INTERNET OF THINGS

(CS-3007) REPORT

On

Smart Traffic Control Monitoring System

B. TECH Program in

COMPUTER SCIENCE AND ENGINEERING

SPRING SEMESTER 2024

CONTENTS

TOPIC: Smart Traffic Control Monitoring System

Abstract

Smart traffic control management has emerged as a pivotal solution to address the challenges posed by growing urbanization and increasing vehicular traffic. This paper presents an overview of smart traffic control management systems, focusing on their design, implementation, and benefits. These systems utilize advanced technologies such as artificial intelligence, machine learning, Internet of Things (IoT), and big data analytics to optimize traffic flow, reduce congestion, and enhance safety on roads.

1. INTRODUCTION

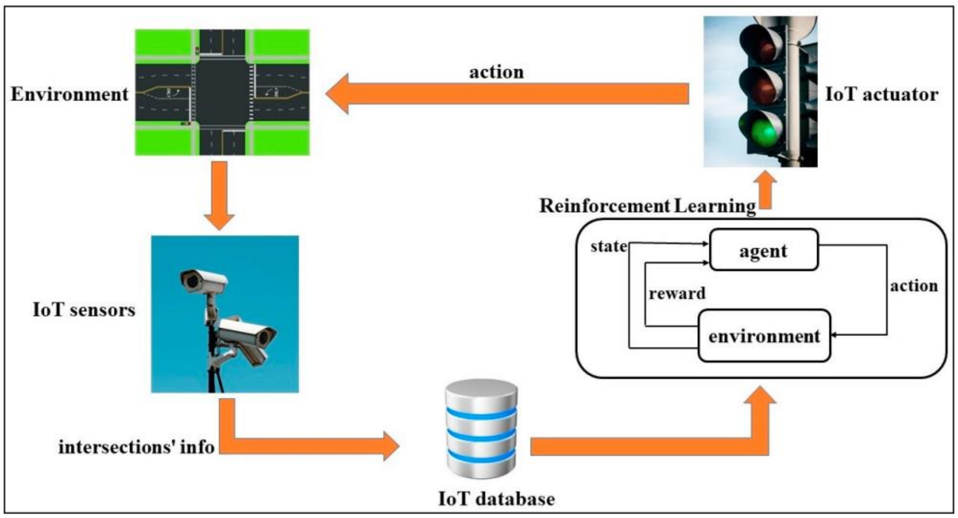
- Brief introduction about the topic

The increasing number of vehicles in metropolitan areas is causing capacity cuts and corresponding Levels of Service on a few road network systems. Mainly Fixated signal timing in traffic management systems is a common source of gridlock. Rising traffic volumes necessitate innovative traffic management methods, and that's where Intelligent Transport Systems come in. According to recent studies, four Indian cities stand in the list of top 10 cities in the world with worst traffic congestion. As per a recent TomTom report on 2022’s traffic trends, the slowest city to drive in India is Bangalore, Pune stands in second place in India, New Delhi stands in third place and Mumbai stands in fourth place in India where there is heavy traffic. Real time road traffic density calculations are necessary to ensure better signal control and effective traffic management, because of the constantly growing volume of traffic. One of the most important factors affecting traffic flows is traffic controllers. There are now three widely established traffic flow management techniques: The first approach, known as "manual controlling," requires the employment of human labor to handle traffic flow. The police utilize a combination of signboards, signal lights, and whistles to direct traffic. The second type of traffic signal is based on classic traffic lights which use static timers. The fixed number is what causes the lights to change from red to green. Third, along the highway, electronic sensors such as sensing devices or proximity sensors may be deployed. These sensors provide information about road traffic. The traffic lights are controlled using data from sensors. These traditional approaches have limitations. The manual control mechanism comes with significant labor expenses. As a result, a more effective form of dynamic traffic control is required. The primary goal of our system is to allow traffic signals to be changed as traffic moves. Our system employs Computer Vision to create a traffic signal controller that can change depending on the flow of traffic. With live video from the security cameras that are installed at busy intersections, determining the amount of traffic in that area can be done in real time and adjusting the green lights suitably. Vehicles are classified into five categories to obtain a reliable estimate of the duration of the green light: automobile, bike, bus, truck, or rickshaw.

- <u>IoT level description</u>

It contains IoT level 4.

At IoT Level 4 within a smart traffic management system, we focus on the control layer. This layer involves the central control system that processes data collected from IoT devices, makes decisions based on that data, and implements actions to optimize traffic flow.



- <u>Objective of our work</u>

In this project we have implemented various software and other components for optimizing traffic control in a real time simulation environment with virtual traffic. We have also implemented a short traffic control circuit which will determine the density of the traffic and determine the distance of the vehicles from the nearby traffic signals and after extracting the data from the software simulation we have analyzed the traffic data to optimize the traffic congestion at various lanes where the traffic is more.

2. LITERATURE REVIEW

Smart traffic control management systems utilizing IoT technologies have emerged as a transformative approach to addressing urban traffic congestion and improving overall traffic efficiency. IoT technologies enable the integration of various devices and sensors, such as traffic cameras, vehicle detectors, and smart traffic signals, into a unified network. These devices collect real-time data on traffic conditions, vehicle movements, and environmental factors, allowing for more accurate and timely traffic management decisions.

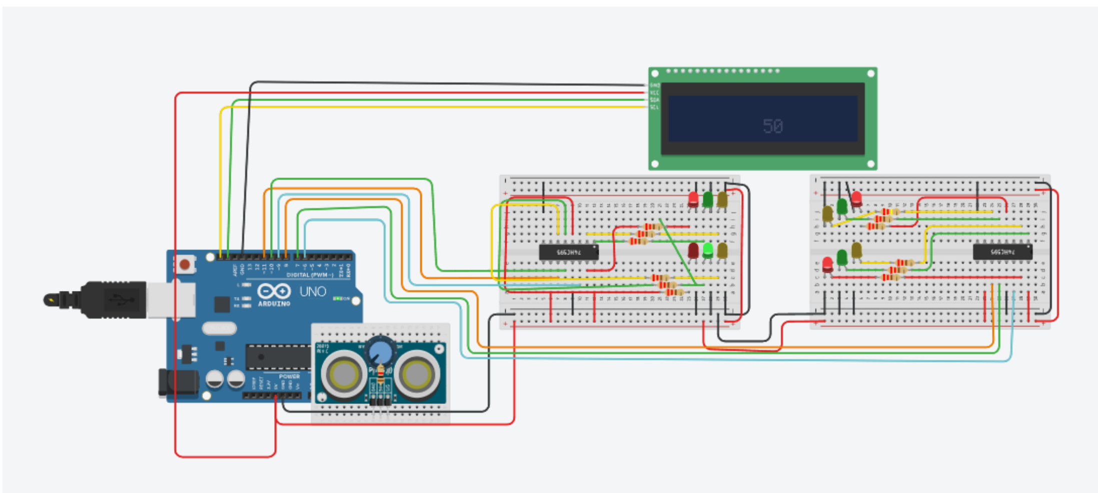
One key component of IoT-enabled traffic control systems is the use of sensors for data collection. These sensors can be embedded in roads, traffic lights, and vehicles to gather information on traffic flow, vehicle speed, and road conditions. This data is then transmitted over communication networks to a central control system, where it is analyzed to generate insights and inform traffic management strategies.

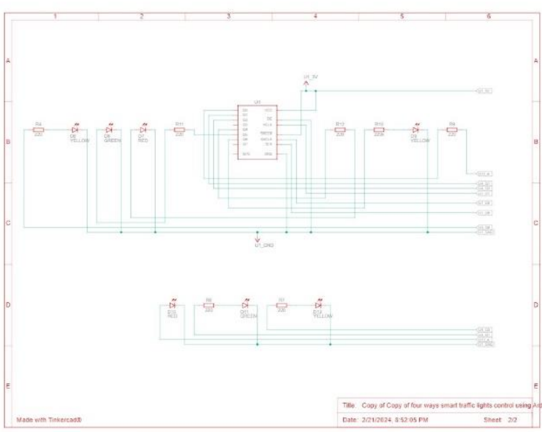
IoT technologies also enable dynamic and adaptive traffic control mechanisms. By analyzing real-time data, traffic signals can be adjusted in response to changing traffic conditions, optimizing traffic flow and reducing congestion. Additionally, IoT-enabled systems can provide valuable information to drivers, such as real-time traffic updates and alternative route suggestions, further improving overall traffic management.

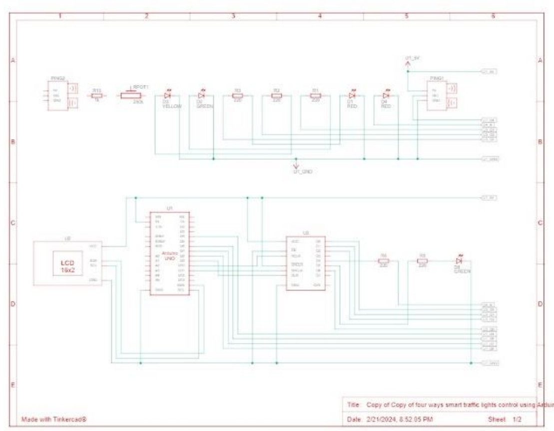
Despite the benefits, IoT-enabled traffic control systems also face challenges. These include data privacy concerns, interoperability issues between different IoT devices, and the need for robust cybersecurity measures. However, ongoing research and development efforts are focused on addressing these challenges and further enhancing the capabilities of IoT in traffic management.

3. SYSTEM MODEL

- Circuit Diagram







Link for Circuit Simulation: https://www.tinkercad.com/things/3Xs1VOxs8em-copy-of-four-ways-smart-traffic-lights-control-using-arduino-

- Components used

1) **Arduino Uno R3:** Arduino R3 can be used to control a traffic light system. We can program it to manage the timing of the lights, simulate different traffic scenarios, and even integrate sensors to detect and respond to traffic conditions. It's a great way to learn about programming, electronics, and traffic management systems.

2) **Potentiometer 250 ohm:** In a traffic light system, a 250-ohm potentiometer could be used to adjust the timing of the lights. By connecting the potentiometer to an analog input pin on the Arduino R3, you can read the resistance value and use it to dynamically adjust the timing of the traffic lights. This allows for manual adjustment of the traffic light timings based on traffic conditions or other factors.

3) **LCD (I2C) Type MCP23008-Based Address 32: Using an LCD (I2C) type MCP23008**-based address 32 in a traffic light system can offer several benefits, primarily in terms of providing status information and control interface. Here's how it can be utilized:

Displaying Status Information: The LCD screen can be used to display various status information related to the traffic light system, such as current signal phases, countdown timers, and system health indicators. This information can be useful for traffic engineers, pedestrians, and drivers to understand the state of the traffic lights.

User Interface for Configuration: The LCD screen can serve as a user interface for configuring the traffic light system parameters, such as timing intervals for each signal phase, emergency override controls, and sensor input settings. This can make it easier for traffic engineers to adjust the system parameters as needed.

Error Reporting and Diagnostics: The LCD screen can also display error messages and diagnostic information in case of system failures or malfunctions. This can help maintenance personnel quickly identify and troubleshoot issues with the traffic light system.

Integration with Control Logic: The MCP23008-based I2C interface can be integrated with the control logic of the traffic light system to provide real-time updates to the LCD screen based on the current state of the system. This ensures that the information displayed on the screen is always accurate and up to date.

Enhanced Visibility and Accessibility: By adding an LCD screen to the traffic light system, important information can be made more visible and accessible to pedestrians and drivers, especially in busy intersections or adverse weather conditions where visibility may be limited.

In this circuit the component only shows the countdown timers of the traffic light.

4) **8-bit shift Register:** Light Sequencing: It controls the sequence of lights for different traffic phases.

Timing Control: It manages the timing of each phase by synchronizing with a clock signal.

Intersections Synchronization: It coordinates multiple intersections, ensuring smooth traffic flow.

Fault Tolerance: It enhances system resilience by quickly recovering from disruptions.

Integration with Microcontrollers: It works seamlessly with microcontrollers for programmable control and flexibility.

Overall, 8-bit shift registers play a crucial role in managing and optimizing traffic light operations, contributing to safer and more efficient urban traffic management.

5) **Ultrasonic Distance sensor:** Vehicle Detection: Optimizing signal timings based on real-time traffic flow.

Pedestrian Safety: Extending crossing times when pedestrians are detected.

Queue Management: Minimizing queue lengths and reducing delays for drivers.

Emergency Vehicle Detection: Preemptively clearing paths for emergency vehicles.

Adaptive Signal Control: Adjusting signal timings in response to changing traffic conditions.

Environmental Monitoring: Alerting drivers and pedestrians to hazardous conditions like flooding or ice accumulation.

6) **resistors 220 ohm each:** Limits LED Current: Ensures LEDs operate within safe current ranges.

Regulates Voltage: Controls current flow based on fixed voltage supplies.

Protects Against Overcurrent: Guards LEDs from electrical fluctuations or power surges.

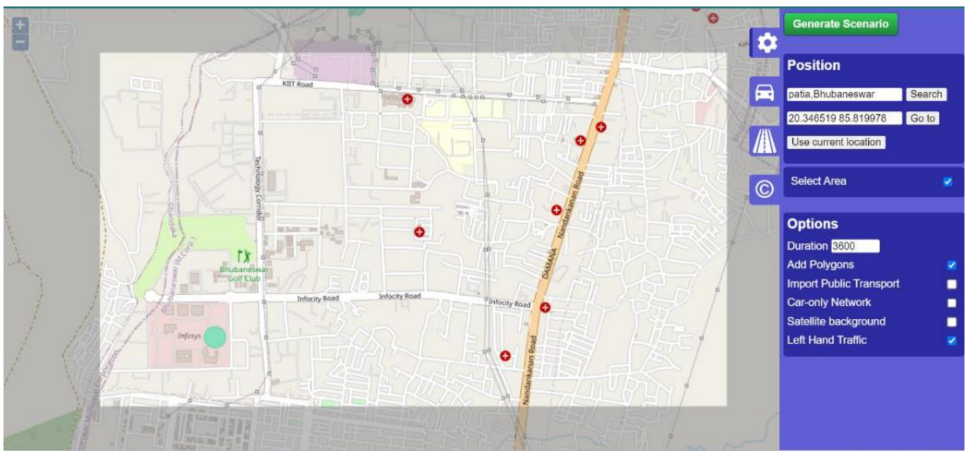
Ensures Consistency: Maintains uniform brightness and performance across signals.

Compatible with Power Supplies: Works effectively with typical traffic light voltage levels.

Apart from the Circuit Components we have used software for virtual simulation of the traffic the software components that we have used are the following:

Osm Web Wizard: The purpose of the OSM (OpenStreetMap) web wizard is to provide a user-friendly interface for creating and editing maps on the OpenStreetMap platform. The web wizard simplifies the process of contributing to OpenStreetMap by guiding users through the steps of adding and editing map features such as roads, buildings, landmarks, and more. It typically includes tools and prompts to help users add data accurately and efficiently, making it easier for both experienced mappers and newcomers to contribute to the OpenStreetMap database.

We have used OSM Web Wizard to create and edit maps of various locations. The movement of vehicles, mainly cars, buses and trucks have been shown in this application on respective maps.

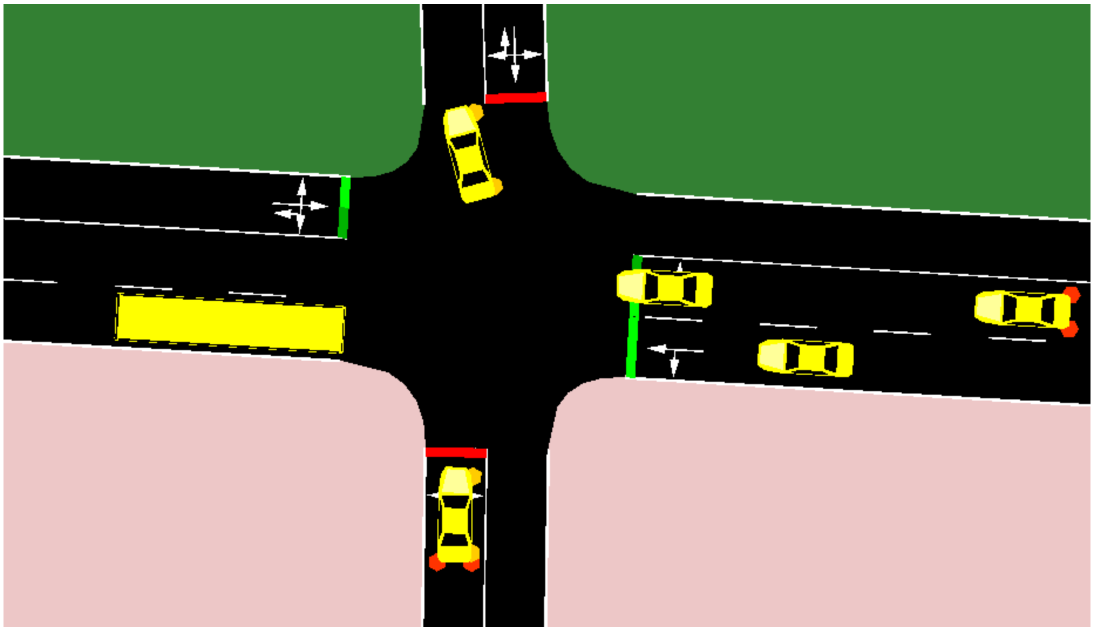


Netedit: Netedit is a software tool used in transportation planning and engineering. Its primary purpose is to facilitate the creation, editing, and analysis of transportation network data. This includes road networks, public transportation routes, intersections, traffic signals, and other related infrastructure elements.

We have used Netedit to add notable traffic signals on main roads.

Sumo-gui: SUMO-GUI, which stands for "Simulation of Urban Mobility - Graphical User Interface," is a component of the SUMO software suite. SUMO is an open-source traffic simulation package that allows users to simulate road traffic, including cars, buses, pedestrians, and other types of vehicles, within urban environments. The purpose of SUMO-GUI is to provide a user-friendly graphical interface for creating, configuring, running, and analyzing traffic simulations using SUMO.

The overall simulation of this project is performed with my Sumo-gui. We have used this to show the movement of various vehicles on respective maps(location). Their speed, turnings and traffic signaling discipline, all have been shown in this simulation.



- Working Principle

In this project we have developed a virtual circuit which will be connected to Sumo GUI software for controlling the traffic signals. The traffic signal roadmap is created virtually where the circuit sensors are implemented at various junctions and controlling the traffic signals, as the sensor works, we automatically receive data of traffic strength on the Sumo-gui. The fetched data will contain the number of vehicles passing through each lane at a certain time interval also if any vehicle breaks the traffic rule it automatically sends the information of the vehicle. All these data collected will help us to optimize the traffic through software platform where we can analyze the data and prepare and optimal solution for smooth traffic control and control the circuit at the junctions accordingly, so the traffic becomes smooth without any congestion and the breaking of traffic rules becomes less.

4. RESULT ANALYSIS

After extracting the traffic data from the simulation, we have performed data analysis to predict the traffic based on various parameters like car count, bus count, truck count and overall traffic at different junctions. We have also created a model using machine learning to predict the traffic based on vehicle type which will help us to optimize the traffic by changing the traffic signals at various lanes.

1. At first, we processed the data to check the data attributes and amount of data we need to analyze the data.

	CarCount	BusCount	TruckCount	Total	Traffic Situation	Unnamed: 5	Junction
0	31	4	4	39	low	NaN	1
1	49	3	3	55	low	NaN	1
2	46	3	6	55	low	NaN	1
3	51	2	5	58	low	NaN	1
4	57	15	16	94	normal	NaN	1

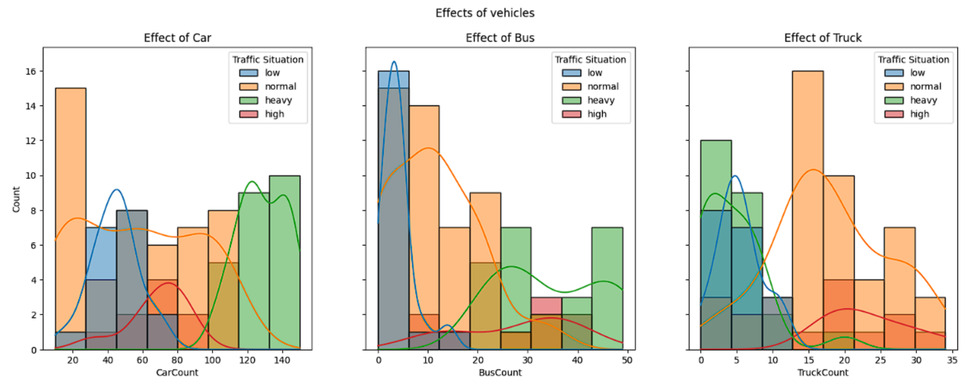
	CarCount	BusCount	TruckCount	Total	Traffic Situation	Unnamed: 5	Junction
94	14	0	33	48	normal	NaN	5
95	17	0	22	41	normal	NaN	5
96	12	1	17	32	normal	NaN	5
97	18	0	29	47	normal	NaN	5
98	16	0	14	31	normal	NaN	5

We have seen that our data has the following attributes which are suitable for further analysis.

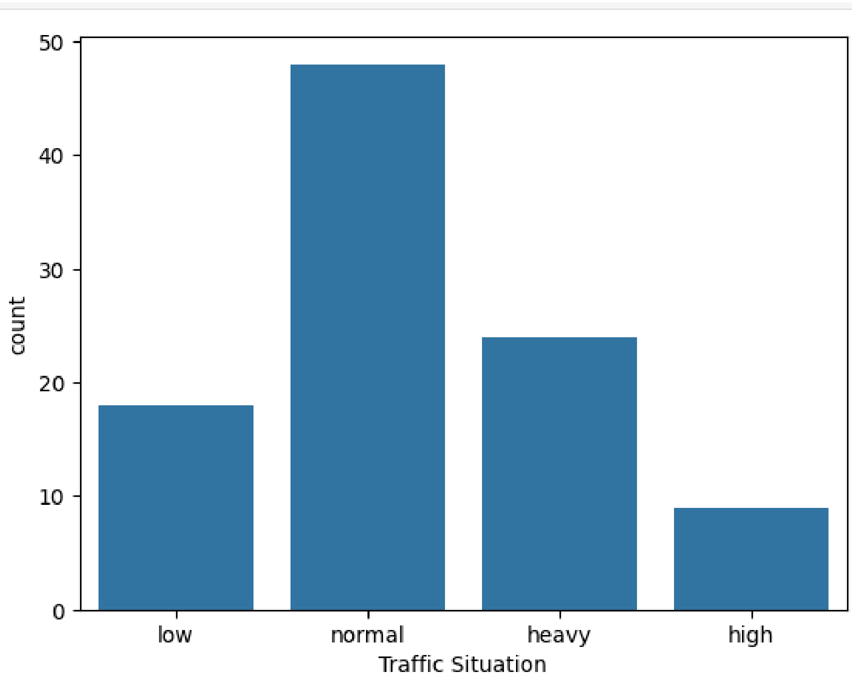
2. After preprocessing the data, we have calculated the mean value and the standard deviation and percentage of the entire dataset which are required for building our model,

	CarCount	BusCount	TruckCount	Total	Unnamed: 5	Junction
count	99.000000	99.000000	99.000000	99.000000	0.0	99.000000
mean	73.343434	17.111111	12.858586	117.868687	NaN	2.787879
std	41.045063	14.484255	9.459916	56.238132	NaN	1.162972
min	10.000000	0.000000	0.000000	27.000000	NaN	1.000000
25%	41.500000	4.000000	5.000000	66.500000	NaN	2.000000
50%	67.000000	14.000000	13.000000	113.000000	NaN	3.000000
75%	108.000000	28.000000	19.500000	163.000000	NaN	3.000000
max	150.000000	49.000000	34.000000	226.000000	NaN	5.000000

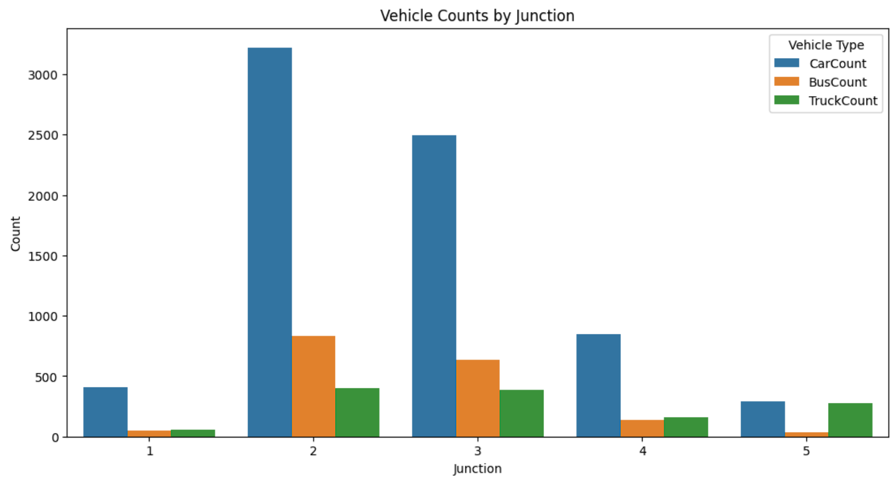
3. After preprocessing the data, we performed data visualization to get the overall idea of the data set. We have plotted various figures to show how each parameter is related to each other.



This plotting the shows us the effect of different vehicles based on traffic situations



This plotting shows us the overall traffic situation based on the dataset that we have collected from the simulation.



This plotting shows the different vehicles count density at different junctions.

4. Model creation

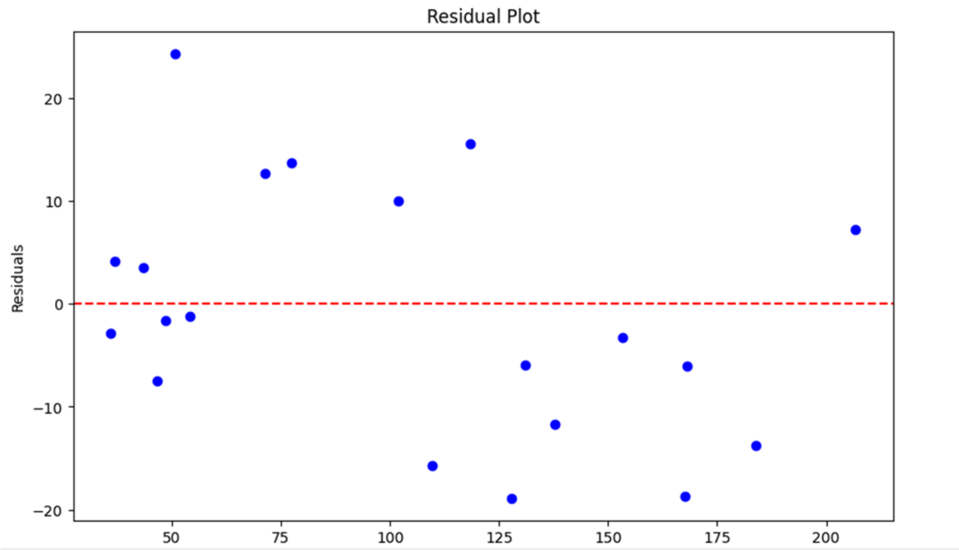
Based on our dataset we have used machine learning algorithm to create a model named as 'Random Forest Model' which will predict the traffic congestion and vehicle count based on the dataset we have extracted. We have trained our model based on different attributes and our model will predict the vehicle count based on traffic situation and junction number.

After creating the model, we found that our model can predict the values with an accuracy of 94% and calculated the mean square error based on the data with which we have trained our model.

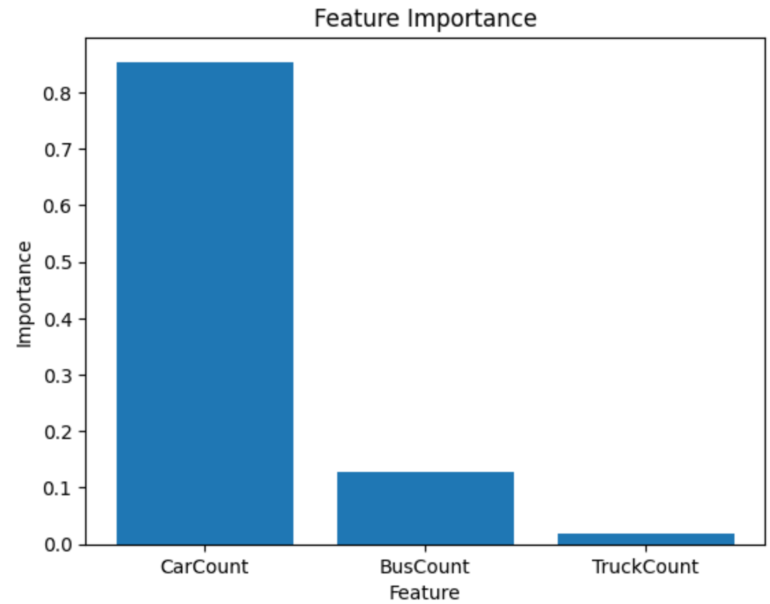
```
Random Forest - Mean Squared Error: 127.710259996583
Random Forest - Accuracy Score: 0.948594870970578
```

Mean Squared Error (MSE) is a common metric used to evaluate the performance of a regression model. It measures the average squared difference between the actual and predicted values in the dataset.

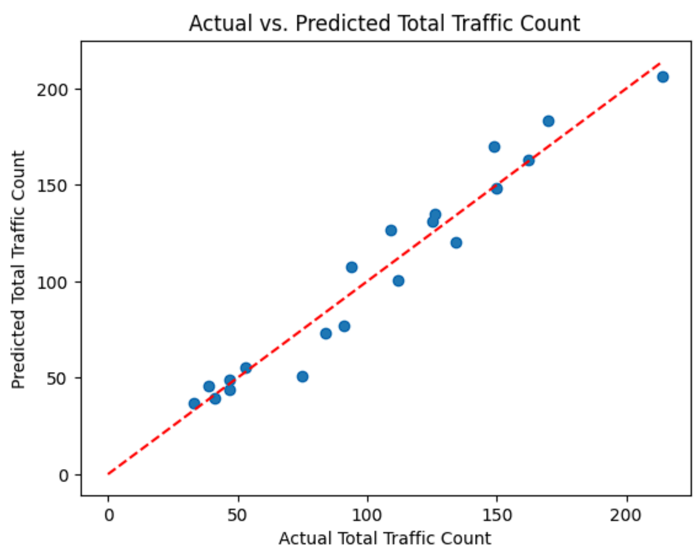
After the model creation we have plotted the accuracy in which we have found that the blue dots are the predicted values and the red dotted line is the actual values we can find that many blue dots are nearly placed on the actual model which determines that the error percentage in our model is very less and the model is best suited for our dataset.



We have also plotted the feature importance of the attributes we have used to train our model.



And lastly, we have plotted the actual and predicted traffic count which our model is trained for



We have found that the model is nearly predicting the traffic count with a high accuracy based on the junction number and the vehicle count in the dataset

5. CONCLUSION

This project mainly focuses on smooth traffic control by analyzing a given set of traffic data through various software and circuit implementations and machine learning algorithms to optimize the traffic congestion.

References:

A SUMO Based Simulation Framework for Intelligent Traffic Management

System

Article in Transportation Research Part C Emerging Technologies · June 2020

DOI: 10.18178/jtle.8.1.1-5

Link-
https://www.researchgate.net/publication/338790110_A_SUMO_Based_Simulation_Framework_for_Intelligent_Traffic_Management_System.

STUDENTS SIGNATURE with Roll No.

- Name: Ayan Kumar Paul Roll: 21052064
- Name: Swapnanil Bera Roll: 21052962
- Name: Shubhadeep Mohanta Roll: 21051937
- Name: Akash Singh Roll: 21052048
- Name: Aditya Singh Roll: 21052642
- Name: Mayank K. Kaushik Roll: 21053369
- Name: Shaheen Haque ROLL: 22057055