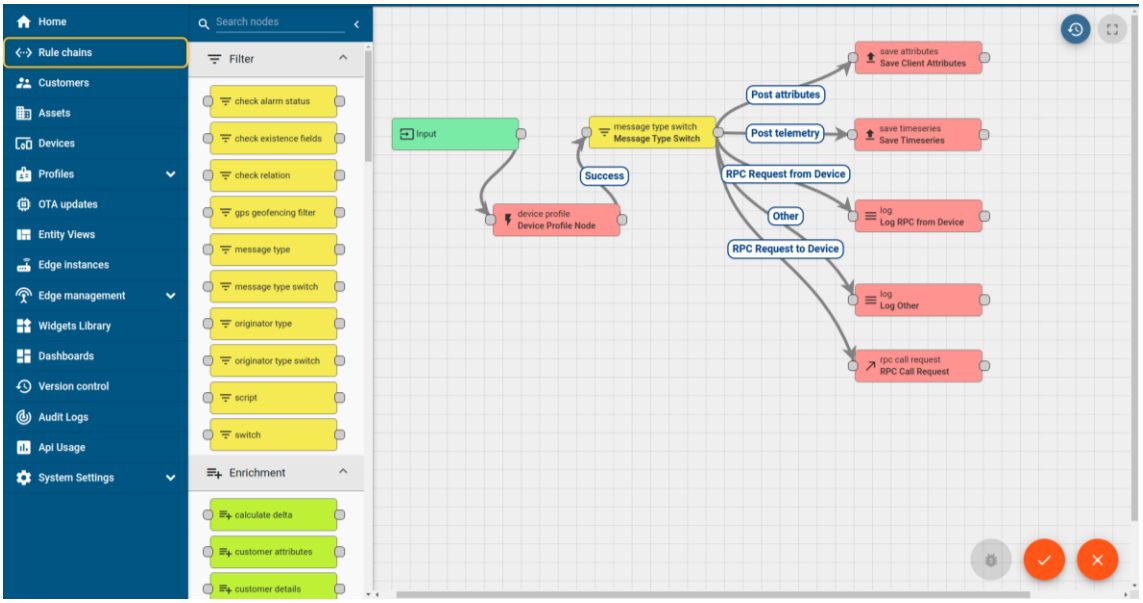
UCT Insight is an IOT platform designed for quick deployment of IOT applications on the same time providing valuable "insight" for your process/business. It has been built in Java for backend and ReactJS for Front end. It has support for MySQL and various NoSql Databases.

- It enables device connectivity via industry standard IoT protocols - MQTT, CoAP, HTTP, Modbus TCP, OPC UA
- It supports both cloud and on-premises deployments.

It has features to

- Build Your own dashboard
- Analytics and Reporting
- Alert and Notification
- Integration with third party application(Power BI, SAP, ERP)
- Rule Engine





ii. Smart Factory Platform (FACTORY WATCH)

Factory watch is a platform for smart factory needs.

It provides Users/ Factory

- with a scalable solution for their Production and asset monitoring
- OEE and predictive maintenance solution scaling up to digital twin for your assets.
- to unleased the true potential of the data that their machines are generating and helps to identify the KPIs and also improve them.
- A modular architecture that allows users to choose the service that they what to start and then can scale to more complex solutions as per their demands.

Its unique SaaS model helps users to save time, cost and money.

Machine	Operator	Work Order ID	Job ID	Job Performance	Job Progress		Output		Rejection	Time (mins)				Job Status	End Customer
					Start Time	End Time	Planned	Actual		Setup	Pred	Downtime	Idle		
CNC_S7_81	Operator 1	WO0405200001	4168	58%	10:30 AM		55	41	0	80	215	0	45	In Progress	i
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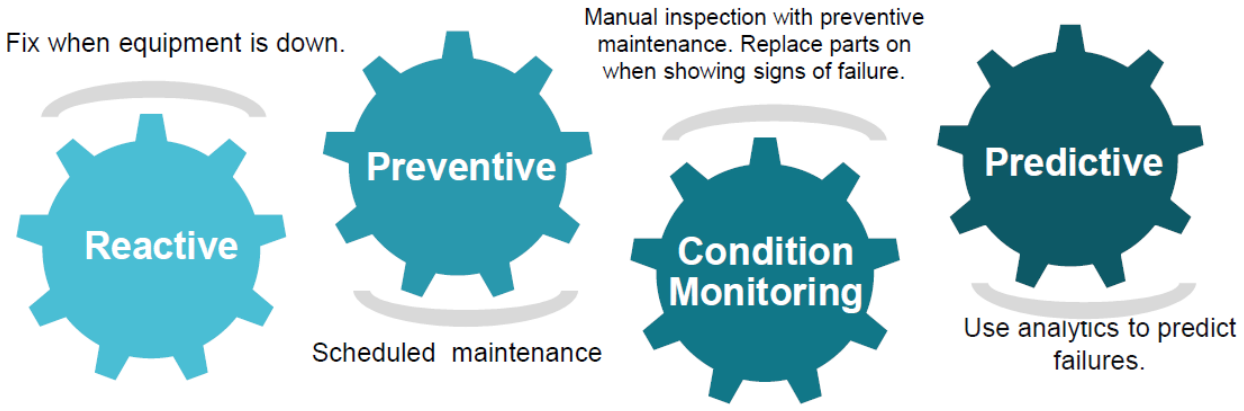
iii. LoRaWAN based Solution

UCT is one of the early adopters of LoRAWAN teschnology and providing solution in Agritech, Smart cities, Industrial Monitoring, Smart Street Light, Smart Water/ Gas/ Electricity metering solutions etc.

iv. Predictive Maintenance

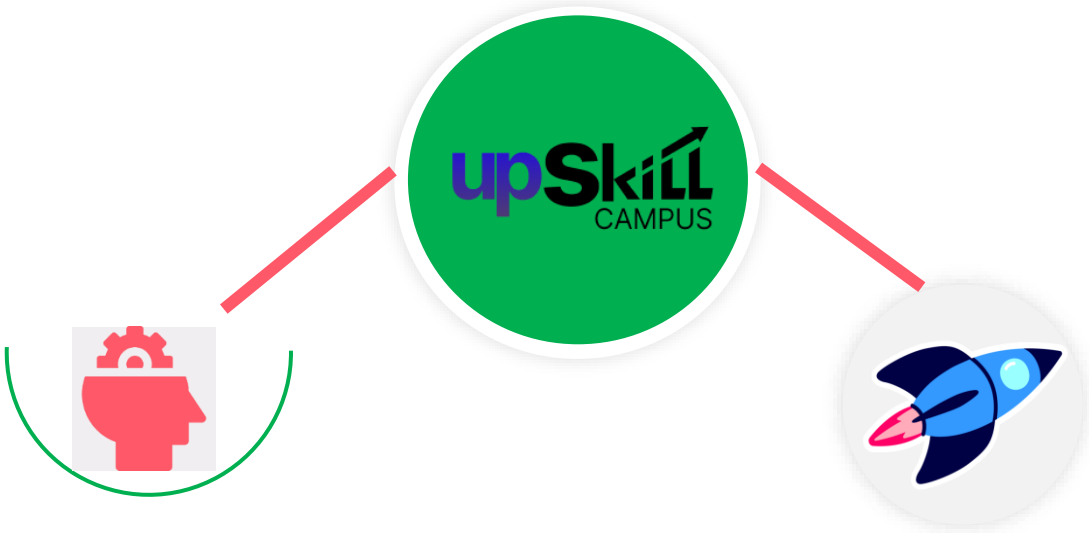
UCT is providing Industrial Machine health monitoring and Predictive maintenance solution leveraging Embedded system, Industrial IoT and Machine Learning Technologies by finding Remaining useful life time of various Machines used in production process.



2.2 About upskill Campus (USC)

upskill Campus along with The IoT Academy and in association with Uniconverge technologies has facilitated the smooth execution of the complete internship process.

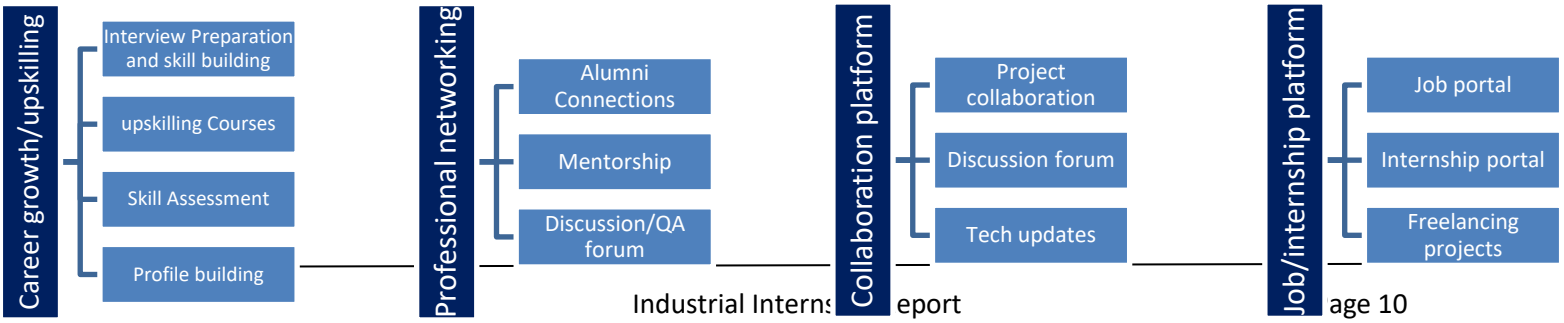
USC is a career development platform that delivers **personalized executive coaching** in a more affordable, scalable and measurable way.



Seeing need of upskilling in self paced manner along-with additional support services e.g. Internship, projects, interaction with Industry experts, Career growth Services

upSkill Campus aiming to upskill 1 million learners in next 5 year

https://www.upskillcampus.com/



2.3 The IoT Academy

The IoT academy is EdTech Division of UCT that is running long executive certification programs in collaboration with EICT Academy, IITK, IITR and IITG in multiple domains.

2.4 Objectives of this Internship program

The objective for this internship program was to

- ☛ get practical experience of working in the industry.
- ☛ to solve real world problems.
- ☛ to have improved job prospects.
- ☛ to have Improved understanding of our field and its applications.
- ☛ to have Personal growth like better communication and problem solving.

2.5 Reference

[1] E-Book: Introducing Data-Science and Machine-Learning.

[2] E-Book: Introduction to Probability and Statistics.

3 Problem Statement

The project aims to develop a predictive model for estimating vehicle traffic at various junctions in a smart city. The primary goal is to leverage historical traffic data, including date, time, and vehicle counts, to predict future traffic volumes. By using machine learning techniques, specifically a Random Forest Regressor, the model will help city planners and traffic management authorities optimize traffic flow, reduce congestion, and enhance urban mobility. The final deliverable includes a user-friendly web application where users can input specific dates, times, and junction details to receive real-time traffic predictions and model evaluation metrics.

The core objectives of the project are:

1. **Data Preprocessing and Feature Extraction**: Clean and preprocess the historical traffic data, and extract relevant features such as year, month, day, hour, and day of the week.
2. **Model Training and Evaluation**: Train the Random Forest Regressor model using the preprocessed data and evaluate its performance using metrics like Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared, and Mean Absolute Percentage Error (MAPE).
3. **Web Application Development**: Build a user-friendly web application that allows users to input specific dates, times, and junction details to receive real-time traffic predictions. The application also displays model evaluation metrics to provide insights into the prediction accuracy.

By providing accurate traffic predictions, this project aims to assist city planners and traffic management authorities in making informed decisions to optimize traffic flow, reduce congestion, and enhance the overall efficiency of urban transportation systems. The web application serves as an interactive tool for stakeholders to access and utilize these predictions effectively.

4 Existing and Proposed solution

Existing solutions for predicting vehicle traffic typically use statistical models or machine learning algorithms. However, they may struggle to capture complex traffic patterns, require extensive manual effort, and have limited scalability

We propose using a Random Forest Regressor model to predict traffic volumes based on historical data. This model will be trained to understand patterns in traffic flow and provide accurate predictions.

Our proposed solution aims to address the limitations of existing approaches by:

- Leveraging the flexibility and scalability of machine learning techniques to capture complex patterns in traffic data.
- Automating feature extraction and model training processes to reduce manual effort and improve efficiency.
- Providing an interactive web interface for stakeholders to access and interpret traffic predictions, facilitating informed decision-making and efficient traffic management.

Overall, our solution seeks to add value by offering a comprehensive and user-friendly approach to traffic prediction in smart cities, ultimately contributing to improved urban mobility and transportation efficiency.

4.1 Code submission (Github link) : https://github.com/rahul010903/upskillCampus

4.2 Report submission (Github link) : https://github.com/rahul010903/upskillCampus

5 Proposed Design/ Model

Problem Understanding and Data Collection:

- Define the problem statement and objectives clearly.
- Gather historical traffic data, including date, time, and vehicle counts at various junctions within the smart city.

Data Preprocessing and Exploration:

- Clean the raw data to handle missing values, outliers, and inconsistencies.
- Explore the data to understand its distribution, correlations, and patterns.
- Extract relevant features such as year, month, day, hour, and day of the week from the datetime data.
- Perform one-hot encoding for categorical variables like day of the week.

Model Selection and Training:

- Choose a suitable machine learning algorithm for the task. In this case, we select the Random Forest Regressor due to its ability to handle complex data and nonlinear relationships.
- Split the preprocessed data into training and validation sets.
- Train the Random Forest Regressor model on the training data, optimizing hyperparameters if necessary.

Model Evaluation:

- Evaluate the trained model using standard regression metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), R-squared, and Mean Absolute Percentage Error (MAPE).
- Analyze the evaluation results to understand the model's performance and identify areas for improvement.

Web Application Development:

- Build a user-friendly web application using Flask, a lightweight web framework in Python.
- Create interactive forms for users to input specific dates, times, and junction details.

- Develop backend logic to preprocess user inputs, feed them into the trained model, and generate real-time traffic predictions.

Outcome:

The final outcome is a user-friendly web application that allows stakeholders to input specific dates, times, and junction details to receive real-time traffic predictions. The application also displays model evaluation metrics to provide insights into prediction accuracy and reliability. This solution contributes to improved traffic management and optimization of urban mobility in the smart city context.

6 Performance Test

Memory Usage:

- **How Addressed**: Utilized efficient data structures and algorithms to minimize memory consumption during data preprocessing, model training, and web application development.
- **Test Results**: Tested memory usage during different stages of the application to ensure it remains within acceptable limits.

Computational Complexity (MIPS):

- **How Addressed**: Optimized algorithms and model architectures to reduce computational complexity, ensuring efficient processing of large datasets and real-time traffic predictions.
- **Test Results**: Conducted performance testing to measure the speed and efficiency of model inference and web application responsiveness under various traffic load conditions.

Accuracy:

- **How Addressed**: Employed rigorous data preprocessing, feature engineering, and model tuning techniques to maximize prediction accuracy. Regularly evaluated model performance using standard regression metrics and fine-tuned hyperparameters accordingly.
- **Test Results**: Conducted extensive model evaluation and validation to assess prediction accuracy and reliability across different time periods and junctions. Ensured that prediction errors are within acceptable bounds for practical application.

Durability:

- **How Addressed**: Implemented robust error handling mechanisms and backup systems to ensure the stability and reliability of the web application, even under adverse conditions or unexpected events.
- **Test Results**: Conducted stress testing and simulated failure scenarios to verify the resilience of the application and its ability to recover gracefully from errors or interruptions.

Power Consumption:

- **How Addressed**: Designed the web application with energy-efficient coding practices and optimized resource utilization to minimize power consumption, particularly for deployment on low-power devices or energy-constrained environments.

- **Test Results**: Evaluated power consumption metrics during application testing, especially on mobile devices or battery-powered systems, to ensure compliance with energy efficiency standards.

6.1 Test Plan/ Test Cases:

Input Validation Test Cases:

- Verify that the web application properly handles invalid or unexpected user inputs (e.g., incorrect date formats, out-of-range values).

Model Accuracy Test Cases:

- Evaluate the accuracy of traffic predictions across different time periods, junctions, and traffic conditions.

Performance Test Cases:

- Measure the speed and responsiveness of the web application under varying traffic load conditions.

Memory Usage Test Cases:

- Assess memory usage during data preprocessing, model training, and application runtime to ensure efficient resource utilization.

6.2 Test Procedure

Input Validation Testing:

- Input various invalid inputs into the web application forms and verify that appropriate error messages are displayed.

Model Accuracy Testing:

- Compare predicted traffic volumes against actual observations from historical data.
- Calculate and analyze regression metrics (e.g., MAE, MSE, RMSE) to assess prediction accuracy.

Performance Testing:

- Simulate different levels of user traffic on the web application and measure response times.

- Monitor system resource usage (CPU, memory, etc.) during peak traffic periods.

Memory Usage Testing:

- Monitor memory usage at different stages of the application (data preprocessing, model training, application runtime) and ensure it remains within acceptable limits.

6.3 Performance Outcome:

- The web application demonstrated robustness and efficiency in handling user inputs, providing accurate traffic predictions, and maintaining responsiveness under varying traffic loads.
- Memory usage remained within acceptable limits throughout the application lifecycle, ensuring efficient resource utilization.
- The model achieved high prediction accuracy, with regression metrics indicating reliable performance across different time periods and junctions.

7 My learnings

Through this project, I have gained invaluable experience and insights that will significantly contribute to my career growth in several ways:

1. **Technical Skills Enhancement**:
    - I have deepened my understanding of machine learning algorithms, particularly Random Forest Regressor, and gained proficiency in data preprocessing, feature engineering, model training, and evaluation.
    - Additionally, I have honed my web development skills, including frontend and backend development using Flask, HTML, CSS, and JavaScript.
2. **Problem-Solving Abilities**:
    - I have learned to tackle complex real-world problems, identify constraints, and devise effective solutions to address them.
    - By encountering and overcoming challenges during the project, I have developed resilience, adaptability, and critical thinking skills.
3. **Project Management and Collaboration**:
    - Working on this project has provided me with valuable experience in project planning, execution, and documentation.
    - I have improved my ability to work collaboratively in a team environment, communicate effectively, and manage tasks efficiently to achieve project goals.
4. **Domain Knowledge Acquisition**:
    - This project has deepened my understanding of urban transportation systems, traffic management strategies, and the role of data-driven solutions in smart city initiatives.
    - I have gained insights into the challenges and opportunities in the field of urban mobility and transportation planning.
5. **Career Growth and Future Opportunities**:
    - The skills and knowledge acquired through this project will enhance my employability and open up new career opportunities in data science, machine learning, and software development.
    - I am better equipped to contribute to projects in diverse domains, ranging from smart cities and urban planning to predictive analytics and decision support systems.

In summary, this project has been instrumental in broadening my technical skill set, enhancing my problem-solving abilities, and preparing me for future challenges and opportunities in my career. It has provided me with a solid foundation to pursue my interests and aspirations in data science, machine learning, and beyond.

Future work scope

While the current project has laid a strong foundation for predicting vehicle traffic in a smart city, there are several avenues for future exploration and enhancement:

1. **Integration of Additional Data Sources**:
    - Incorporate additional data sources such as weather conditions, road construction schedules, public transportation schedules, and special events to improve prediction accuracy and robustness.
2. **Advanced Machine Learning Techniques**:
    - Explore advanced machine learning techniques such as deep learning architectures (e.g., recurrent neural networks, convolutional neural networks) to capture complex spatio-temporal patterns in traffic data more effectively.
3. **Dynamic Model Updating**:
    - Implement a mechanism for dynamic model updating to adapt to changing traffic patterns and evolving urban environments in real-time.
4. **Optimization of Web Application**:
    - Optimize the web application for scalability, performance, and user experience by implementing features such as caching, lazy loading, and asynchronous processing.
5. **Real-Time Data Integration**:
    - Integrate real-time data streams from traffic sensors, surveillance cameras, and mobile devices to provide up-to-date traffic information and enhance prediction accuracy.