“ Traffic Prediction And Signal Control ”
traffic.ai

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FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT FOR THE DEGREE OF BACHELOR OF COMPUTER SCIENCE (HONOURS)

DEPARTMENT OF INFORMATION TECHNOLOGY
LINCOLN UNIVERSITY COLLEGE

September 17th, 2024

DECLARATION

I hereby declare that the project titled "Traffic Prediction and Signal Control System" is an original piece of work completed under the supervision of **Dr. Pawan Kumar Sharma** at Texas College of Management & IT.

The project involves building the frontend using HTML/CSS and the backend with Flask, incorporating machine learning models and real-time data from cameras to predict traffic patterns and dynamically adjust signal timings.

I affirm that this project has not been submitted, in whole or in part, for any other academic or professional qualification.

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Student ID: LC00017001699
Date: 8/17/2024

Supervisor Signature:

ACKNOWLEDGEMENT

First and foremost, I would like to express my heartfelt gratitude to the faculty and staff of Texas College of Management & IT for providing the essential resources and a supportive environment that facilitated my research.

I am deeply appreciative of **Dr. Suman Thapaliya**, Head of Department, for their guidance and support throughout my study.

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ABSTRACT

Urban traffic jam is a significant challenge in modern cities, resulting in longer travel times, increased fuel consumption, and higher pollution levels. Traditional traffic management systems with fixed traffic light timings often fail to address the changing nature of traffic, especially during peak hours or unexpected incidents like accidents. This project proposes a real-time traffic monitoring and control system to tackle these issues.

The system integrates high-resolution cameras for collecting real-time traffic data, dynamic traffic light control algorithms, and machine learning models that predict traffic patterns. By adjusting traffic light timings based on current and historical traffic data, the system aims to improve traffic flow and reduce congestion. The machine learning models help the system learn from past traffic patterns, making it more effective in handling unusual situations.

Keywords: Artificial Intelligence, Machine Learning, Traffic Light Control, Traffic prediction,Traffic Management.

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LIST OF ABBREVIATION

AI	Artificial Intelligence
API	Application Programming Interface
CSS	Cascading Style Sheets
DFD	Data Flow Diagram
ER	Entity Relation
HTML	Hyper Text Markup Language
ML	Machine Learning
UI	User Interface
VS code	Visual Studio Code

CHAPTER 1

1.1 Introduction

The Traffic Prediction and Signal Control project focuses on building a system that can monitor and manage traffic in real-time. It uses cameras to capture live traffic conditions, machine learning models to predict traffic patterns, and smart algorithms to adjust traffic light timings. By combining these technologies, the system aims to reduce traffic congestion and make the flow of vehicles smoother at busy intersections.

Currently, many traffic lights operate on fixed schedules, which often don't match the real-time traffic situation. This leads to unnecessary delays and longer wait times for drivers. The goal of this project is to create a more efficient system that can adapt to changing traffic conditions throughout the day. By predicting traffic patterns and responding quickly the system will help improve traffic flow and reduce congestion in cities.

1.2 Problem Statement

In many cities, traffic congestion is a serious issue that leads to long delays, wasted fuel, and higher pollution. The current traffic light systems, which have fixed timings, are not flexible enough to adapt to the constantly changing traffic conditions. This makes it difficult to manage traffic effectively, especially during rush hours or when unexpected incidents like accidents happen. As a result, traffic congestion continues to be a major challenge that needs a more intelligent and responsive solution.

1.3 Objectives

- Create a system that monitors traffic in real-time using cameras.
- Develop algorithms that adjust traffic light timings based on real-time and past traffic data.
- Use machine learning to predict traffic patterns and identify incidents, helping to smooth out traffic flow .

CHAPTER 2

2.1 Background Study

Traffic management has been a critical aspect of urban planning for decades, primarily relying on pre-programmed traffic light timings to control vehicle flow at intersections. Traditionally, these systems operate on fixed schedules that change traffic lights at specific intervals, regardless of the actual traffic conditions. While this method is straightforward, it often proves inefficient, particularly during peak hours when traffic volumes are high, or during off-peak hours when the roads are relatively empty. As cities grow and the number of vehicles on the road increases, the limitations of these traditional systems become more apparent.

In response to the growing challenges of urban traffic, there has been a shift towards integrating advanced technologies into traffic management systems. The introduction of cameras, sensors, and other data collection devices has opened up new possibilities for real-time traffic monitoring. By continuously gathering data on traffic flow, these technologies enable a more dynamic approach to traffic control, where traffic lights can be adjusted based on current conditions rather than fixed schedules. This represents a significant advancement in the ability to manage traffic more effectively in real-time.

Moreover, the rise of machine learning and artificial intelligence has further enhanced the potential of these systems. Machine learning models can analyze vast amounts of traffic data, learning from patterns and trends to make predictions about future traffic conditions. This predictive capability allows for a more proactive approach to traffic management, where potential congestion can be anticipated and mitigated before it becomes a problem. The combination of real-time data collection and machine learning represents a promising direction for the future of traffic management.

2.2 Literature Review

The academic and technical literature on traffic management systems reveals a growing consensus on the benefits of real-time monitoring and dynamic control. Studies have shown that traditional fixed-timing systems are often inadequate in managing the complex and fluctuating nature of urban traffic. Researchers have explored various approaches to improving these systems, with a particular focus on integrating real-time data collection through cameras and sensors. For instance, several studies have demonstrated how data from traffic cameras can be used to adjust traffic light timings in real-time, significantly reducing congestion at busy intersections.

Furthermore, there is substantial research on the application of machine learning in traffic management. Machine learning models have been developed to predict traffic patterns based on 6 historical data, enabling systems to anticipate congestion before it occurs. For example, some studies have used deep learning techniques to analyze traffic flow data and predict the likelihood of congestion at specific times and locations. These predictive models allow traffic management systems to adjust traffic lights preemptively, thereby smoothing traffic flow and preventing bottlenecks.

Additionally, literature on the implementation of dynamic traffic control systems highlights the practical challenges and solutions in deploying these technologies in real-world environments. Issues such as the integration of different data sources, the reliability of real-time data, and the computational demands of machine learning models are frequently discussed. Despite these challenges, the overall findings in the literature suggest that the benefits of dynamic and intelligent traffic management systems far outweigh the difficulties. Many studies conclude that these systems offer a more efficient and responsive solution to the growing problem of urban traffic congestion

CHAPTER 3

3.1 System Analysis

3.1.1 Requirement Analysis

I. Functional Requirement

FRID	Requirement	Description	Priority
F101	Real-Time Data Collection	The system must use high-resolution cameras to collect live traffic data from various intersections.	High
F102	Dynamic Traffic Light Control	The system should adjust traffic light timings based on real-time traffic data and predefined algorithms.	High
F103	Incident Detection	The system must identify and report incidents such as accidents or unusual traffic patterns.	Medium
F104	Traffic Pattern Prediction	The system should use machine learning models to predict future traffic patterns based on historical data.	High
F105	User Interface	The system must provide a user friendly interface for traffic management authorities to view and control traffic light settings.	High
F106	Data Storage and Management	The system should store collected data securely and allow for retrieval and analysis of historical data.	High
F107	Reporting and Analytics	The system must generate reports and analytics on traffic flow, congestion, and system performance.	Medium
F108	Integration with Existing Systems	The system should integrate with existing traffic management systems and infrastructure.	Medium

Table 1 : Functional Requirements

II. Use Case Diagram

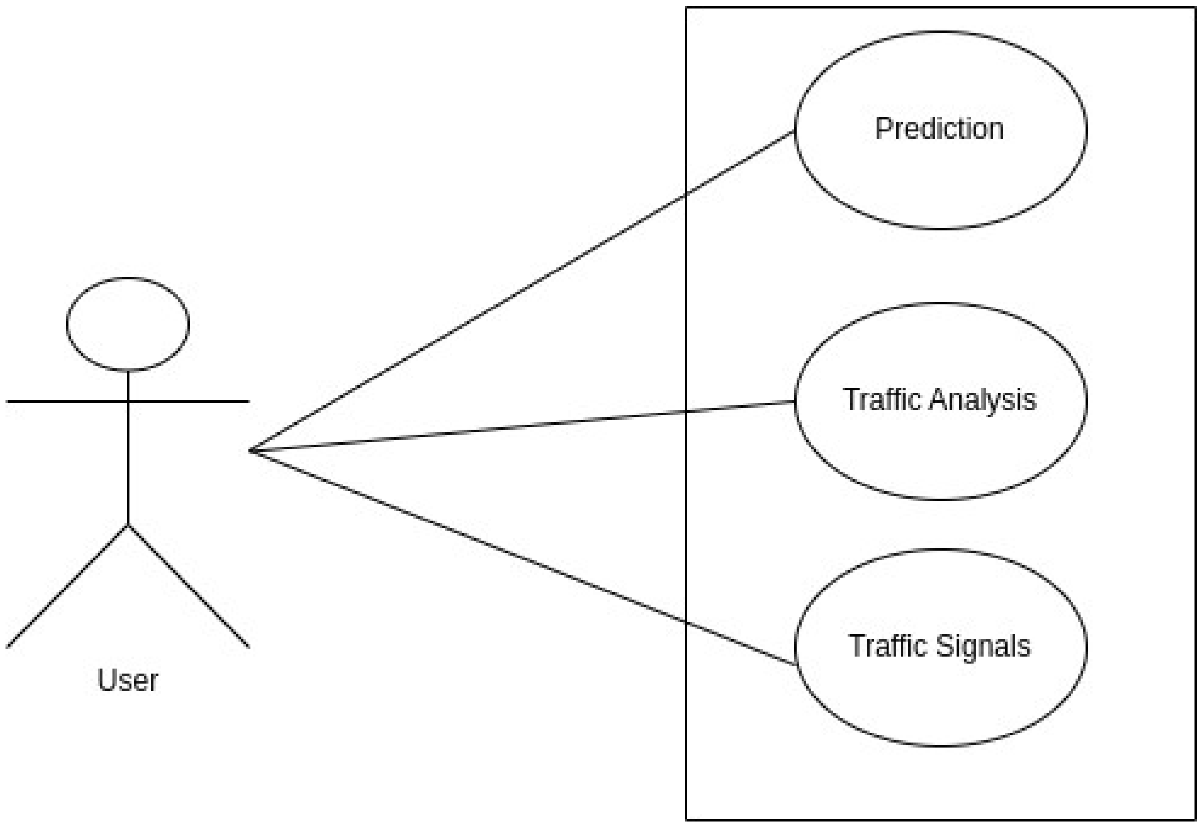


Fig 1.0 Use Case Diagram

III. Non Functional Requirements

1. Performance: The system must process real-time data and adjust traffic light timings with minimal latency to ensure timely responses.
2. Scalability: The system should be able to handle data from multiple intersections and scale up as the number of monitored areas increases.
3. Reliability: The system must operate consistently and accurately, with minimal downtime and error rates.
4. Security: The system must ensure the security of collected data and protect against unauthorized access or tampering.
5. Usability: The user interface must be intuitive and easy to navigate for traffic management personnel, with minimal training required.

3.1.2 Feasibility Study

I. Technical Feasibility

The technical feasibility of the Traffic Management and Signal Control project is strong, considering the availability of advanced technologies and tools. The project leverages higher resolution cameras, machine learning models, and dynamic traffic light control algorithms to monitor and manage traffic flow in real time. These technologies are well-supported by existing infrastructures, such as cloud computing and edge devices, which offer the necessary computational power and scalability. The implementation of machine learning models for traffic prediction is feasible with frameworks like TensorFlow or PyTorch, which are capable of handling large datasets and complex algorithms. Additionally, the integration of real-time data processing from various sensors and cameras into the system is achievable with current networking and data streaming technologies. The use of Python and Flask for the backend ensures that the system is robust, flexible, and capable of interfacing with various components like databases, APIs, and frontend applications. Overall, the project's technical requirements are well within the capabilities of current technology, making it highly feasible from a technical standpoint.

II. Operational Feasibility

Operational feasibility focuses on the practical aspects of implementing and sustaining the Traffic Management and Signal Control project. The project is designed to be user-friendly for traffic management authorities, with intuitive dashboards and automated alerts that require minimal manual intervention. The system's ability to adapt to different traffic conditions and environments, such as urban or suburban areas, enhances its operational feasibility. Moreover, the use of real-time data allows for dynamic adjustments to traffic signals, improving traffic flow and reducing congestion, which aligns with the goals of city planners and traffic management authorities. The project also considers the ease of maintenance and scalability, ensuring that the system can be updated and expanded as needed without significant disruptions. Training requirements for operators are minimal, as the system is largely automated, with user interfaces designed to be intuitive. Overall, the project's operational feasibility is high, as it is designed to integrate seamlessly into existing traffic management systems and provide significant improvements in efficiency and safety.

3.1.3 Gantt Chart

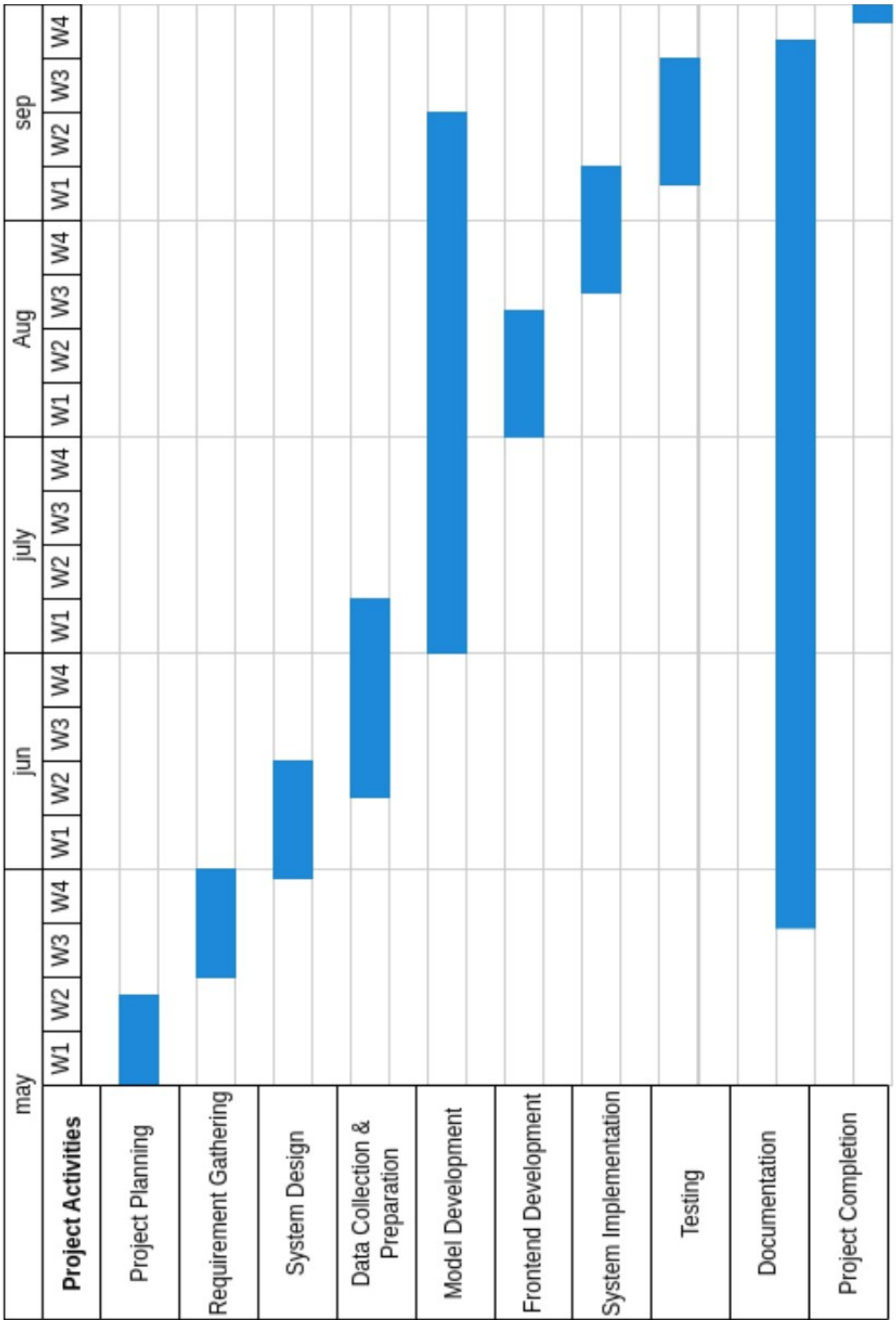


Fig 2.0 Gannt Chart

3.1.4 Data Modeling

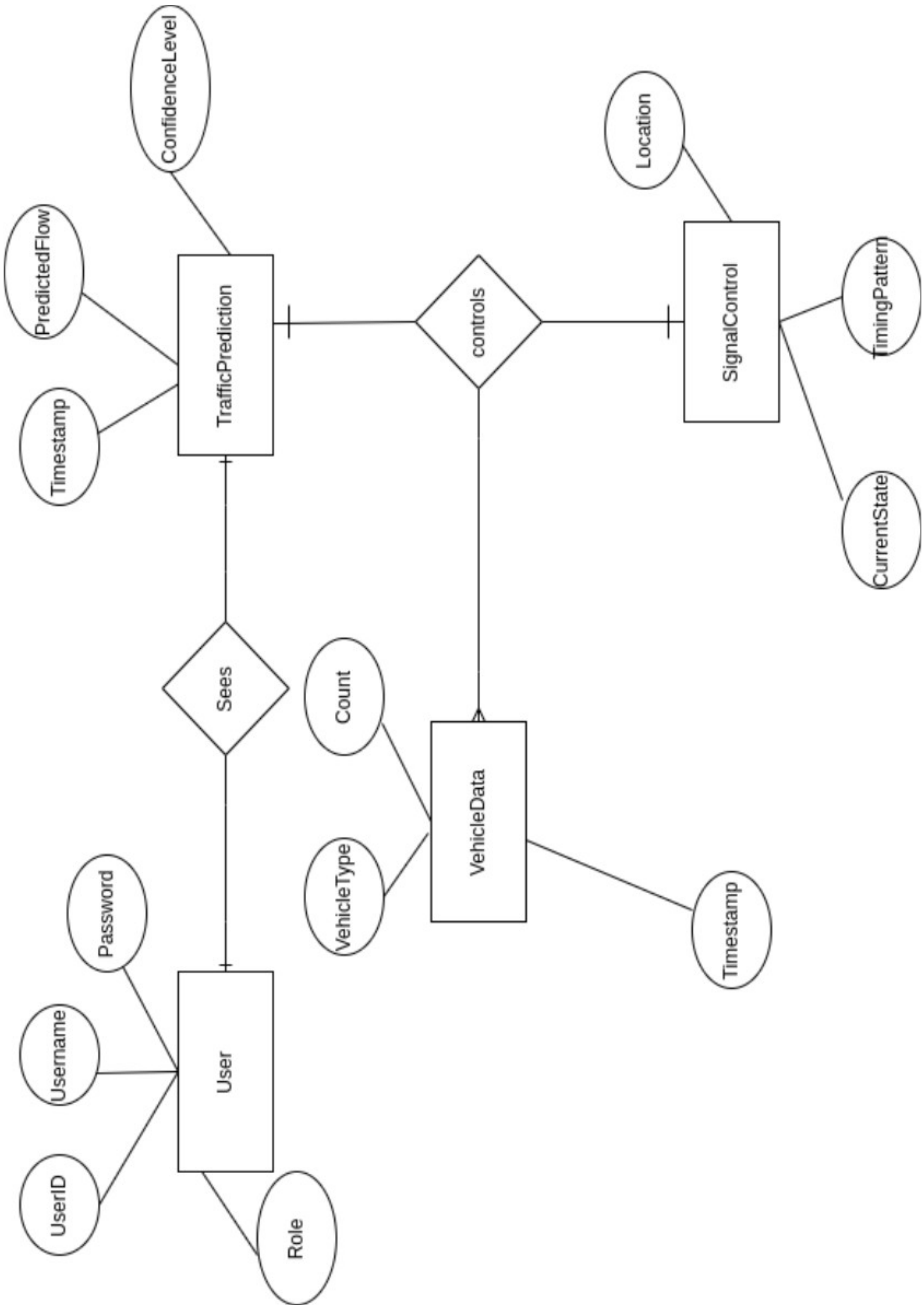


Fig 3.0 ER Diagram

3.1.5 Process Modeling

I. Context Diagram

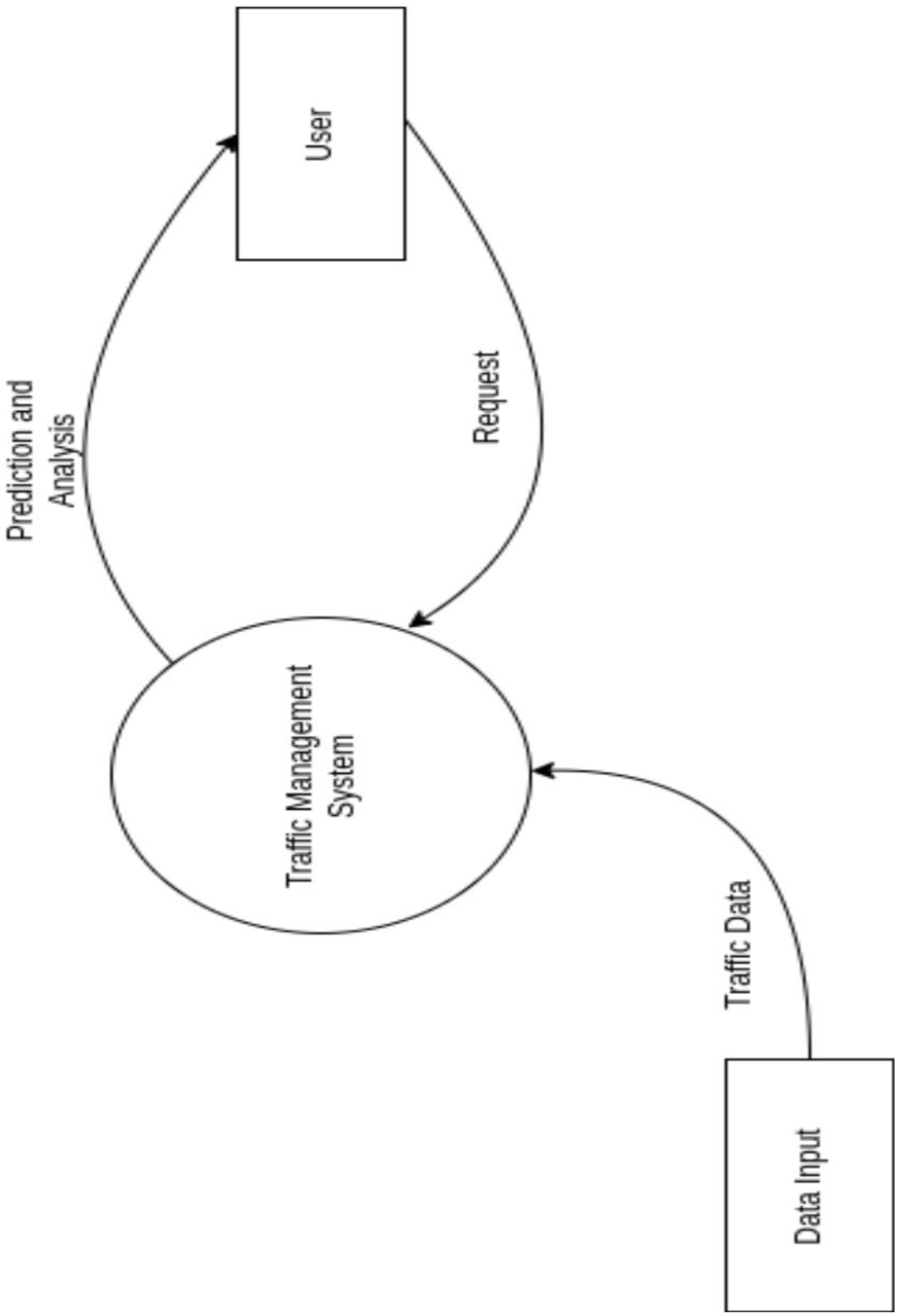


Fig 4.0 Context Diagram

II. DFD LEVEL 0

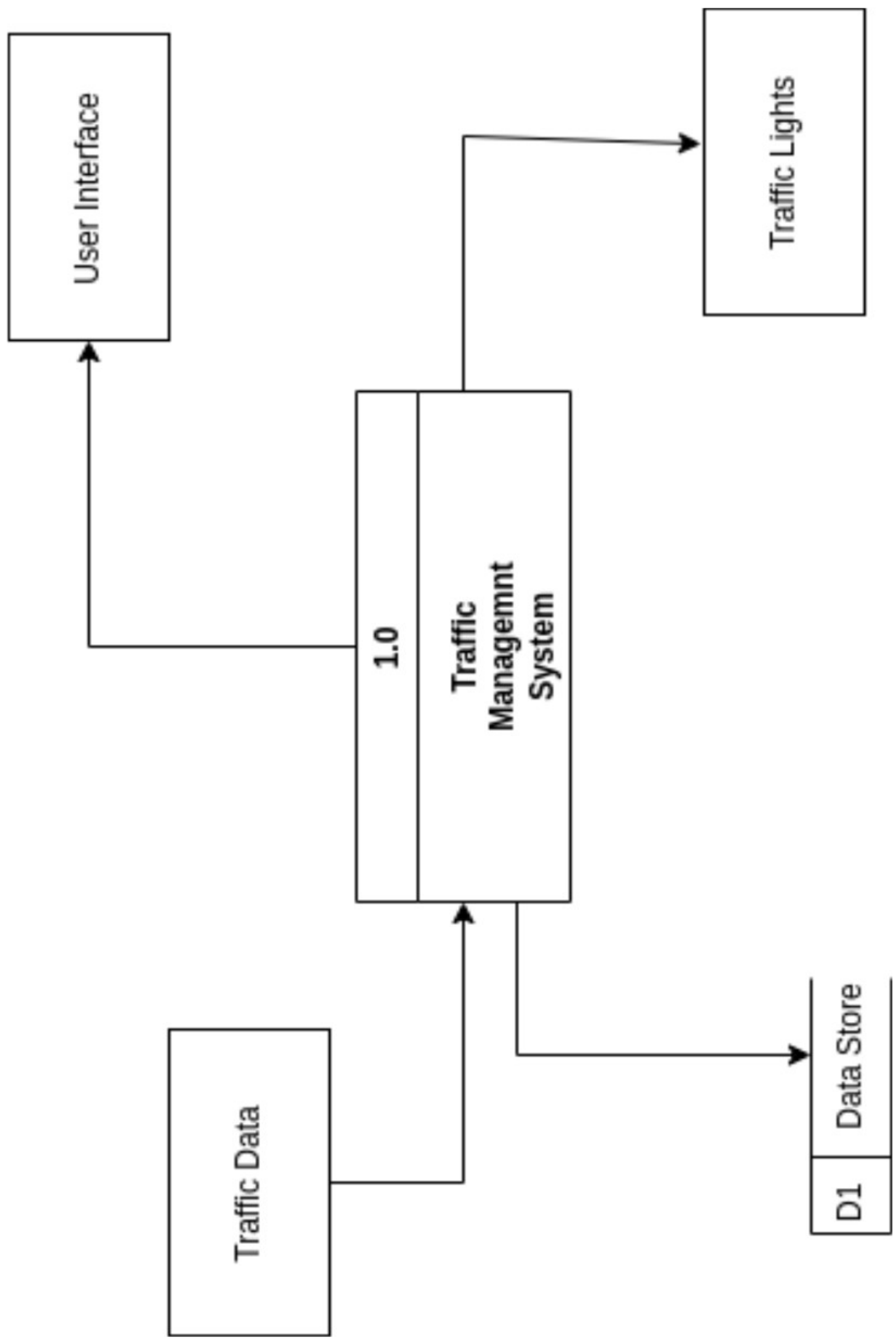


Fig 5.0 DFD Level 0

III. DFD LEVEL 1

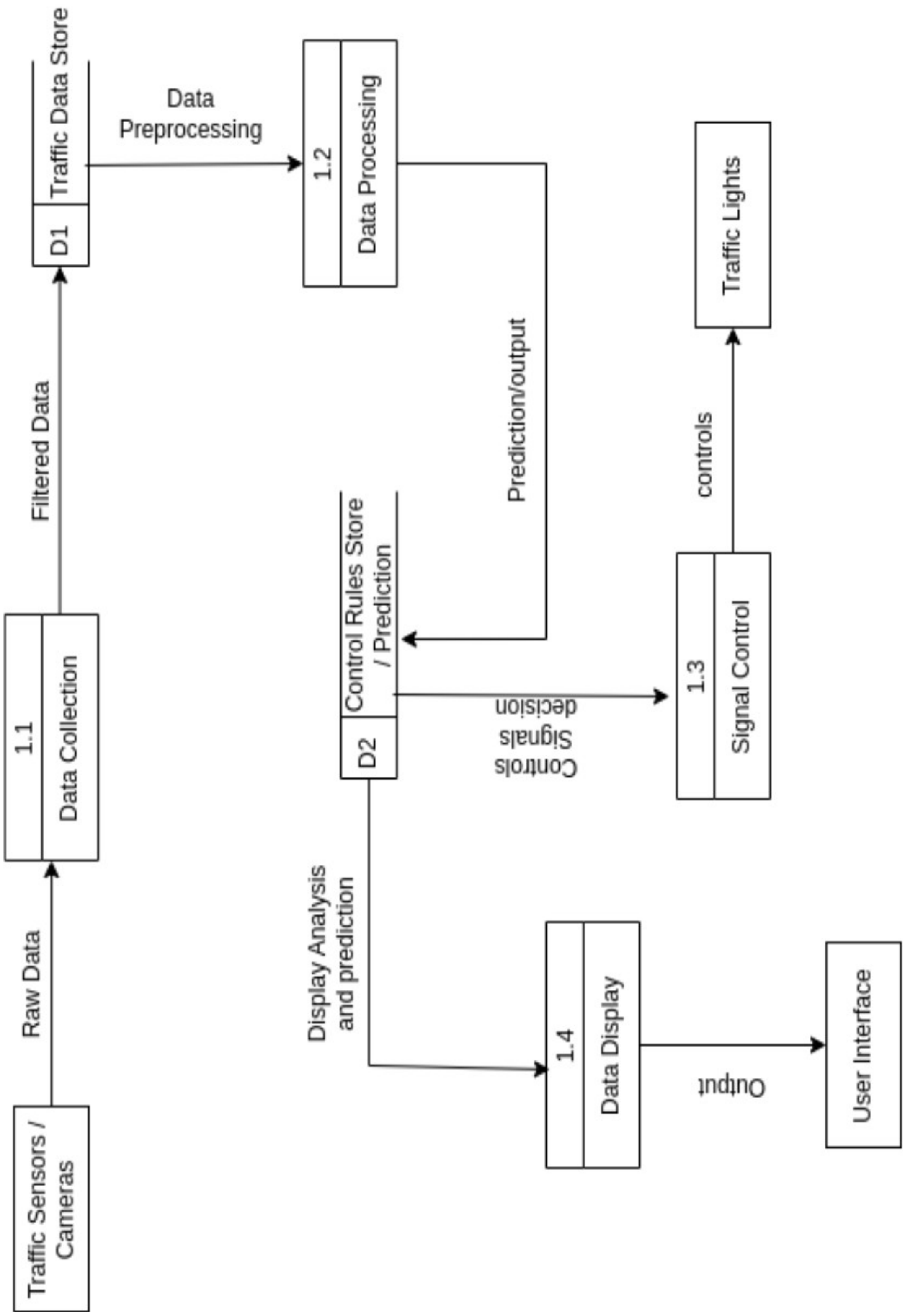


Fig 6.0 DFD Level 1

3.2 System Design

3.2.1 System Architecture

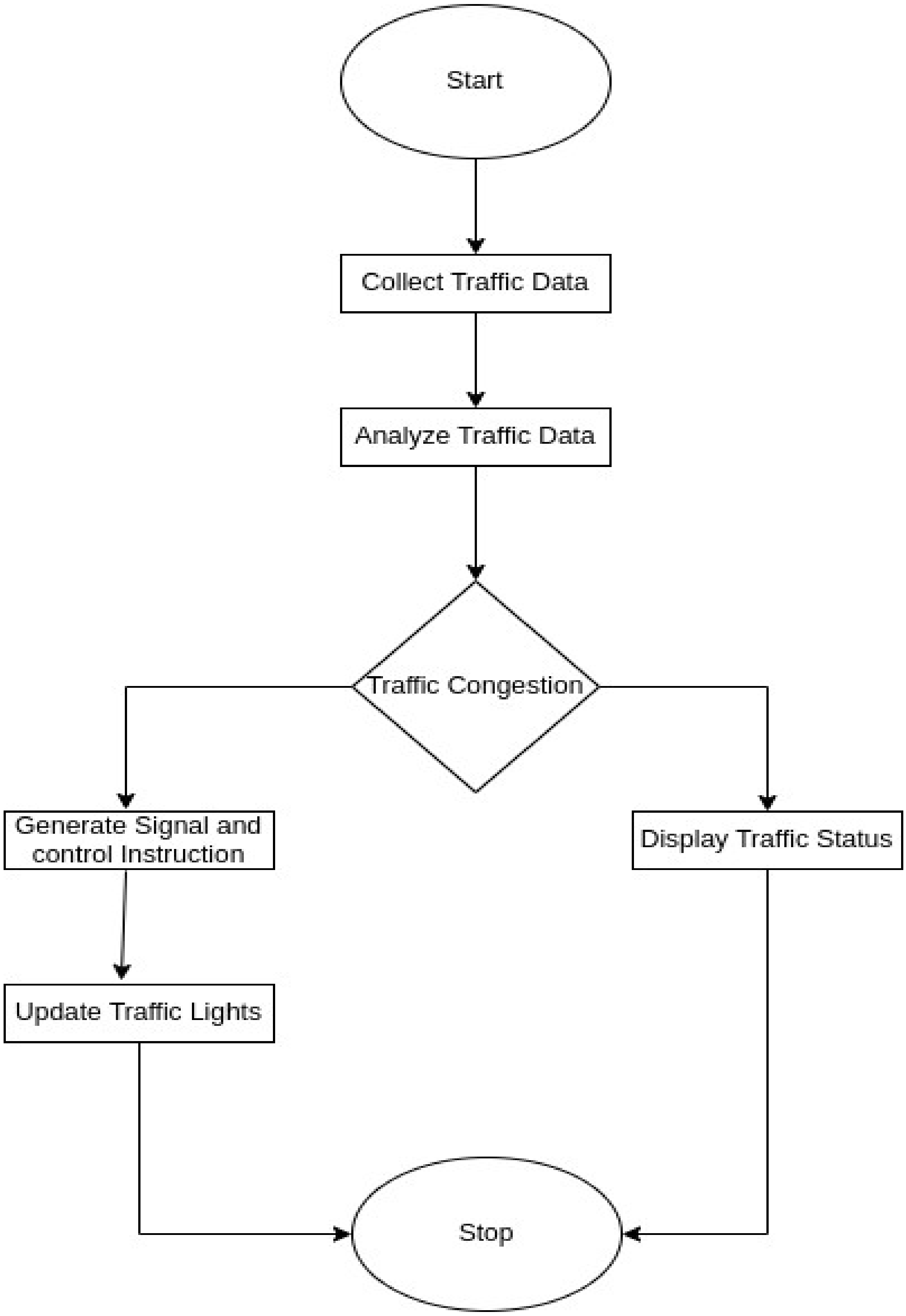


Fig 7.0 Flow Chart

3.2.2 Interface Design (UI Interface)

Fig 8.0 HomePage

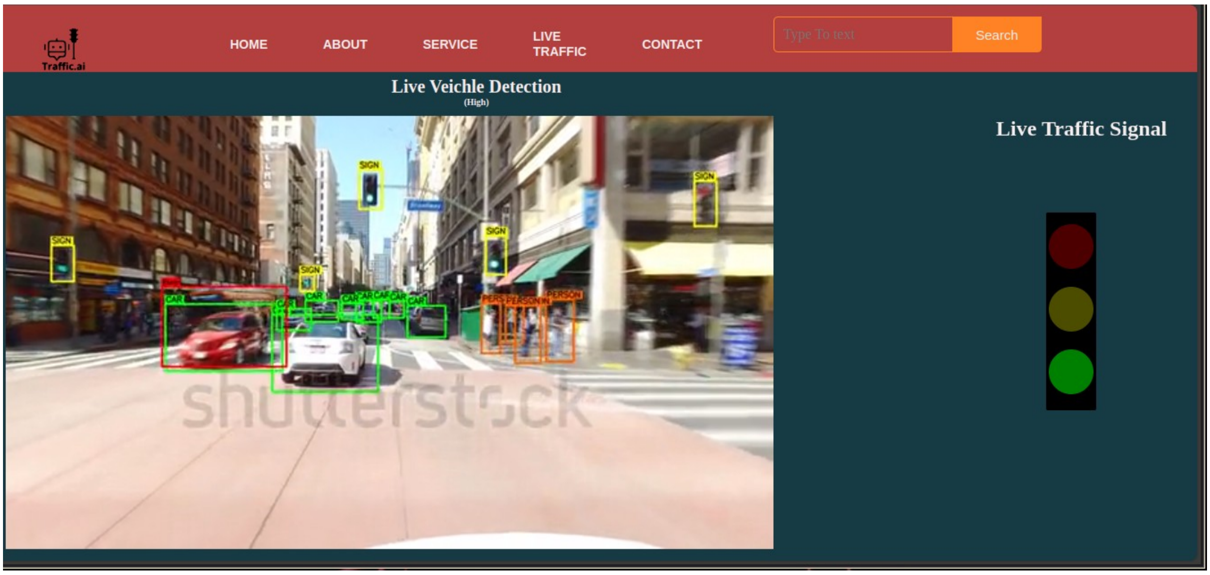


Fig 9.0 Detection

Fig 10.0 Analysis and Prediction

CHAPTER 4

4.1 Implementation

4.1.1 Tools and Technologies Used

- GitHub: For version control and team collaboration. GitHub's robust features allowed efficient management of code versions, tracking changes, and streamlining collaborative development among team members.
- High-Resolution Cameras: Used to capture real-time traffic data. These cameras provided the high-quality images and videos necessary for accurate traffic analysis and monitoring.
- Flask: Chosen as the backend framework due to its simplicity and flexibility. Flask facilitated the creation of RESTful APIs and integration with the machine learning models, handling requests and serving responses efficiently.
- Python: Used extensively for backend development and the implementation of machine learning models. Python's vast libraries and frameworks were integral in data processing, model training, and inference.
- TensorFlow/PyTorch: These machine learning libraries were used to build, train, and deploy models that analyze traffic patterns, detect congestion, and optimize traffic light sequences.
- HTML/CSS: Employed for developing the frontend interface. The use of simple HTML and CSS ensured a responsive and user-friendly design, making the traffic monitoring system accessible and easy to navigate.
- Google Colab: Used for data storage, processing, and model deployment. Google Colab provided the necessary computational power and a collaborative environment to work with large-scale data and complex machine learning models.
- VS Code: The primary code editor for the project. Its support for multiple programming languages and extensive range of extensions made it a suitable choice for both frontend and backend development.
- Dynamic Traffic Light Control Algorithms: Implemented to optimize traffic flow based on real-time data analysis. These algorithms were crucial in adjusting traffic light timings to minimize congestion and improve road safety.

4.2 Testing

Test Case	Expected Input	Expected Output	Actual Input	Actual Output	pass/ fail
Vehicle Type Detection	Image input showing multiple vehicle types (cars, buses, trucks)	Accurate classification of each vehicle type.	Image input showing multiple vehicle types.	Correct classification of each vehicle type (car, bus, truck, etc.)	pass
Traffic Light Adjustment	High congestion detected on the main road.	Traffic light timing adjusts to favor the main road to alleviate congestion.	High congestion detected on the main road.	Traffic light timing adjusts as expected to reduce congestion on the main road	pass
Traffic Volume Prediction	Real-time camera feed data from a busy intersection.	Predicted traffic volume (number of vehicles) for the next 5 minutes.	Real-time camera feed data from a busy intersection	Predicted traffic volume matches the expected number based on historical data	pass

Table 2.0 Testiing

CHAPTER 5

5.1 Future Planning

- Enhanced Machine Learning Models: Continuously improve and update the machine learning models with new data to enhance their accuracy in predicting traffic patterns and detecting incidents. Exploring advanced algorithms and techniques could further optimize traffic control.
- User Feedback and Interface Improvements: Collect feedback from traffic management personnel to identify areas for improvement in the user interface. Enhancing usability and adding features based on user needs can improve the overall effectiveness of the system.
- Improve Traffic Analysis : Integrating more tools and technologies to make easy analysis of traffic.

5.2 Conclusion

In conclusion, this project successfully addresses the issue of urban traffic congestion through the development of a real-time traffic monitoring and control system. By integrating higher resolution cameras for live data collection, dynamic traffic light control algorithms, and machine learning models for predicting traffic patterns, the system offers a more adaptive and efficient approach to managing traffic. The implementation of real-time data adjustments and predictive analytics has demonstrated significant potential for improving traffic flow, reducing congestion, and enhancing overall traffic management.

The system's ability to respond to changing traffic conditions and anticipate issues before they escalate represents a major advancement over traditional fixed-timing traffic light systems. Through continuous data collection and real-time analysis, the system provides traffic management authorities with valuable tools to optimize traffic control, ultimately leading to smoother traffic flow, reduced delays, and lower emissions. The successful integration of these technologies highlights the potential for creating smarter, more sustainable urban mobility solutions.

Appendices

```
newdf = df.drop(columns=['Date'])
newdf.head()
```

	Time	Day of the week	CarCount	BikeCount	BusCount	TruckCount	Total	Traffic Situation
0	12:00:00 AM	Tuesday	13	2	2	24	41	normal
1	12:15:00 AM	Tuesday	14	1	1	36	52	normal
2	12:30:00 AM	Tuesday	10	2	2	32	46	normal
3	12:45:00 AM	Tuesday	10	2	2	36	50	normal
4	1:00:00 AM	Tuesday	11	2	1	34	48	normal

Fig 11.0 Data Visualizaation

```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

RForest_clf = RandomForestClassifier(n_estimators = 100)
RForest_clf.fit(X_train, y_train)
y_pred = RForest_clf.predict(X_test)
accuracy = accuracy_score(y_test, y_pred)*100
print(f'Accuracy: {accuracy}')
```

```
Accuracy: 99.58018471872376
```

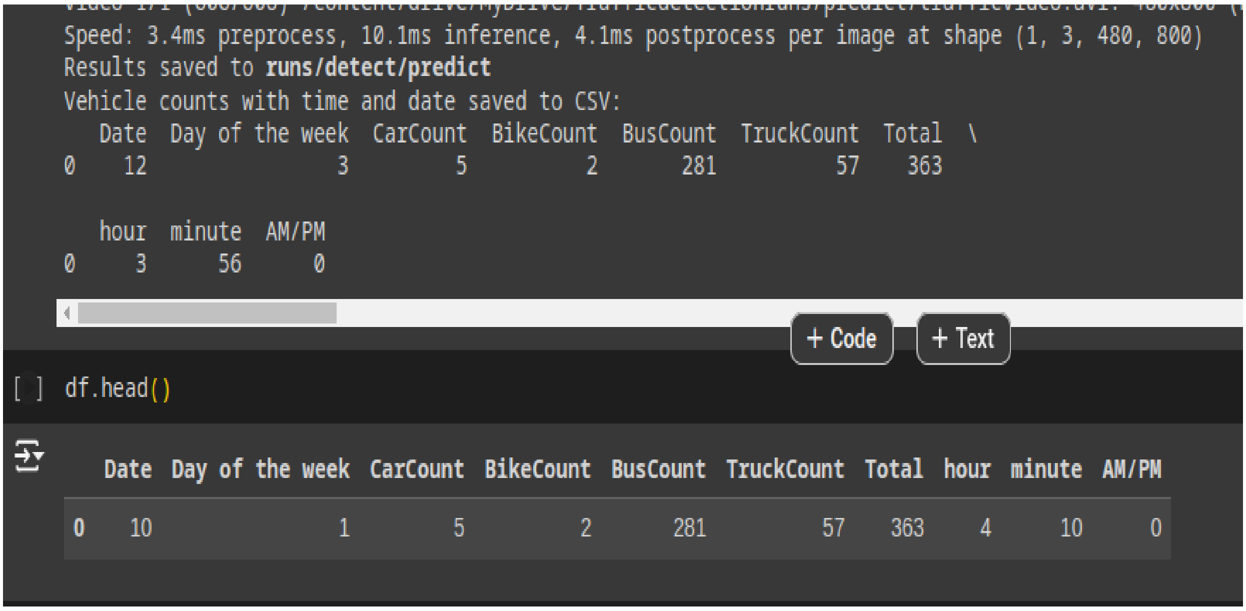
```
import joblib
# Save the trained model to a file
joblib.dump(RForest_clf, 'random_forest_model.pkl')

print("Model saved successfully.")
```

```
Model saved successfully.
```

Fig 12.0 Model Trainning

Fig 13.0 Vehicle Detection and Counting



```
Speed: 3.4ms preprocess, 10.1ms inference, 4.1ms postprocess per image at shape (1, 3, 480, 800)
Results saved to runs/detect/predict
Vehicle counts with time and date saved to CSV:
   Date  Day of the week  CarCount  BikeCount  BusCount  TruckCount  Total  \
0    12                3         5          2       281          57    363

   hour  minute  AM/PM
0     3      56      0
```

```
[ ] df.head()
```

	Date	Day of the week	CarCount	BikeCount	BusCount	TruckCount	Total	hour	minute	AM/PM
0	10	1	5	2	281	57	363	4	10	0

Fig 14.0 Live Traffic Data

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