B. Tech ECE PROJECT 1 Review 2

Advancement in Predictive Vehicle Collision Avoidance Technologies & Traffic Simulation

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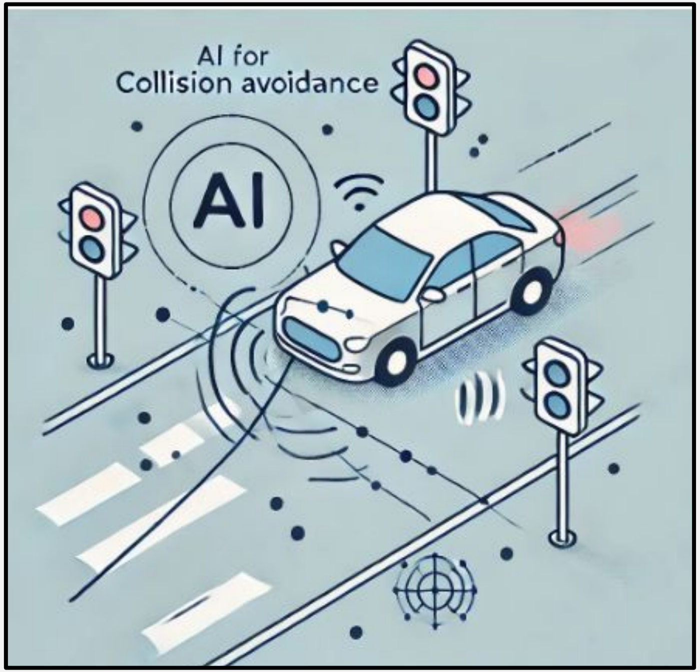
LITERATURE SURVEY

Ref No.	Publisher	Date of Journal	Focus/Scope of Paper	Methodology	Test Data	Results	Merits & Demerits	Future Scope
1	IEEE Transactions on ITS	2022	Machine learning for predictive vehicle collision	Deep Learning Neural Networks	Real-time vehicle sensor data	95% accuracy in collision prediction	High accuracy, but computationally intensive.	Focus on real-time deployment for autonomous vehicles
2	Springer: Advances in Simulation	2021	Traffic simulation models for vehicle avoidance	Multi-Agent Simulation	Traffic flow data, synthetic dataset	Improved traffic flow with 30% fewer collisions	Simulated data limits generalization; high simulation cost.	Integration with real-world traffic management systems
3	Elsevier: Transportation Research Part C	2020	Comparative analysis of ML algorithms for collision avoidance	SVM, Decision Trees	Crash incident data	SVM outperformed decision trees in predictive accuracy	Good performance in sparse data; overfitting in decision trees.	Incorporating more data and hybrid models
4	ACM Digital Library	2023	Predictive analytics for real-time collision avoidance	Reinforcement Learning	Live traffic data	20% improvement in real-time response rate over traditional systems	Real-time adaptability, but requires extensive training data.	Training on diverse traffic conditions
5	MDPI Sensors	2022	IoT sensors for enhancing vehicle collision prevention	IoT-based ML algorithms	Sensor-generated vehicle data	Accurate detection of potential collisions with 85% reliability	High sensor accuracy, but potential hardware limitations in older cars.	Development of low-cost IoT-based solutions

IDENTIFYING THE GAP

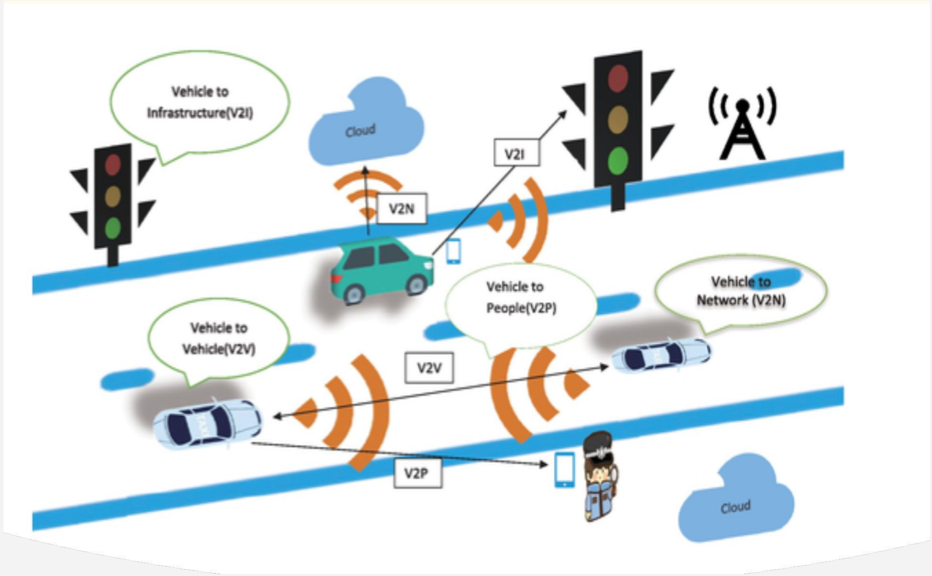
- Drastically reduce the rate of road accidents, Incorporate available advanced technology, and Seek public safety.
- Benefiting with economic savings to environmental sustainability, it reaches to more direct impacts toward setting international safety standards and sustainable development efforts.
- **Data Challenges:** Limited high-quality data, diversity, and bias issues.
- **Model Limitations:** Complex models can be difficult to interpret and computationally intensive.
- **Ethical Concerns:** Liability, privacy, and job displacement.



PROBLEM STATEMENT

Despite all of the above-mentioned preventive measures that have been mentioned in an attempt to combat the problem of road safety, the cases of road accidents are still aggressively high.

This is why there is a necessity of allowing reliable communication for vehicles to communicate with each other and to distribute some of the decision-making activities to a smarter, intelligent system that can use information obtained from the exchange of messages for detecting possible collisions and then to take automatic actions to avoid them. V2V communication enables vehicles to exchange messages among themselves with the aim of warning drivers of impending accidents and preventing crashes. The NHTSA believes that V2V technology may save 82 percent of multi-vehicle crashes.



Relevance of the problem statement w.r.t to SDG

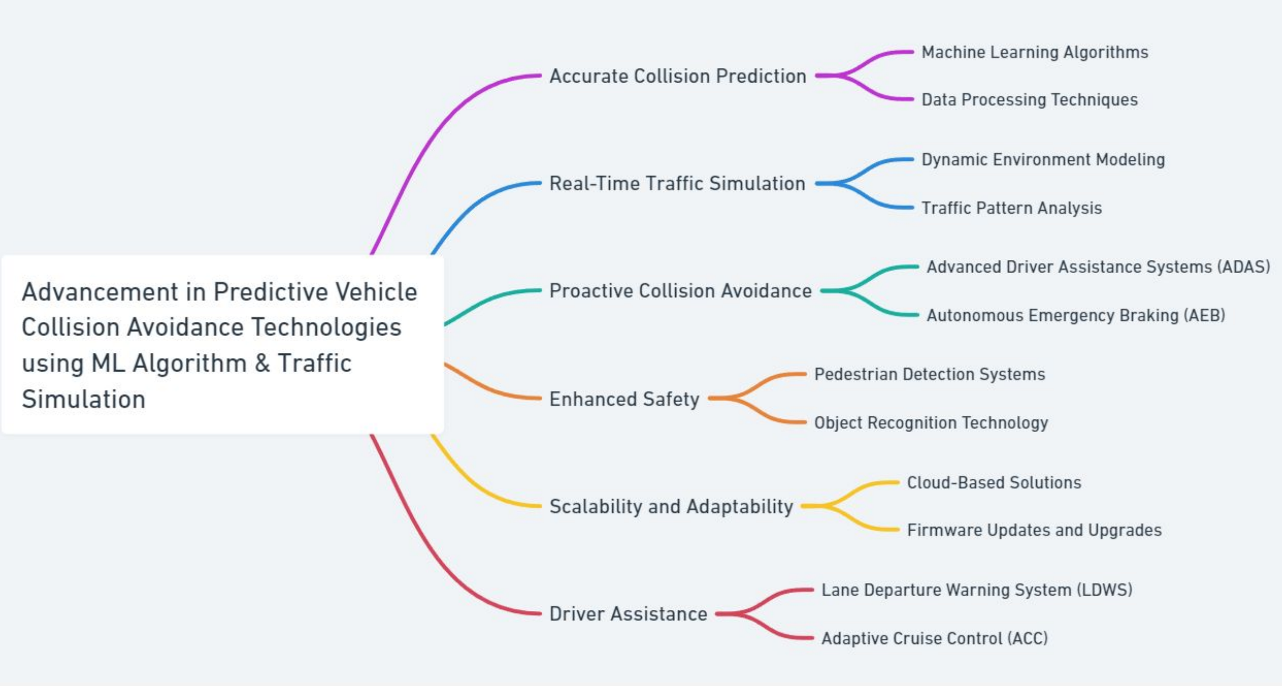
The **Predictive Vehicle Collision Avoidance System (PVCAS)** aligns with several **Sustainable Development Goals (SDGs)** set by the United Nations, particularly those focused on safety, sustainability, and innovation. Below are some of the key SDGs:

- SDG 3: Good Health and Wellbeing
- SDG 9: Industry, Innovation, and Infrastructure
- SDG 11: Sustainable Cities and Communities
- SDG 12: Responsible Consumption and Production
- SDG 13: Climate Action
- SDG 8: Decent Work and Economic Growth
- SDG 16: Peace, Justice, and Strong Institutions
- SDG 17: Partnerships for the Goals

PROJECT OBJECTIVE

The key objectives for **Advancement in Predictive Vehicle Collision Avoidance Technologies using ML Algorithm & Traffic Simulation**:

- Accurate Collision Prediction
- Real-Time Traffic Simulation
- Proactive Collision Avoidance
- Enhanced Safety
- Scalability and Adaptability
- Driver Assistance



PROPOSED SYSTEM/ARCHITECTURE/DESIGN

(Design Approach/System Model/Algorithm)

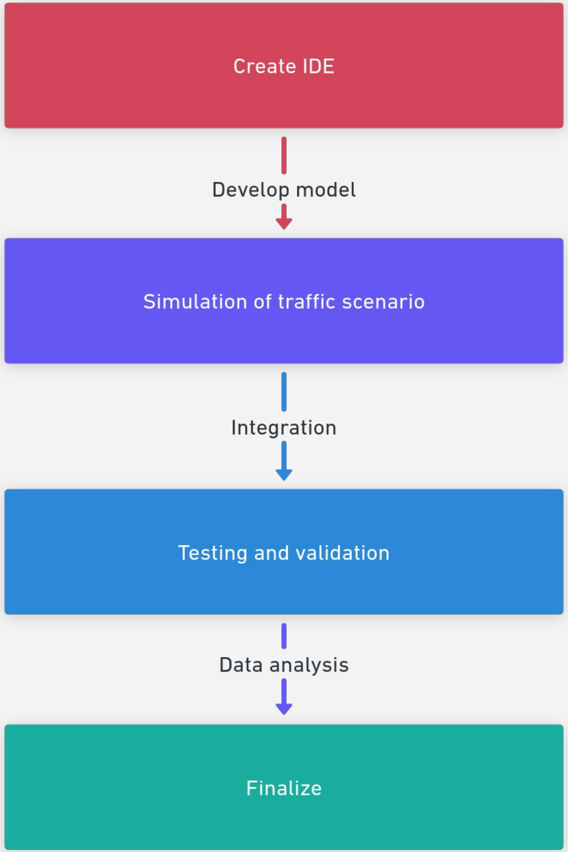
1. **Create IDE:** The IDE (Integrated Development Environment) for this SUMO-based traffic simulation project should include Tools like SUMO , Notepad ++ ,NetEdit, Python/TraCI

2. **Model Development:** Traffic models are built by defining roads, setting traffic demand, configuring signals, and running simulations to analyze and improve traffic flow in urban areas.

3. **Simulation of Complex Scenarios of Traffic:** To calibrate the system towards predicting a collision in complex traffic environments and scenarios.

4. **Integration of the model :** Integrating ML models within traffic systems and vehicle sensors so that collision avoidance can be achieved

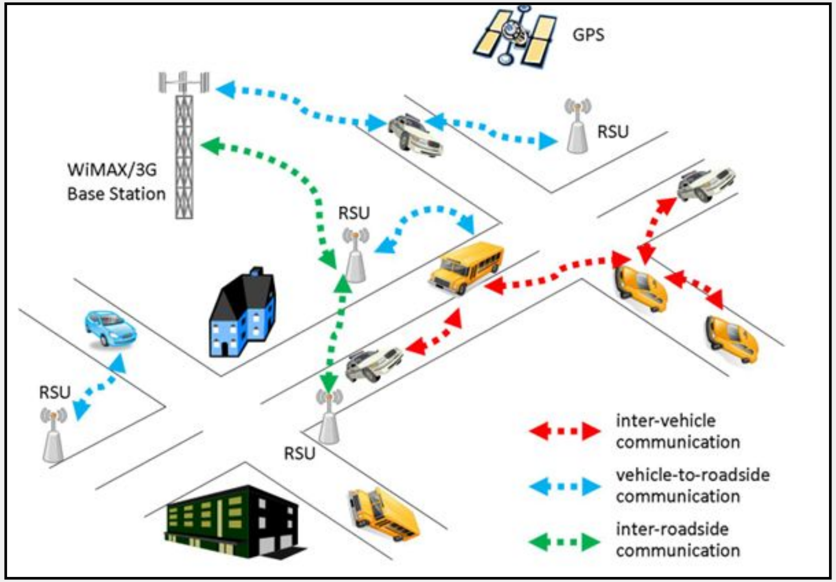
5. **Testing and validation :** Testing in simulated environments as well as actual real-world tests, with the objective of optimizing performance, accuracy, and safety.



ANALYTICAL AND THEORETICAL DESCRIPTION

Vehicular Ad-Hoc Networks allow Dedicated Short-Range Communications of vehicles in the 5.9 GHz band, based on the IEEE 802.11p standard. They support Intelligent Transport Systems with both, V2V) and (V2I) communications for applications in the both the near and far environment Vehicular Ad hoc Networks are formed applying the principles of mobile ad hoc networks and constitute a subcase of Mobile Ad hoc Networks.

VANETs use any wireless communication technology to generate the networks enhancing Vehicle-to-Vehicle communication, as well as vehicle-to-infrastructure communication. VANETs are prone to partitioning, as their topology is highly dynamic. This fact implies that there will most probably be many disconnections during those changes in structure in their network. This characteristic makes the designing of an efficient solution to disseminate data in a particular way between vehicles a very difficult challenge in the area of V2V communications.

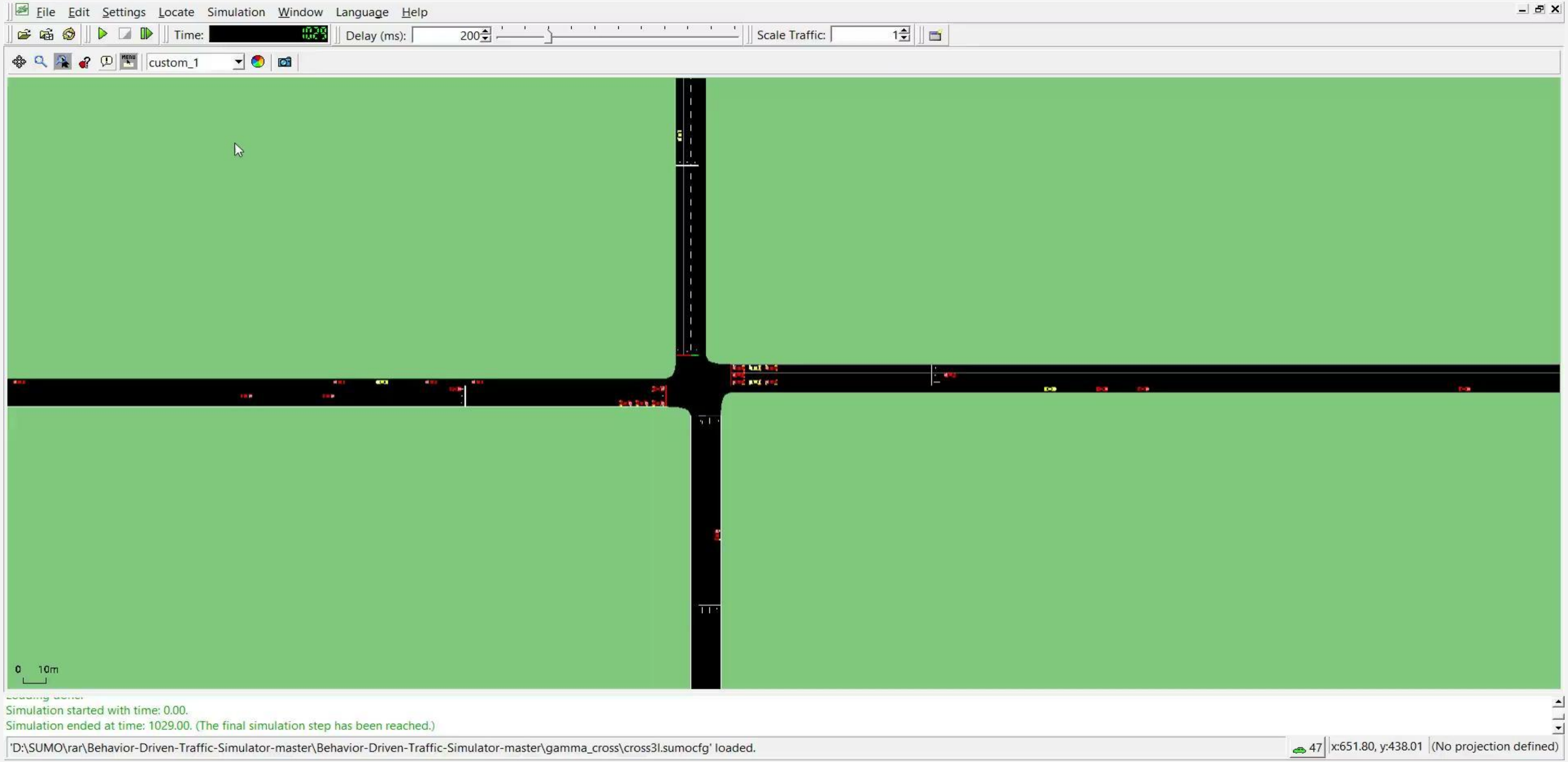


HARDWARE/SOFTWARE DETAILS

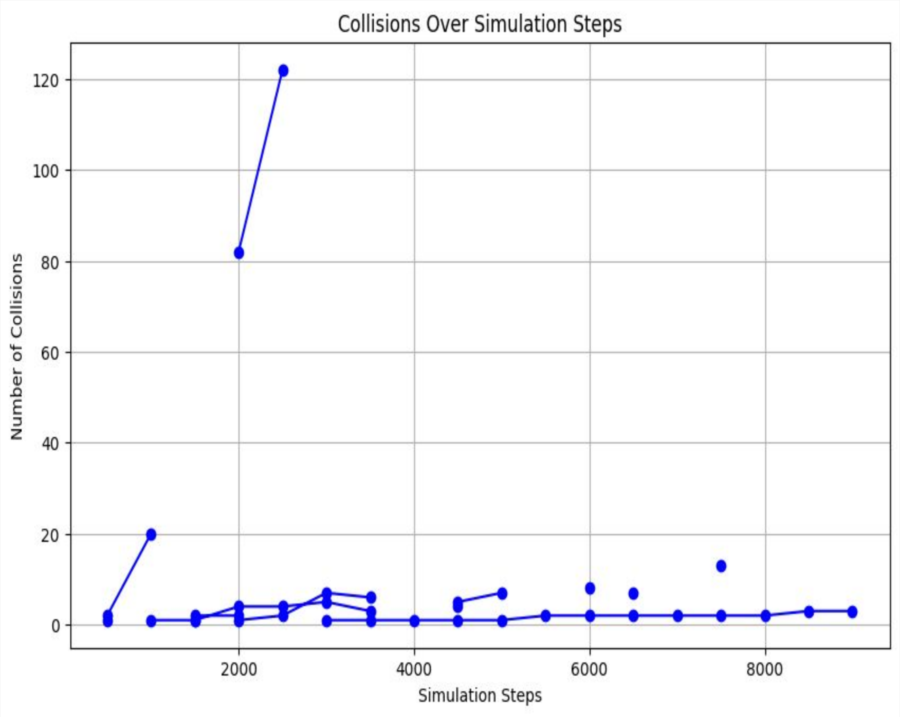
Tools and Technologies in Integrated Environment

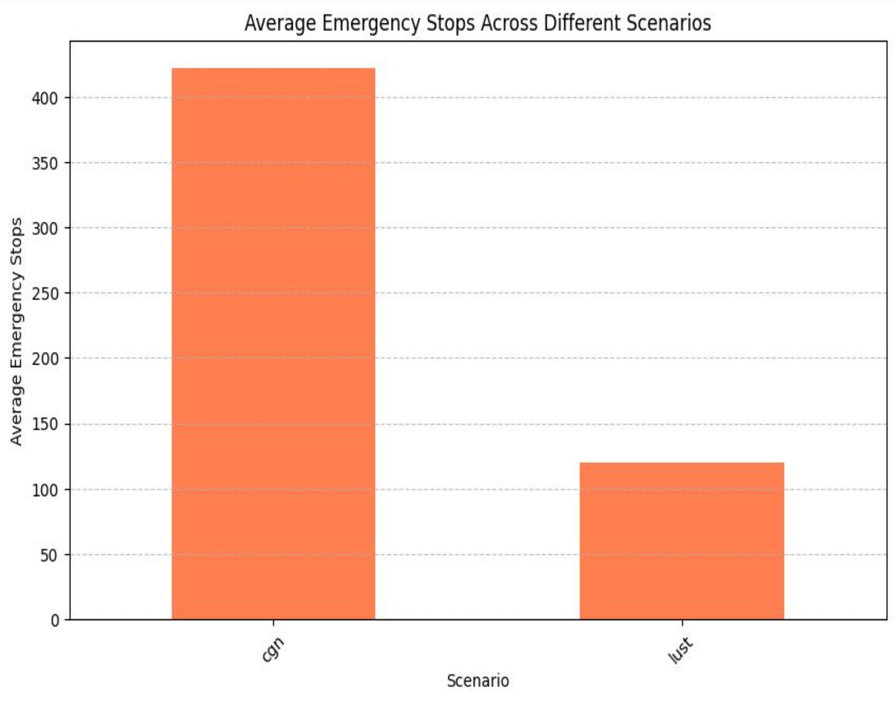
Component	Tools/Technologies
Simulation Environment	SUMO, Netedit
Python API	TraCI
Data Processing	NumPy, Pandas
Visualization	Matplotlib, Seaborn
IDE	VS Code, Google Colab
Open Source Library	Notepad++ (Scintilla Editing)

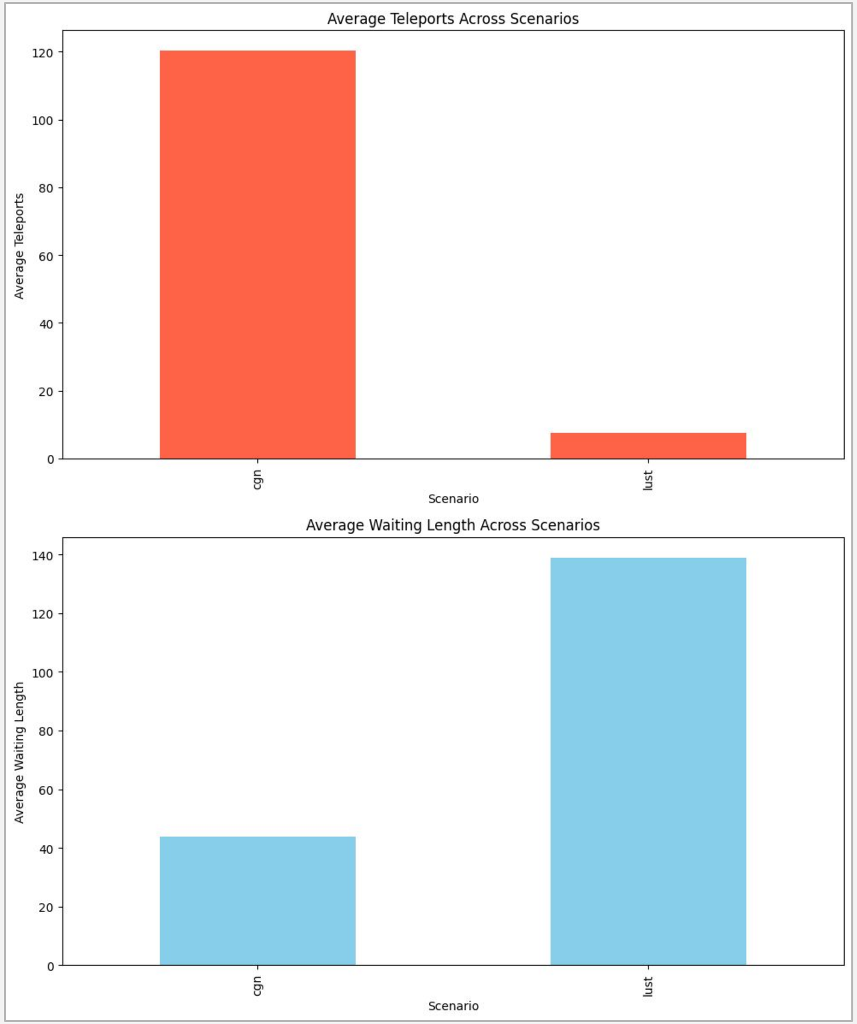
SIMULATION

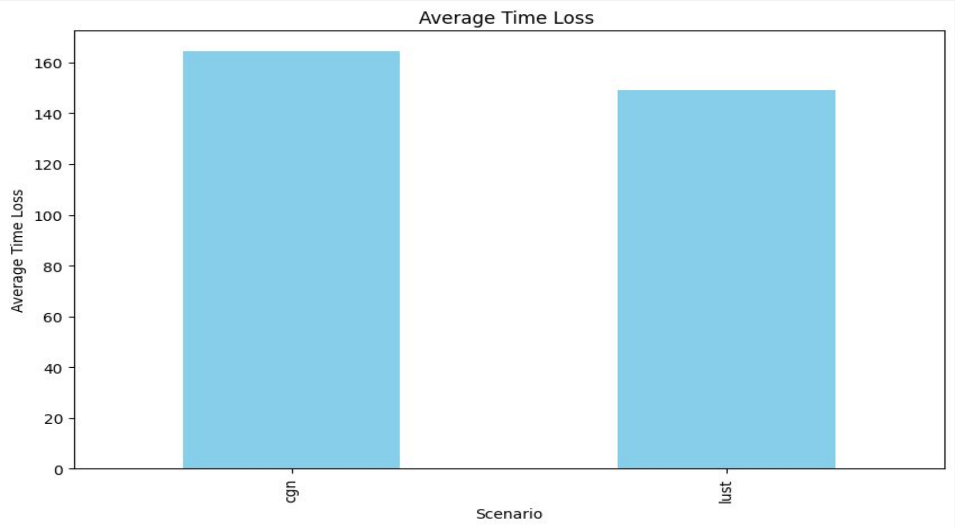

File Edit Settings Locate Simulation Window Language Help
Time:
Delay (ms): 200
Scale Traffic: 1
custom_1
0 10m
Simulation started with time: 0.00.
Simulation ended at time: 1029.00. (The final simulation step has been reached.)
'D:\SUMO\rar\Behavior-Driven-Traffic-Simulator-master\Behavior-Driven-Traffic-Simulator-master\gamma_cross\cross3l.sumocfg' loaded.
47
x:651.80, y:438.01
(No projection defined)

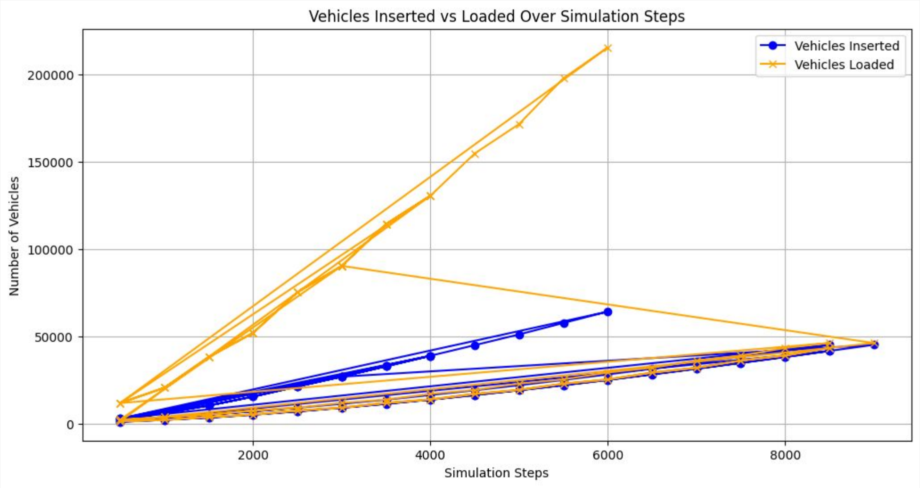
RESULTS


Collisions Over Simulation Steps
Number of Collisions
Simulation Steps
0
20
40
60
80
100
120
2000
4000
6000
8000


Average Emergency Stops Across Different Scenarios
Average Emergency Stops
Scenario
0
50
100
150
200
250
300
350
400
cgn
lust


Average Teleports Across Scenarios
Average Teleports
0
20
40
60
80
100
120
cgn
lust
Scenario
Average Waiting Length Across Scenarios
Average Waiting Length
0
20
40
60
80
100
120
140
cgn
lust
Scenario


Average Time Loss
Average Time Loss
0
20
40
60
80
100
120
140
160
cgn
lust
Scenario

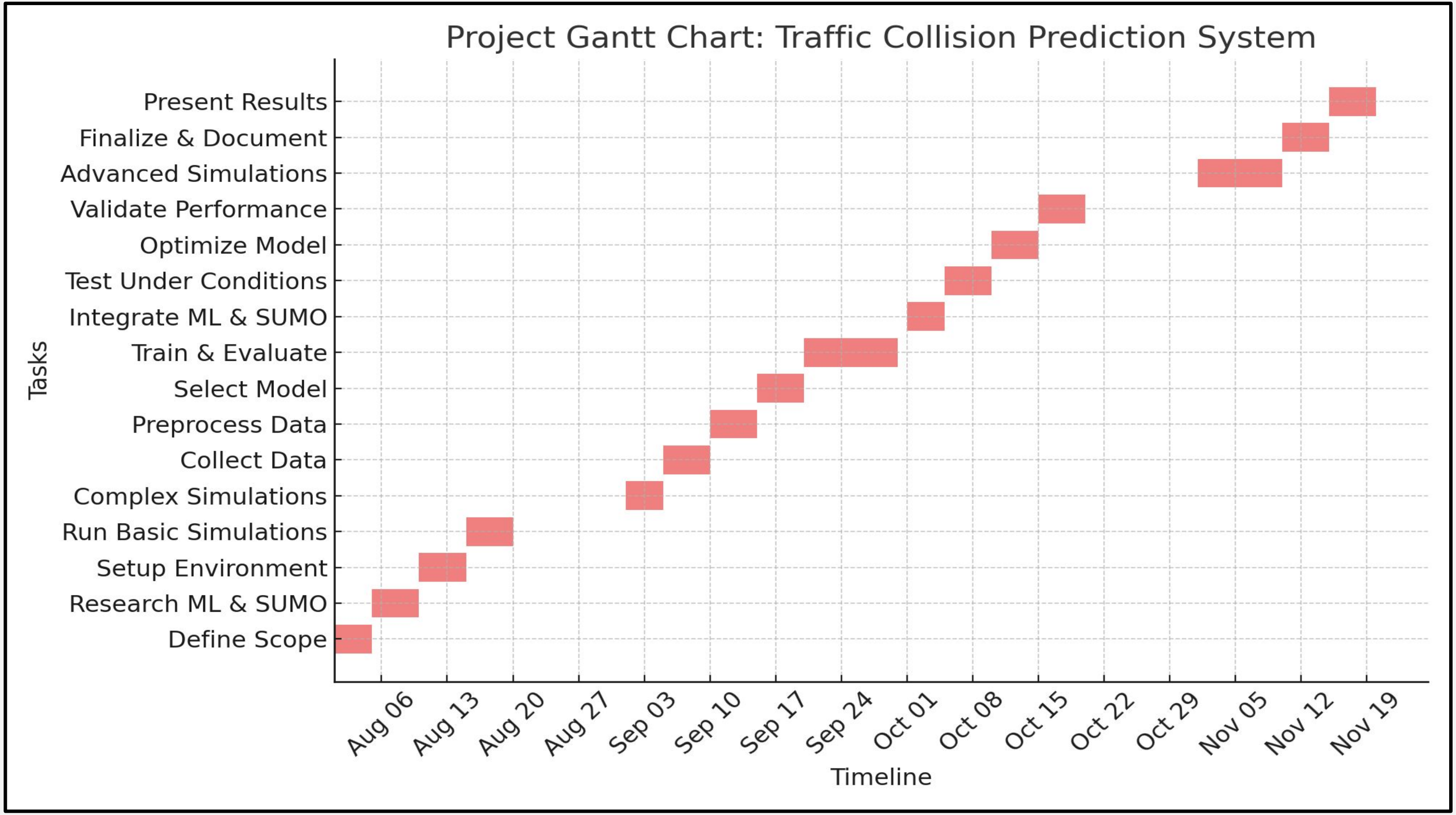

Vehicles Inserted vs Loaded Over Simulation Steps
Vehicles Inserted
Vehicles Loaded
Number of Vehicles
0
50000
100000
150000
200000
2000
4000
6000
8000
Simulation Steps

SOCIAL AND ENVIRONMENTAL IMPACT

The scope for improvement in such systems includes several areas that can enhance their efficiency, accuracy, and overall reliability. Here are some key areas for improvement:

- V2V Communication (Vehicle to Vehicle)
- Environmental Awareness
- Cost Effectiveness
- User Feedback Integration
- Cybersecurity and Data Privacy
- Vehicle Dynamics Prediction
- Human Factors and Driver Interaction
- Sensor Fusion

WORK PLAN/TIMELINE



INDIVIDUAL CONTRIBUTION

Tushar Pati Tripathi - Sumo Stimulation , Data Interpretation & Scraping, Result Analysis

Aiyushi Srivastava- Research work , Literature review , Algorithm working

Rohan Joshi - Integrating Development Environment (IDE), Data Interpretation , Result Interpretation

COST ANALYSIS

The cost of developing and deploying predictive vehicle collision avoidance technologies involves a multifaceted analysis, considering factors such as:

- **Research and Development:** Significant investments in research and development are essential to advance ML algorithms, sensor technologies, and traffic simulation tools.
- **Infrastructure:** Upgrading road infrastructure with necessary sensors and communication systems can be costly.
- **Vehicle Hardware and Software:** Equipping vehicles with advanced sensors, computing hardware, and specialized software requires substantial initial and ongoing costs.
- **Data:** The collection, storage, and processing of large datasets for training and validating ML models can be expensive, especially for high-quality, real-world data.
- **Operational Costs:** Ongoing costs include data storage, cloud computing, network connectivity, and cybersecurity measures to ensure system reliability and security.
- **Regulatory Compliance:** Adhering to evolving regulatory standards and industry best practices can incur additional costs.
- **Public Acceptance:** Public perception and acceptance of autonomous vehicle technologies can influence adoption rates and, consequently, the overall cost-benefit analysis.

PROJECT OUTCOME

The outcome of a project focused on predictive vehicle collision avoidance technologies and traffic simulation would typically provide both direct benefits and insights for urban mobility, traffic safety, and autonomous vehicle development. Here’s a summary of the potential outcomes:

1. Enhanced Traffic Safety
2. Improved Traffic Flow
3. Lower Environmental Impact
4. Data-Driven Insights for Future Policy and Infrastructure
5. Advancement in Autonomous Vehicle Development
6. User and Public Acceptance of Advanced Technologies

Overall, such a project would likely result in safer, more efficient roadways and contribute valuable data toward a future of autonomous, smart cities.

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