# MANTHRA-X:

## PIONEERING PRECISION, THE FUTURE O F AUTONOMOUS MOBILITY

Project ID; 24_25J_213

# MEMBERS

Main Supervisor
Mr. Samadhi Rathnayake

Co-Supervisor
Dr. Lakmini Abeygunawardhana

Akalanka P.A.A
IT21160448

Ganepola G.A.N.B.
IT21155048

Athukorala W.A.A.D.D.T
IT21162978

D.M.M.I.T Dissanayaka
IT21174780

# INTRODUCTION

# BACKGROUND

# Currently Available

### Waymo’s Perception System

- Waymo uses a combination of LiDAR, cameras, and radar with advanced CNNs and RNNs for object detection and scene understanding.

- Limitations:
  - Data Requirements: High dependency on large volumes of labeled data for training.
  - Computational Resources: Requires substantial computational power for real-time processing.
  - Generalization: May struggle with scenes not well-represented in training data and not suitable for under-developed infrastructure.

# Currently Available

**Tesla's Autopilot**

- Tesla's system uses camera-based vision with deep learning models to interpret the environment and make driving decisions.

- Limitations:
  - Weather Conditions: Performance can degrade in adverse weather conditions.
  - Edge Cases: Difficulty handling rare or unusual driving scenarios.

# Currently Available

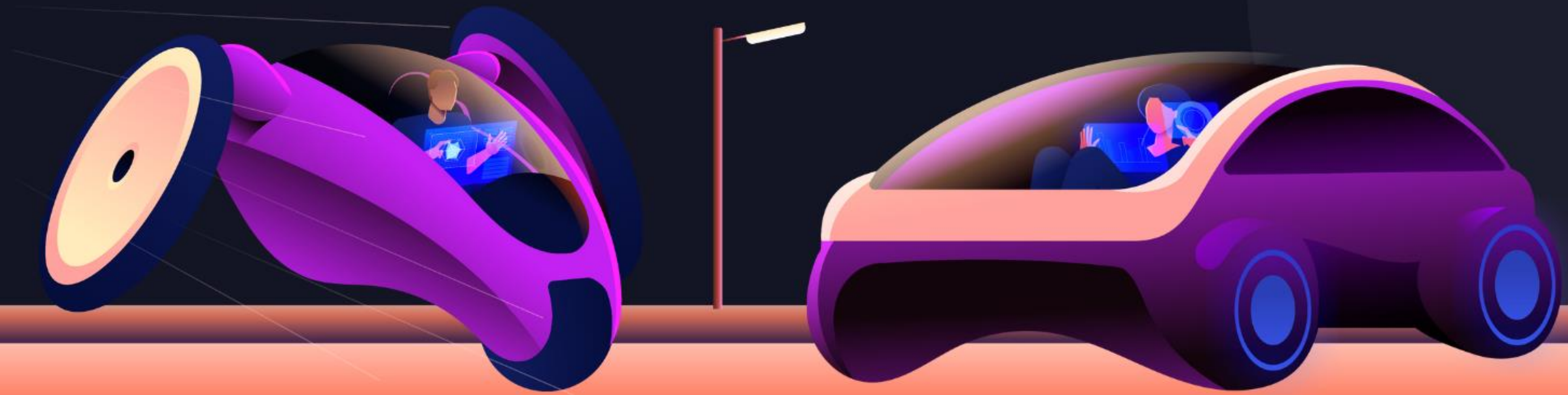
**Nuro's Autonomous Delivery Vehicles**

- Employs reinforcement learning and planning algorithms for navigation and collision avoidance. Optimized for specific tasks like delivery routes with a focus on efficiency and safety.

- Limitations:
  - Limited Context: Designed primarily for delivery routes, not general driving environments.
  - Predictive Accuracy: May struggle with predicting and adapting to human drivers' unpredictable behaviors.

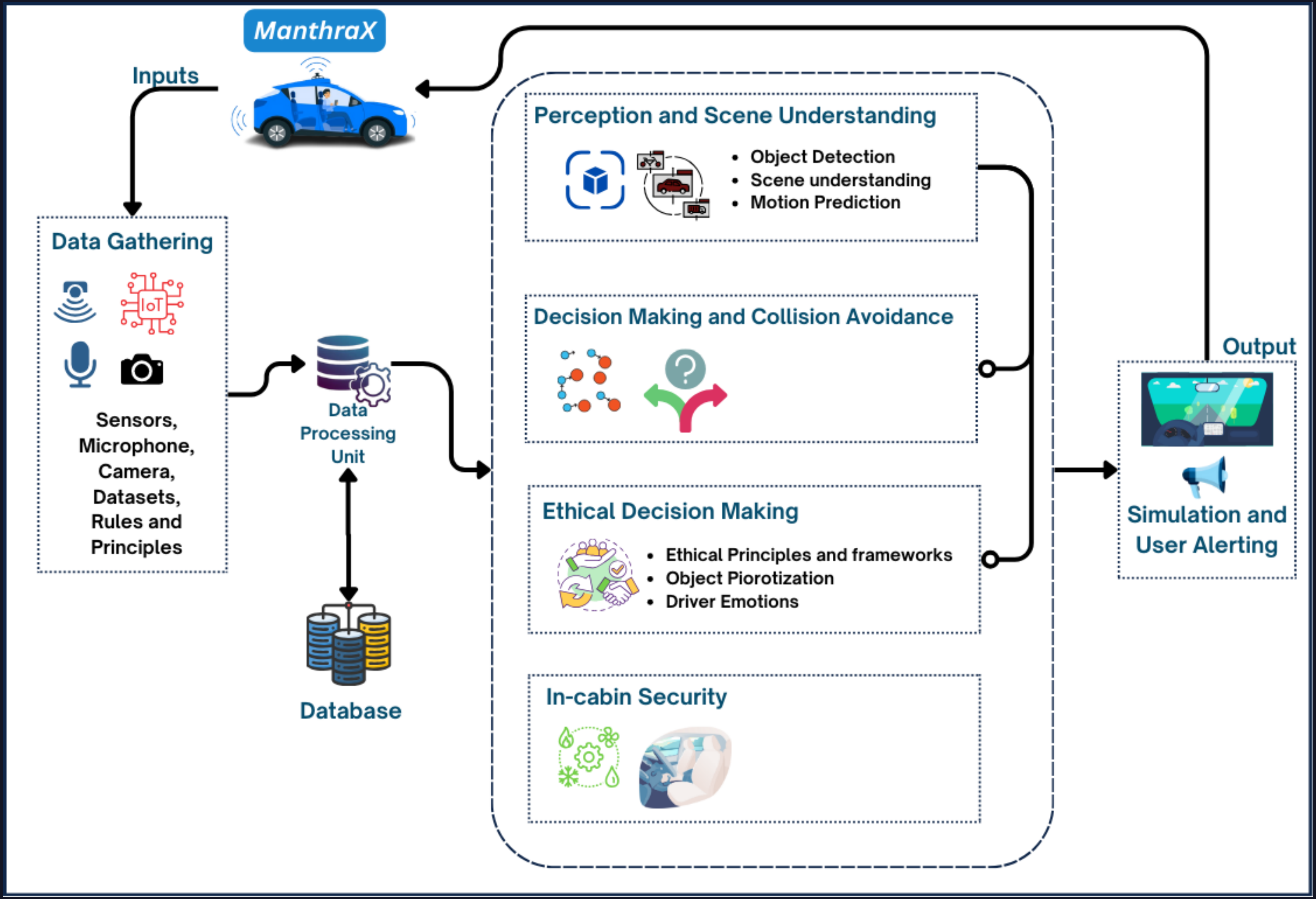
# OBJECTIVE

Manthra-X is enhancing perception and scene understanding, decision-making, and in-cabin security. This involves integrating advanced machine learning models and simulations to improve vehicle safety, ethical decision-making, and passenger comfort in autonomous systems.



# PROPOSED SOLUTION

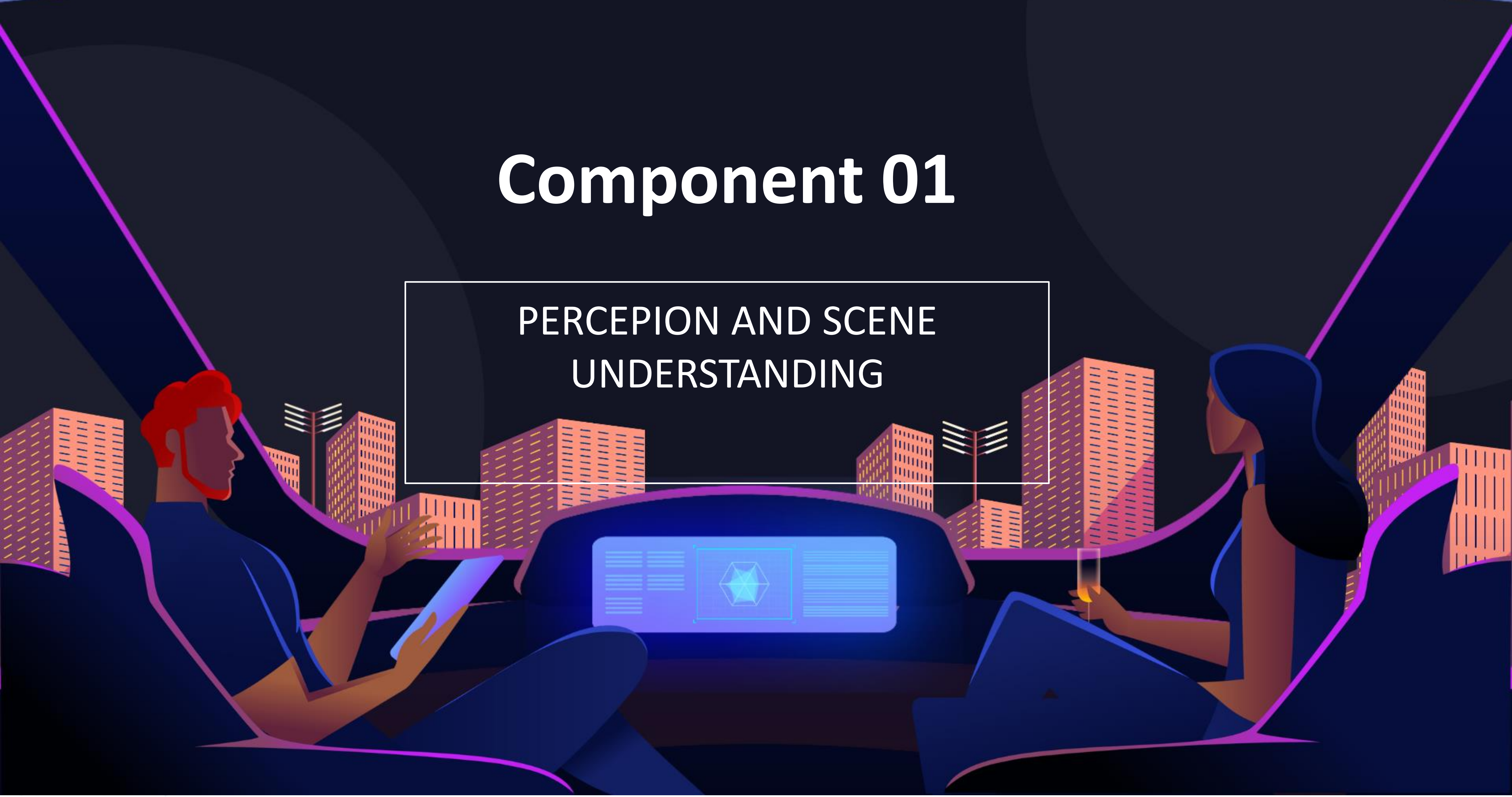
# Overall System Diagram



# IT21160448 | AKALANKA P.A.A

BSc (Hons) Degree in Information Technology (specialization in Data Science)

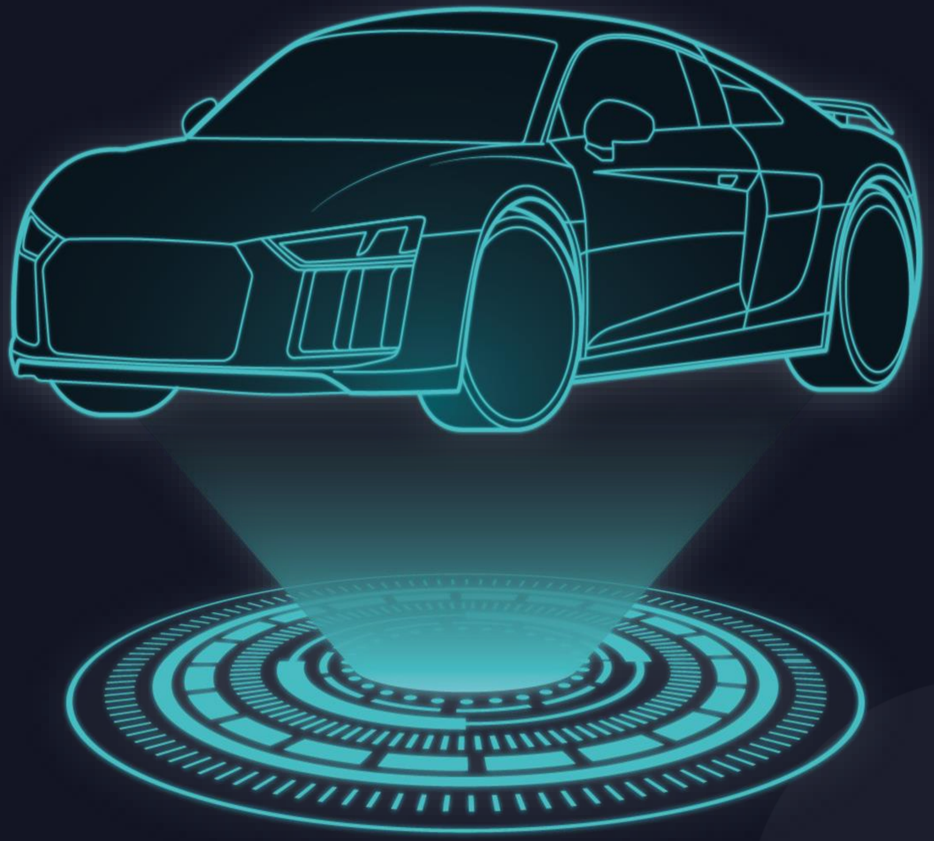
DATA SCIENCE

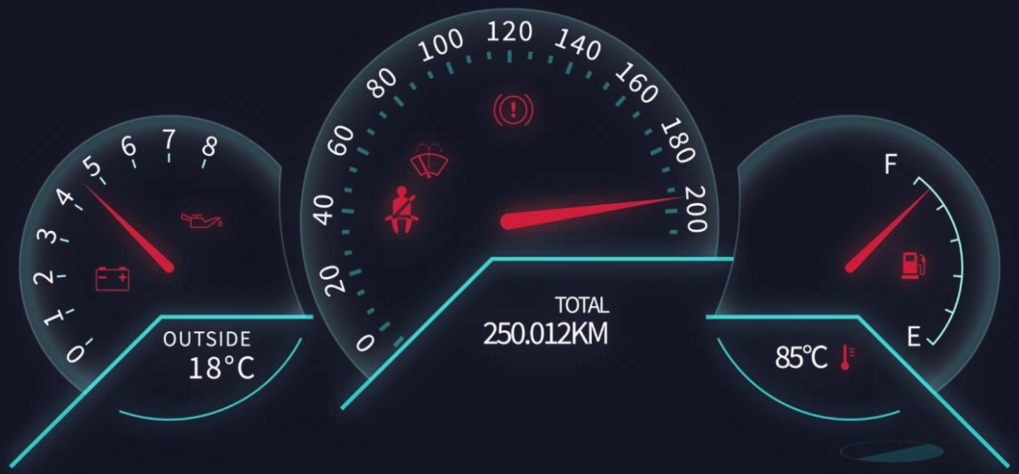


# Component 01

PERCEPION AND SCENE UNDERSTANDING

# Enhancing Perception and Motion Prediction in Autonomous Vehicles Through Hybrid Modeling and Self-Supervised Learning.






# BACKGROUND

# Why Enhancing perception and Scene Understanding?

Improved Safety

Data Efficeincy

Expanded Capabilities

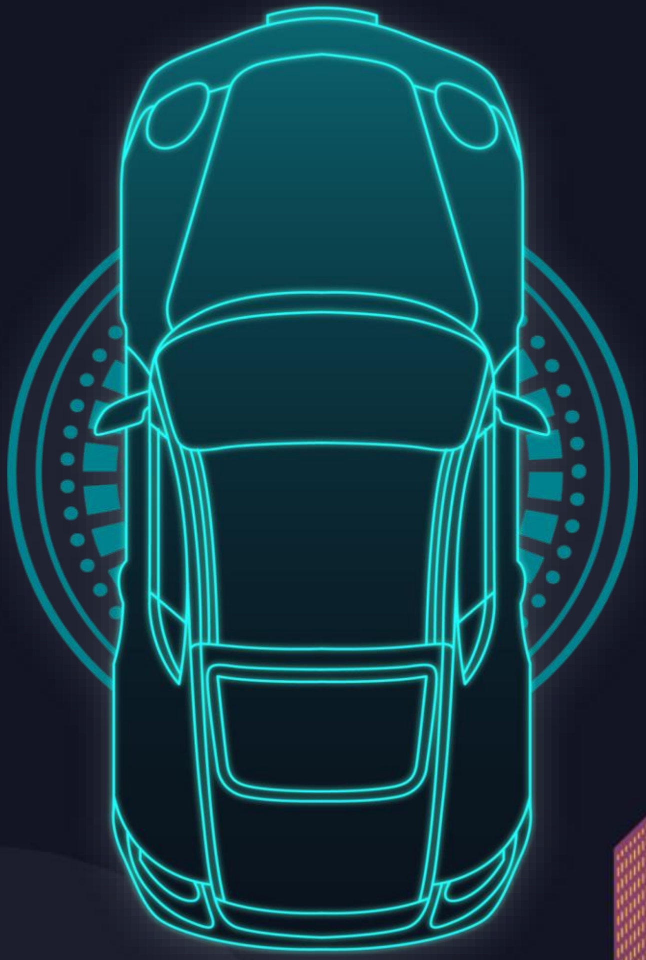
Enhanced Driving Experience

# EXISTING AUTONOMOUS VEHICLES LACK,

Complex Scenario Handling

Sensor Improvements

Minimized Data Dependency



# RESEARCH GAP

**Research 01**
**“TransVOD: Transformer-Based Visual Object Detection for Self-Driving Cars”**

**Research 02**
**“TrackFormer: Multi-Object Tracking with Transformers:”**

**Research 03**
"Transformers in Autonomous Driving: A Survey"

**Research 04**
**"Dynamic Graph Neural Networks for Modeling Object Interactions"**

**Research 05**
**"Self-Supervised Learning for Object Detection and Tracking"**

# RESEARCH GAP

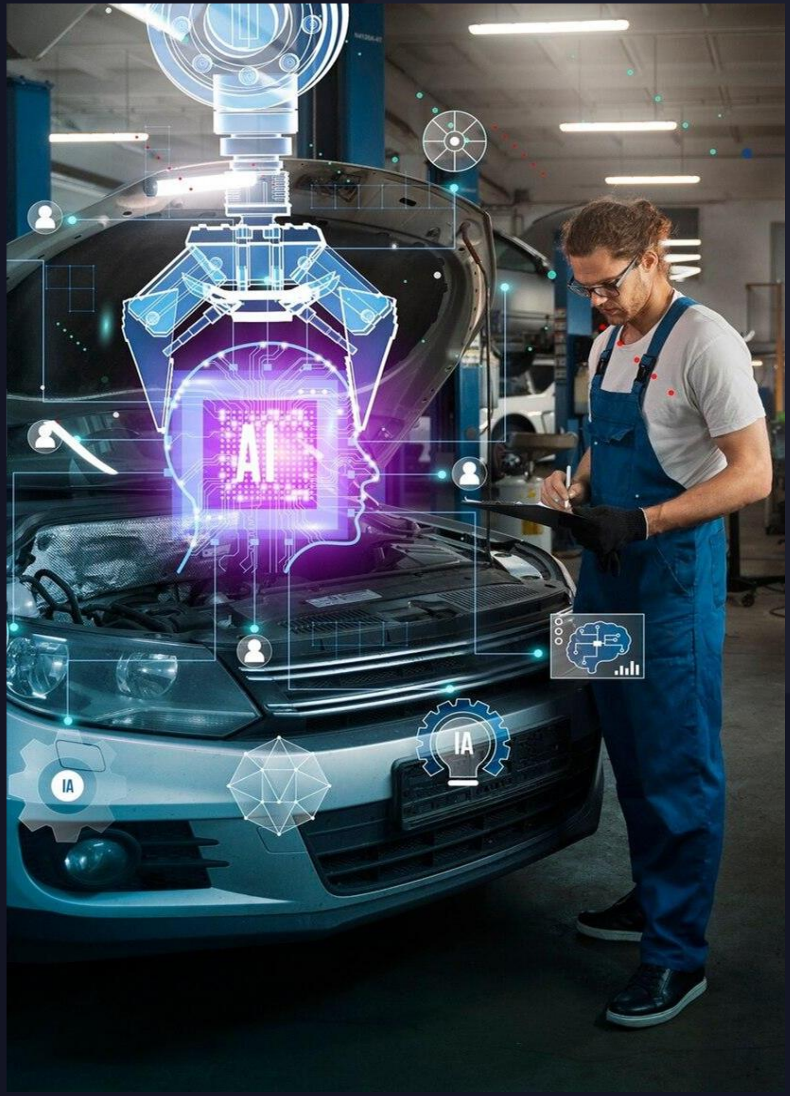
| Features | Research 1 | Research 2 | Research 3 | Research 4 | Research 5 | MANTHRA-X |
|---|---|---|---|---|---|---|
| Modeling of Spatial relationship between objects. | No | No | No | No | No | ✓ |
| Address both spatial relationships and temporal dependencies in object detection. | No | No | No | No | No | ✓ |
| Improved accuracy in occlusions and object deformations. | No | Yes | No | No | No | ✓ |
| Enhanced model's learning capability from unlabeled data. | No | No | No | No | Yes | ✓ |
| Combines different sensor modelities. | Yes | Yes | No | No | No | ✓ |

# RESEARCH PROBLEM?

- How can graph neural networks be effectively integrated with transformer architectures for multi-modal sensor fusion in autonomous vehicles?

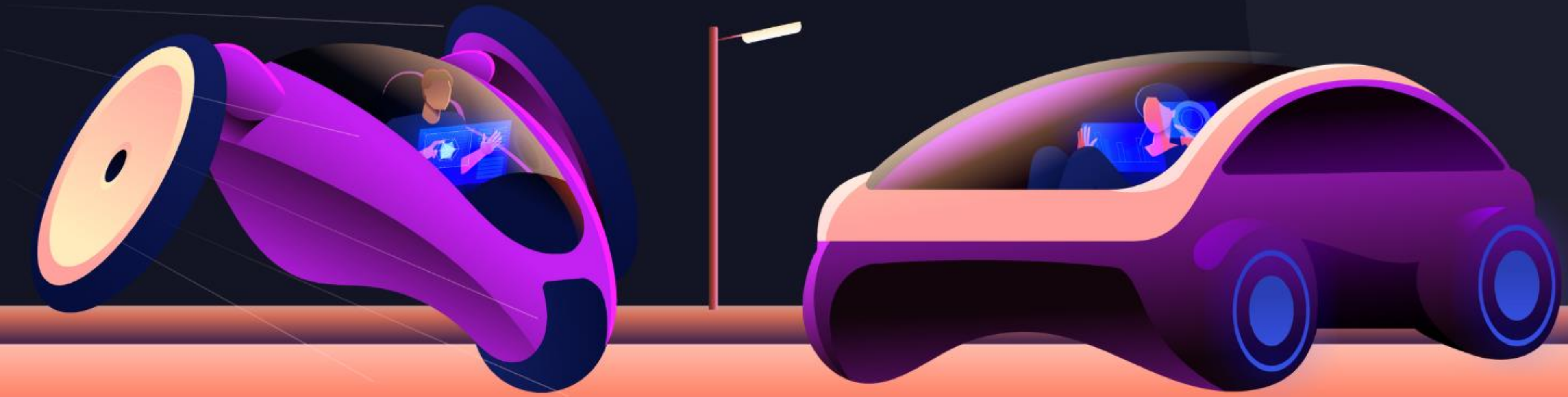
- What self-supervised tasks are most effective for improving object detection and motion prediction in challenging driving conditions?

- Can self-supervised pre-training enhance the performance of hybrid models for autonomous vehicle perception?



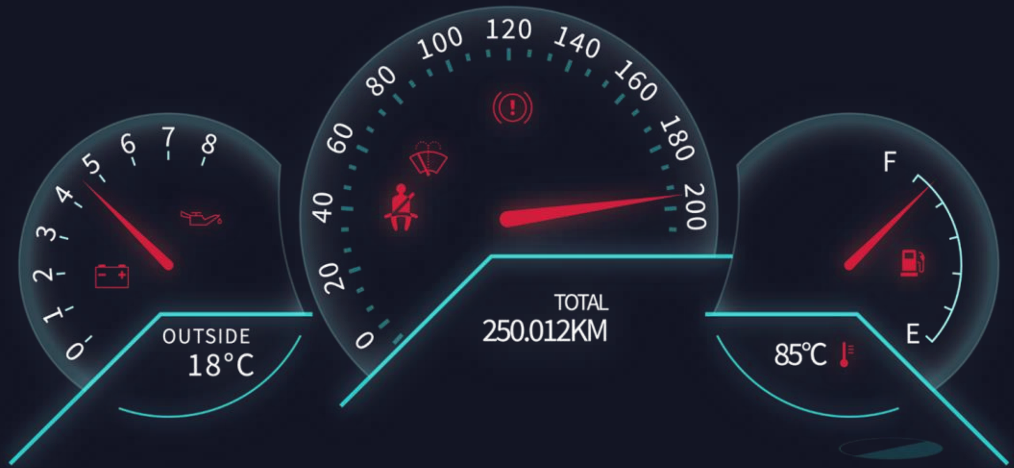

# SPECIFIC OBJECTIVE

- To develop a robust and efficient perception system for autonomous vehicles capable of accurately detecting, tracking, and predicting the behavior of objects in complex urban environments by integrating hybrid model architectures and self-supervised learning techniques.



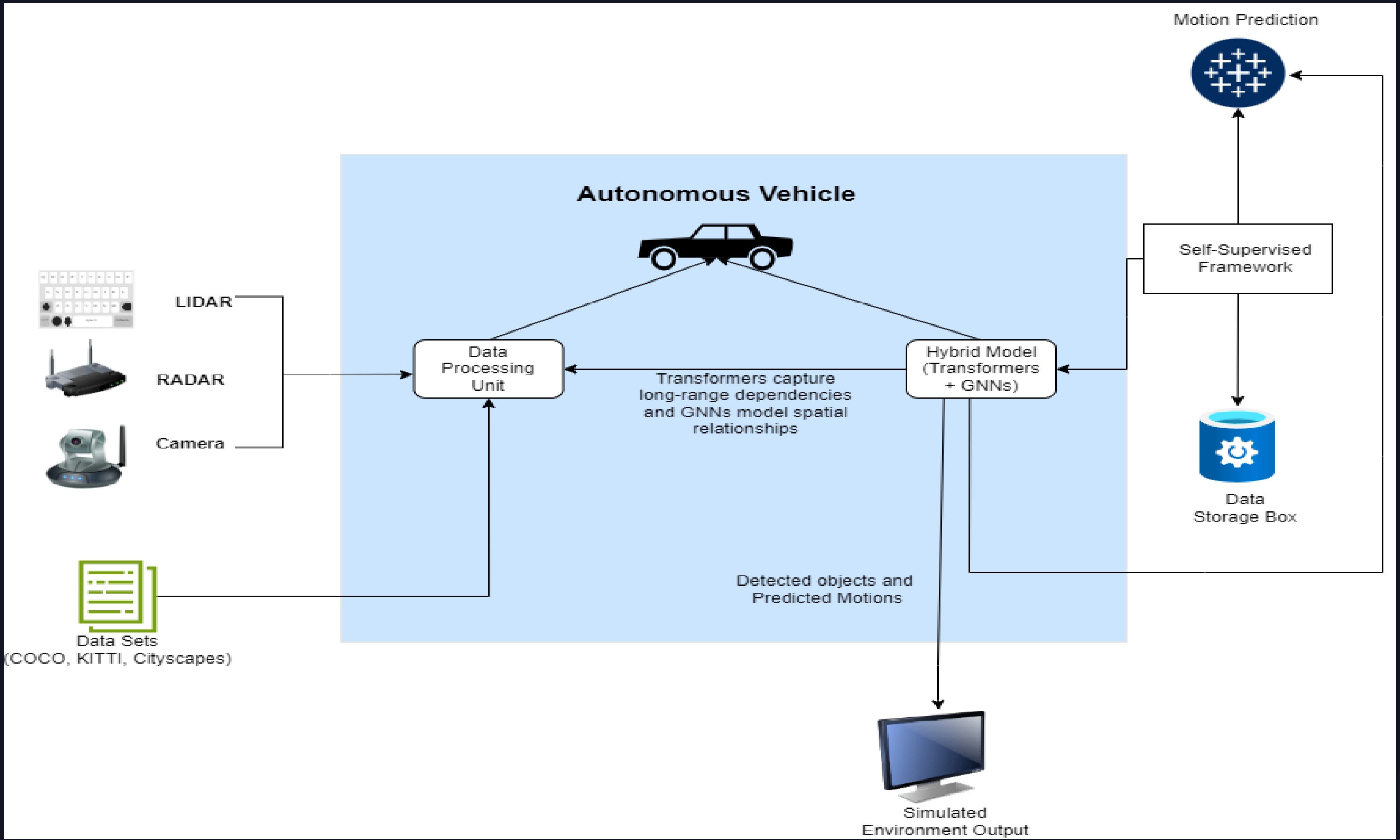
# SUB-OBJECTIVES

- **Develop a hybrid model architecture:** Design and implement a hybrid model combining transformer and graph neural network components to effectively fuse multi-modal sensor data for enhanced object perception and tracking.
- **Improve object detection and tracking:** Enhance object detection and tracking performance in challenging conditions, such as occlusions, low visibility, and dynamic environments.
- **Advance motion prediction:** Develop accurate motion prediction models capable of predicting the future trajectories of objects, including pedestrians, vehicles, and cyclists.
- **Optimize for real-time performance:** Design and implement efficient algorithms and data structures to enable real-time operation of the perception system.
- **Leverage self-supervised learning:** Explore effective self-supervised learning techniques to improve model generalization and reduce reliance on labeled data.




# METHODOLOGY

# SYSTEM DIAGRAM



# REQUIREMENT SPECIFICATION

## System Requirements

- **High-performance computing (HPC) cluster or workstations:** For model training, simulation, and real-time processing.
- **LiDAR sensors:** For accurate distance and object detection.
- **Radar sensors:** For object detection and velocity estimation in adverse weather conditions.
- **High-resolution cameras:** For capturing detailed visual information.
- **IMU (Inertial Measurement Unit):** For vehicle motion sensing and stabilization.

# REQUIREMENT SPECIFICATION

## Software Requirements

Development Tools:
IDEs: VSCode, PyCharm, Jupyter Notebook
Version Control: Git(GitHub, GitLab)

Frameworks and Libraries:
AI/ML: Tensorflow, Pytorch, Keras
Libraries: OpenCV, PCL, RADAR Data processing libraries

Simulation Frameworks:
CARLA, AirSim, or Unity

Databases:
NoSQL Databases: MongoDB, Cassandra

Cloud Services:
Microsoft Azure for Computing, storage, and machine Learning

Security: Cryptography Libraries

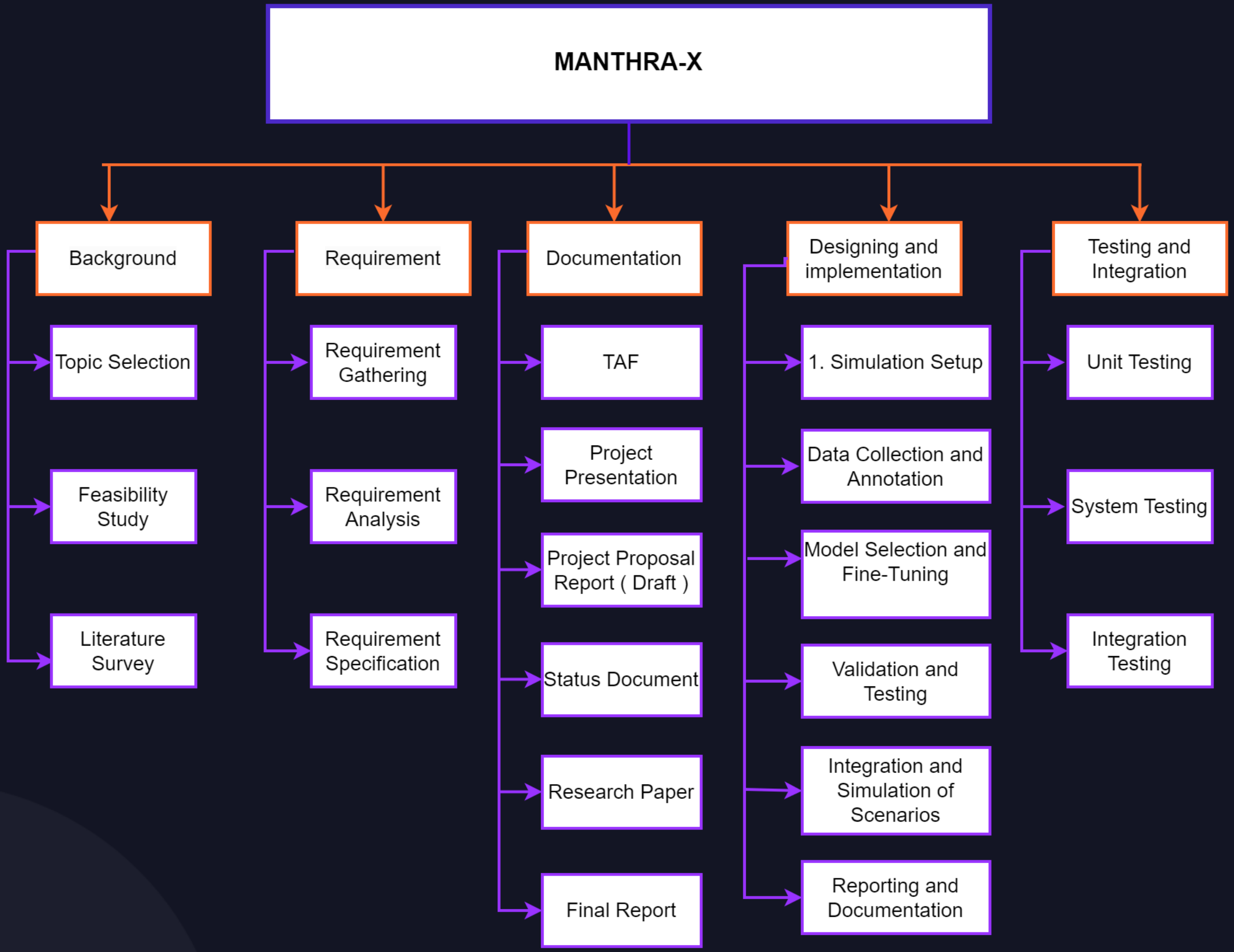
Web Frameworks: Node.js, Flask, Django

# REQUIREMENT SPECIFICATION

## Personal Requirements

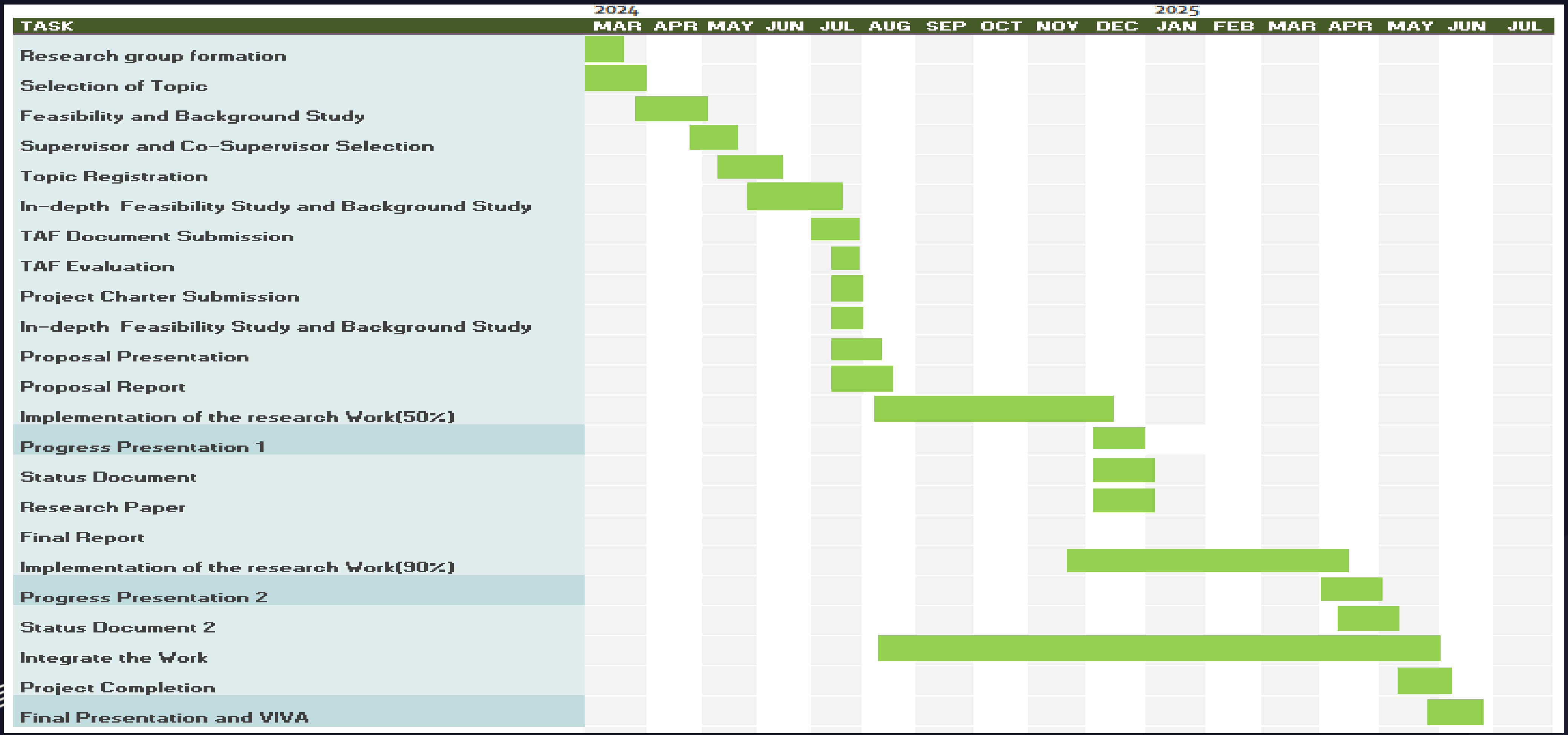
- Skills and Expertise.
- Time Management.
- Continuous Learning.
- Collaboration and Communication.
- Project Management

# WBS



MANTHRA-X
Background
Topic Selection
Feasibility Study
Literature Survey
Requirement
Requirement Gathering
Requirement Analysis
Requirement Specification
Documentation
TAF
Project Presentation
Project Proposal Report ( Draft )
Status Document
Research Paper
Final Report
Designing and implementation
1. Simulation Setup
Data Collection and Annotation
Model Selection and Fine-Tuning
Validation and Testing
Integration and Simulation of Scenarios
Reporting and Documentation
Testing and Integration
Unit Testing
System Testing
Integration Testing

# GANNT CHART



2024
2025
TASK
MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL
Research group formation
Selection of Topic
Feasibility and Background Study
Supervisor and Co-Supervisor Selection
Topic Registration
In-depth Feasibility Study and Background Study
TAF Document Submission
TAF Evaluation
Project Charter Submission
In-depth Feasibility Study and Background Study
Proposal Presentation
Proposal Report
Implementation of the research Work(50%)
Progress Presentation 1
Status Document
Research Paper
Final Report
Implementation of the research Work(90%)
Progress Presentation 2
Status Document 2
Integrate the Work
Project Completion
Final Presentation and VIVA

# REFERENCES


[1]Jyoti Madake;Tejas Lokhande;Atharv Mali;Nachiket Mahale;Shripad Bhatlawande, **“TransVOD: Transformer-Based Visual Object Detection for Self-Driving Cars”**, 2024 International Conference on Current Trends in Advanced Computing (ICCTAC)Year: 2024 | Conference Paper | Publisher: IEEE

[2]Tim Meinhardt;Alexander Kirillov;Laura Leal-Taixé;Christoph Feichtenhofer, **“TrackFormer: Multi-Object Tracking with Transformers:”**, 2022 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Year: 2022 | Conference Paper | Publisher: IEEE

**[3]"Transformers in Autonomous Driving: A Survey"**

**[4]"Dynamic Graph Neural Networks for Modeling Object Interactions"**

**[5]"Self-Supervised Learning for Object Detection and Tracking"**

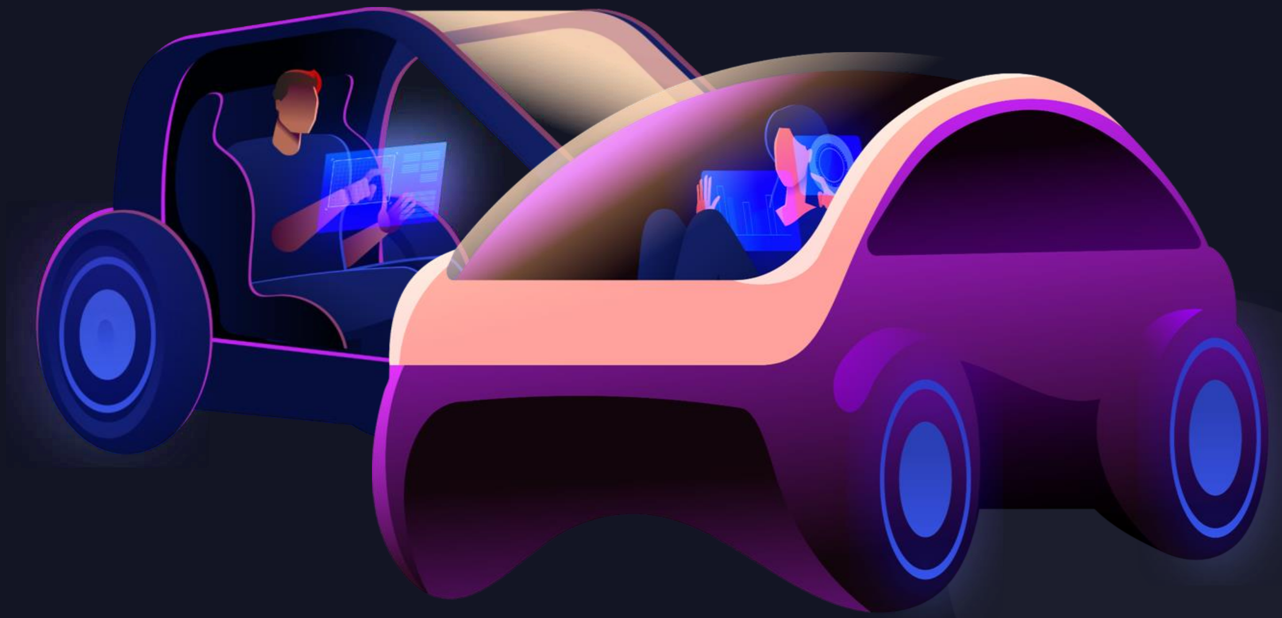
# IT21155048|GANEPOLA G.A.N.B.

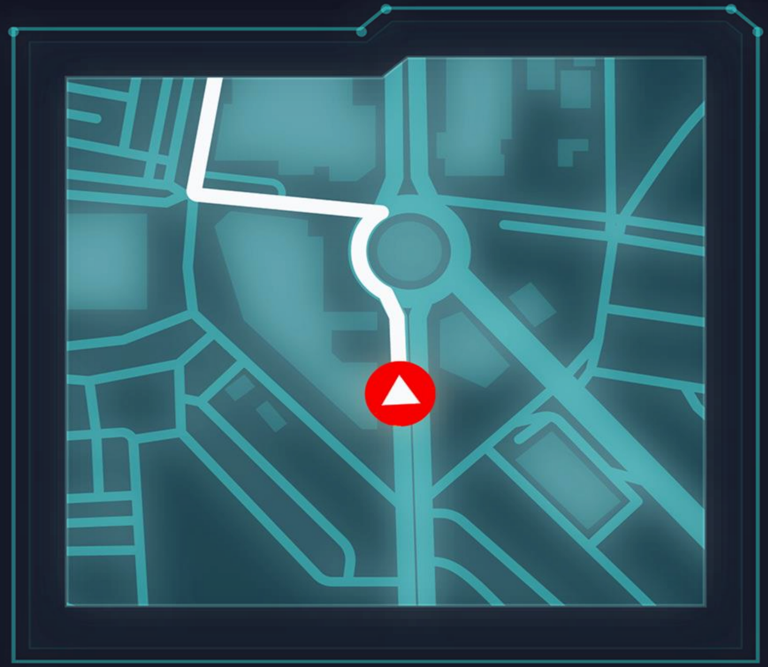
BSc (Hons) in Information Technology (specialization in Data Science)

# Component 02

DECISION MAKING AND COLLISION AVOIDANCE

# Decision Making and Path Planning Approach for Navigation in Complex Traffic, Ensuring Collision Avoidance and Seamless Driving Support.





# BACKGROUND

# Why Advanced Decision Making is important?

Complex Traffic Scenarios

Safety Enhancement

Human Like Decision Making

Scalability Across Regions

# RESEARCH GAP

**Research 01**
Path Planning for Autonomous Vehicles using Model Predictive Control

**Research 02**
"Risk Assessment and Mitigation in Local Path Planning for Autonomous Vehicles With LSTM Based Predictive Model

**Research 03**
Multipolicy Decision Making in Dynamic,
Uncertain Environments for Autonomous Driving

**Research 04**
Deep Reinforcement Learning for Human Like Driving Policies in Collision Avoidance Tasks of Self Driving Cars

**Research 05**
Path planning and integrated collision avoidance for autonomous vehicles

# RESEARCH GAP

| Features | Research 1 | Research 2 | Research 3 | Research 4 | Research 5 | MANTHRA-X |
|---|---|---|---|---|---|---|
| **Adaptive Decision Making** | No | Yes | Yes | Yes | Yes | ✓ |
| **Real Time Path Planning** | Yes | Yes | No | No | Yes | ✓ |
| **Collision Avoidance Mechanism** | Yes | Yes | No | Yes | Yes | ✓ |
| **Human Like Behavior** | No | No | No | Yes | No | ✓ |
| **Complex and Dynamic Traffic Interaction** | No | No | Yes | No | No | ✓ |

# RESEARCH PROBLEM

What are the key challenges in ensuring reliable decision making for vehicles interacting with multiple agents?

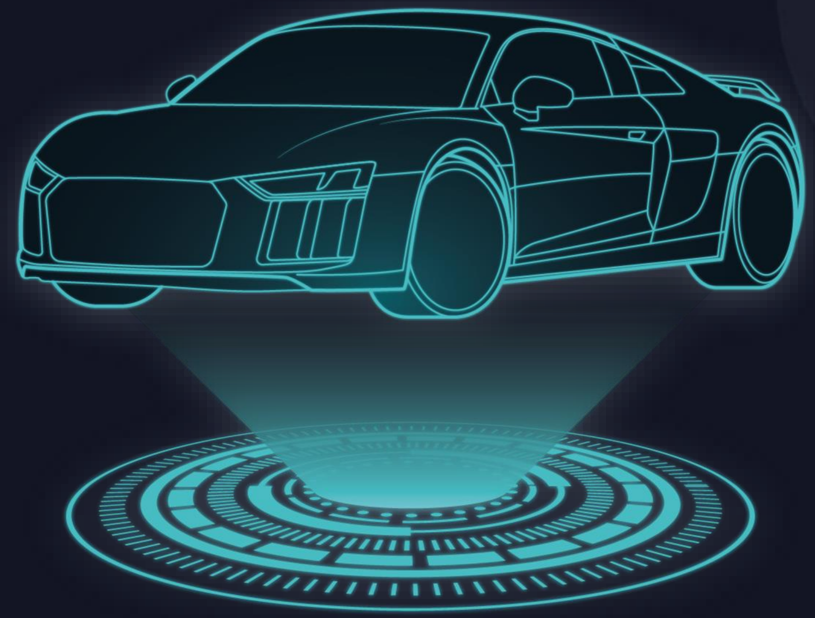
Why is it important to accurately model and mimic human driving behaviors in autonomous systems?

How can systems that adapt to unpredictable vehicle interactions and environmental conditions in real time?

How can decision making and path planning algorithms be tailored to meet the unique challenges of dynamic and unstructured traffic conditions

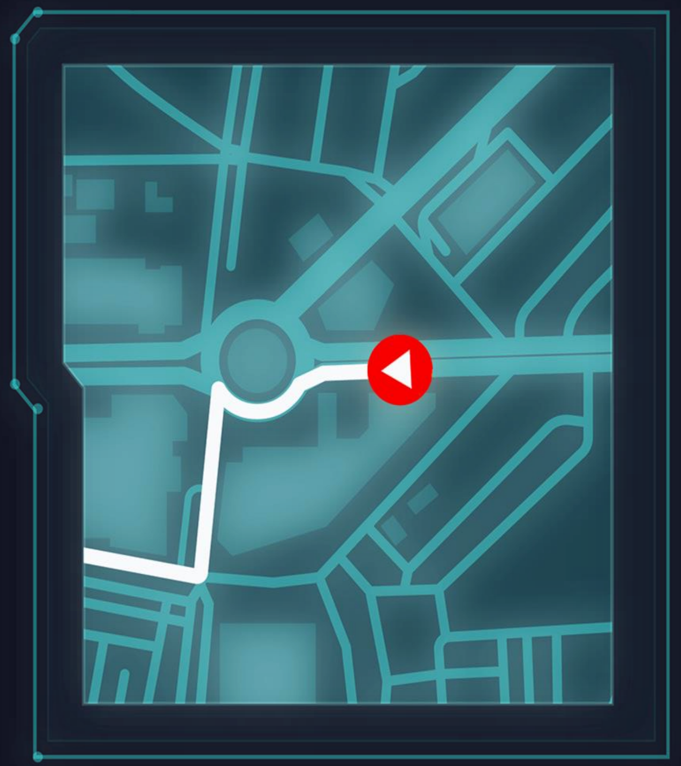
# SPECIFIC OBJECTIVE

Develop and integrate advanced decision making and path planning capabilities for vehicles to improve collision avoidance and adaptability in dynamic traffic environments, with a particular focus on addressing the unique driving conditions.



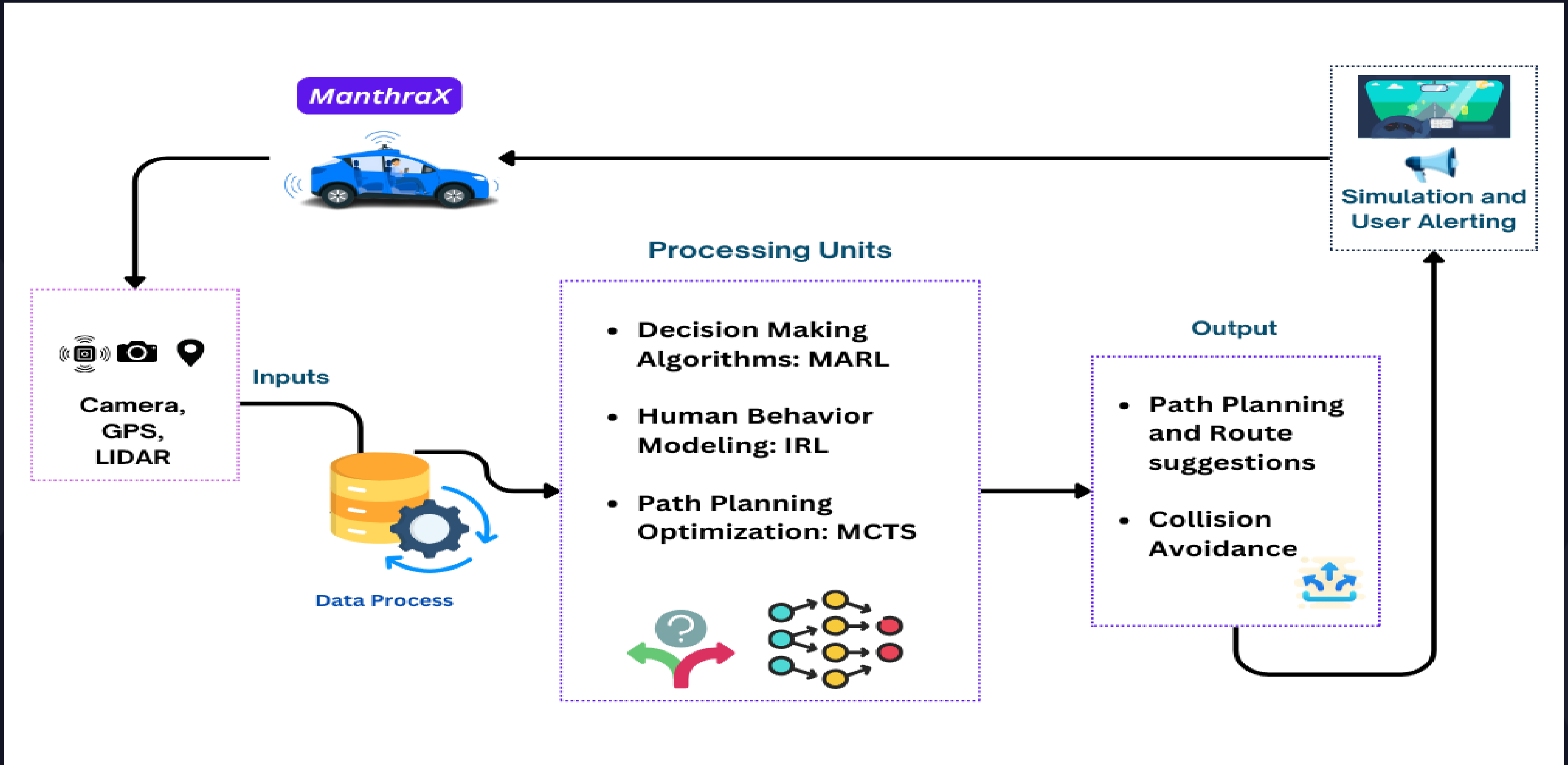
# SUB OBJECTIVES

- Dynamic human behavior adaptation
- Adaptive multi agent learning for mixed traffic environments
- Create a decision making system that can explore different future actions and outcomes in real time
- Predict potential collision risks based on the surrounding vehicles

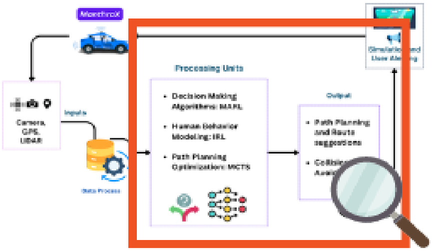


# METHODOLOGY

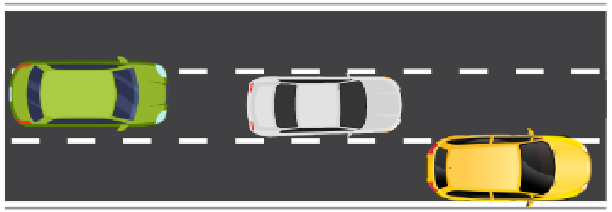
# SYSTEM DIAGRAM



# SYSTEM DIAGRAM




- Agent Filtering (Identify Relevant Agents)
- Prediction: Apply IRL and MARL to Predict Behavior of Relevant Agents
- Decision-Making: Use MCTS for Optimal Decision Selection
- Output: Execute Optimal Decision



- Path Selection: Generate and provide the best path for the vehicle.
- Collision Avoidance: Identify potential threats early and adjust the path to avoid collisions in real time.

# REQUIREMENT SPECIFICATION

## System Requirements

- **High-Performance Computing (HPC) Resources :** HPC clusters or workstations for processing complex algorithms and run the simulation.
- **Sensors :** Cameras (for visual data), LIDAR (for depth and distance measurements), GPS (for location tracking)
- **Networking :** High speed internet connection for real time data transfer and communication with external systems.
- **Cloud Storage**: For storing large datasets, including historical decision-making scenarios and real-time logs.

# REQUIREMENT SPECIFICATION

## Software Requirements

**Development Tools:**
IDEs: VSCode, PyCharm, Jupyter Notebook
Version Control: Git(GitHub, GitLab)

**Frameworks and Libraries:**
AI/ML: Tensorflow, Pytorch, Keras, Scikit-learn, Pgmpy.

**Cloud Services:**
Microsoft Azure Services

**Databases:**
NoSQL Databases: MongoDB, Cassandra

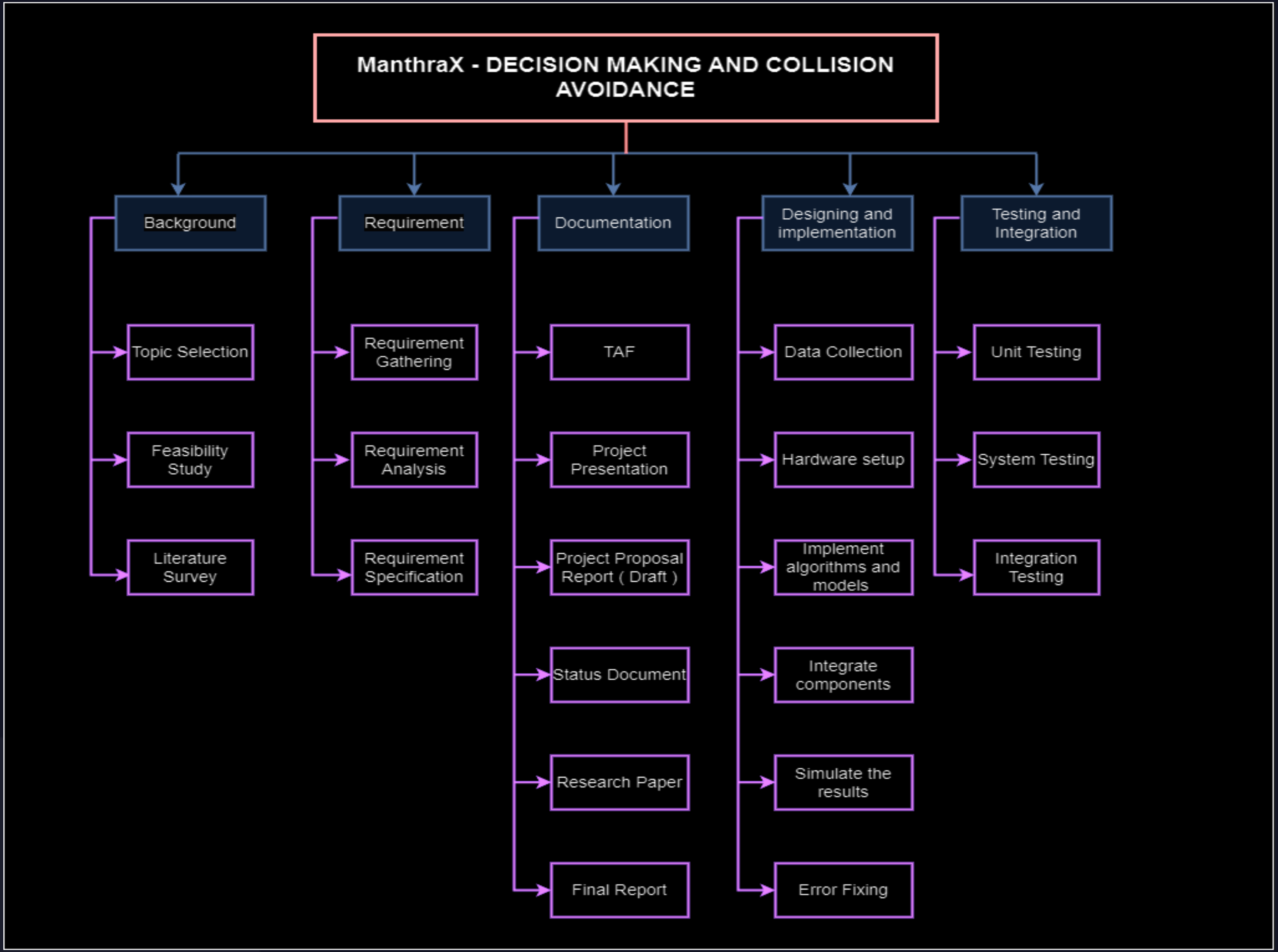
- **Simulation Frameworks:**
CARLA, AirSim, or Unity

# REQUIREMENT SPECIFICATION

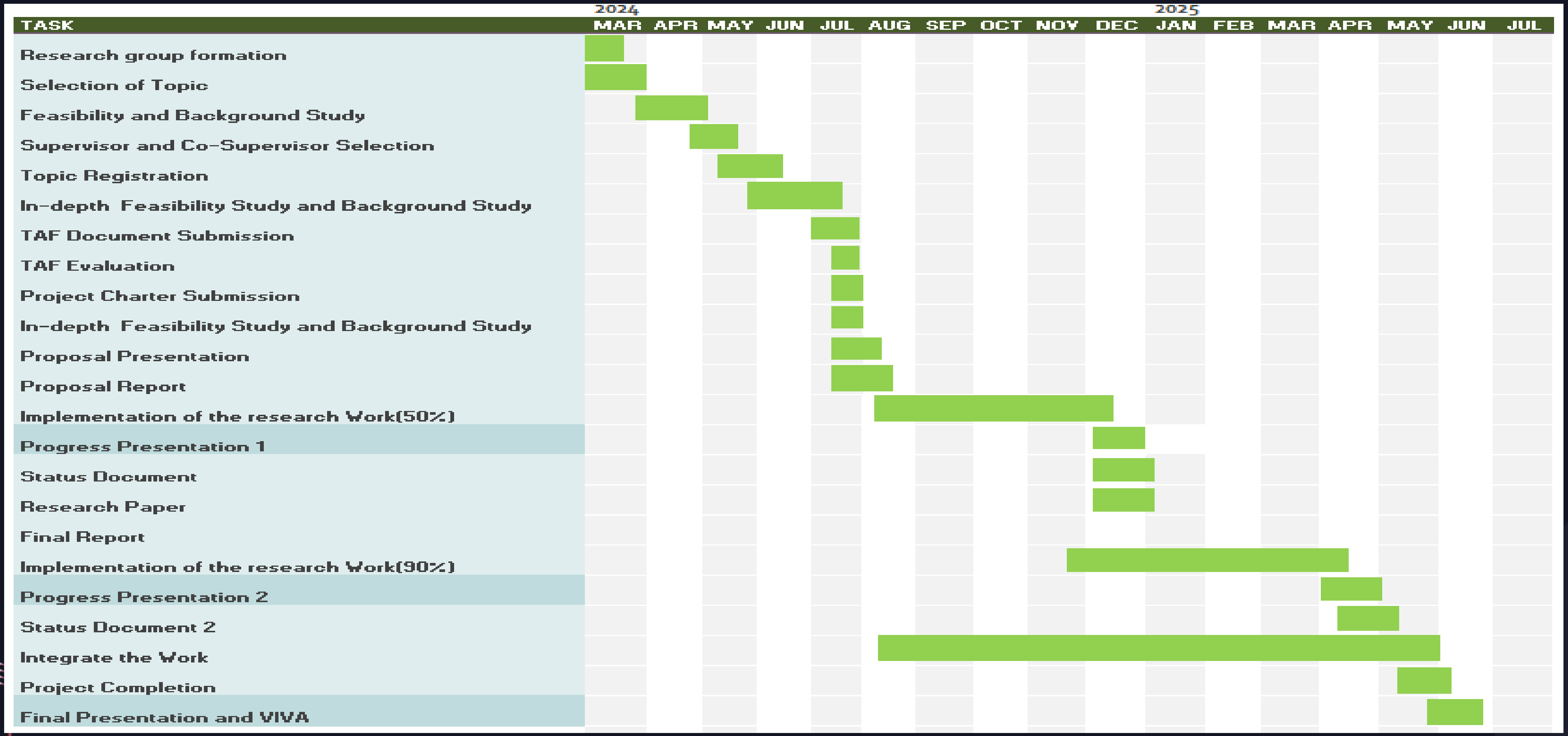
## Personal Requirements

- Technical Proficiency
- Experience with Tools and Frameworks
- Problem Solving Abilities
- Teamwork and Communication
- Project Management
- Adaptability
- Time Management Skills

# WORK BREAKDOWN CHART



# GANNT CHART


TASK
2024
2025
MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL
Research group formation
Selection of Topic
Feasibility and Background Study
Supervisor and Co-Supervisor Selection
Topic Registration
In-depth Feasibility Study and Background Study
TAF Document Submission
TAF Evaluation
Project Charter Submission
In-depth Feasibility Study and Background Study
Proposal Presentation
Proposal Report
Implementation of the research Work(50%)
Progress Presentation 1
Status Document
Research Paper
Final Report
Implementation of the research Work(90%)
Progress Presentation 2
Status Document 2
Integrate the Work
Project Completion
Final Presentation and VIVA

# References

[1] C. Liu, S. Lee, S. Varnhagen and H. E. Tseng, "Path planning for autonomous vehicles using model predictive control," 2017 IEEE Intelligent Vehicles Symposium (IV), Los Angeles, CA, USA, 2017, pp. 174-179, doi: 10.1109/IVS.2017.7995716.

[2] H. Wang et al., "Risk Assessment and Mitigation in Local Path Planning for Autonomous Vehicles With LSTM Based Predictive Model," in IEEE Transactions on Automation Science and Engineering, vol. 19, no. 4, pp. 2738-2749, Oct. 2022, doi: 10.1109/TASE.2021.3075773.

[3] A. G. Cunningham, E. Galceran, R. M. Eustice and E. Olson, "MPDM: Multipolicy decision-making in dynamic, uncertain environments for autonomous driving," 2015 IEEE International Conference on Robotics and Automation (ICRA), Seattle, WA, USA, 2015, pp. 1670-1677, doi: 10.1109/ICRA.2015.7139412.

[4] R. Emuna, A. Borowsky, and A. Biess, "Deep reinforcement learning for human-like driving policies in collision avoidance tasks of self-driving cars," arXiv preprint arXiv:2006.04218, 2020.

[5] K. Berntorp, "Path planning and integrated collision avoidance for autonomous vehicles," 2017 American Control Conference (ACC), Seattle, WA, USA, 2017, pp. 4023-4028, doi: 10.23919/ACC.2017.7963572.

# IT21162978|ATHUKORALA W.A.A.D.D.T

BSc (Hons) Degree in Information Technology (specialization in Data Science)

# Component 03

Ethical Decision Making in Autonomous Vehicles

Enhance Ethical Decision Making by Integrating Ethical Frameworks, Driver Emotions and Object Prioritization.

# BACKGROUND

# RESEARCH GAP

**Research 01**
"Incorporating Ethical Considerations Into Automated Vehicle Control"

**Research 02**
"Decision-Making Technology for Autonomous Vehicles: Learning-Based Methods, Applications and Future Outlook"

**Research 03**
"Large Language Models for Autonomous Driving: Real-World Experiments"

**Research 04**
"Ethical Decision Making in Autonomous Vehicles: The AV Ethics Project"

**Research 05**
"Emotion detection and face recognition of drivers in autonomous vehicles in IoT platform"

# RESEARCH GAP

| Features | Research 1 | Research 2 | Research 3 | Research 4 | Research 5 | MANTHRA-X |
| --- | --- | --- | --- | --- | --- | --- |
| **Personalized Ethical Decision-Making** | No | No | Yes | No | No | ✓ |
| **Integration of Real-Time Driver Emotion into Ethical Decision Making** | No | No | Yes | No | Yes | ✓ |
| **Culturally sensitive Ethical Decision making** | No | No | No | No | No | ✓ |
| **Sophisticated Object Prioritization** | No | No | No | Limited | No | ✓ |
| **Ethical Framework Consistency Across Scenarios** | Yes | Yes | Yes | No | Yes | ✓ |
| **Multi-Criteria Decision-Making Approaches** | No | No | No | Yes | Yes | |

# RESEARCH PROBLEM

How can ethical decision-making models be developed that accurately reflect individual driver preferences and emotional states?

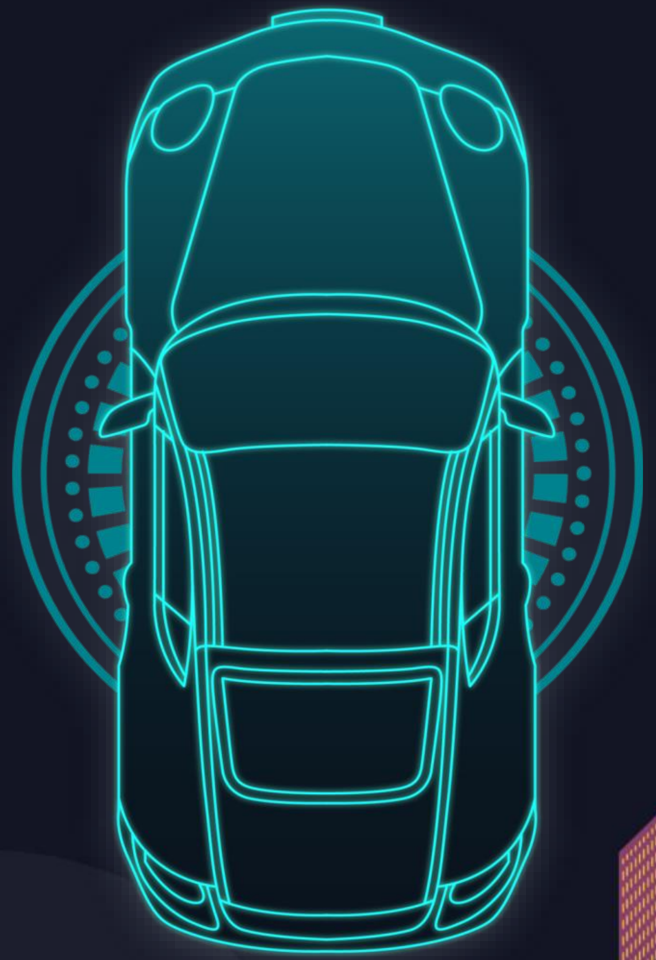
What factors should be considered when prioritizing objects in complex driving scenarios, and how can these be integrated?

What facial features and expressions are most indicative of driver emotional states relevant to driving?

How can vocal cues be used to assist autonomous vehicles in making ethical decisions by interpreting driver intent, emotional state, and workload?

# SPECIFIC OBJECTIVE

To develop a comprehensive ethical decision-making system for autonomous vehicles that prioritizes human safety, incorporates driver preferences, and adapts to dynamic environments, with a focus on ethical frameworks, object prioritization and personalized ethical considerations.



# SUB OBJECTIVES

- Incorporate and Operationalize Ethical Principles and Frameworks
- Develop and Integrate Driver Emotion Recognition
- Establish Object and Road User Prioritization Techniques
- Ensure System Adaptability to Dynamic and Diverse Environments
- Enhance Transparency and User Trust

# METHODOLOGY

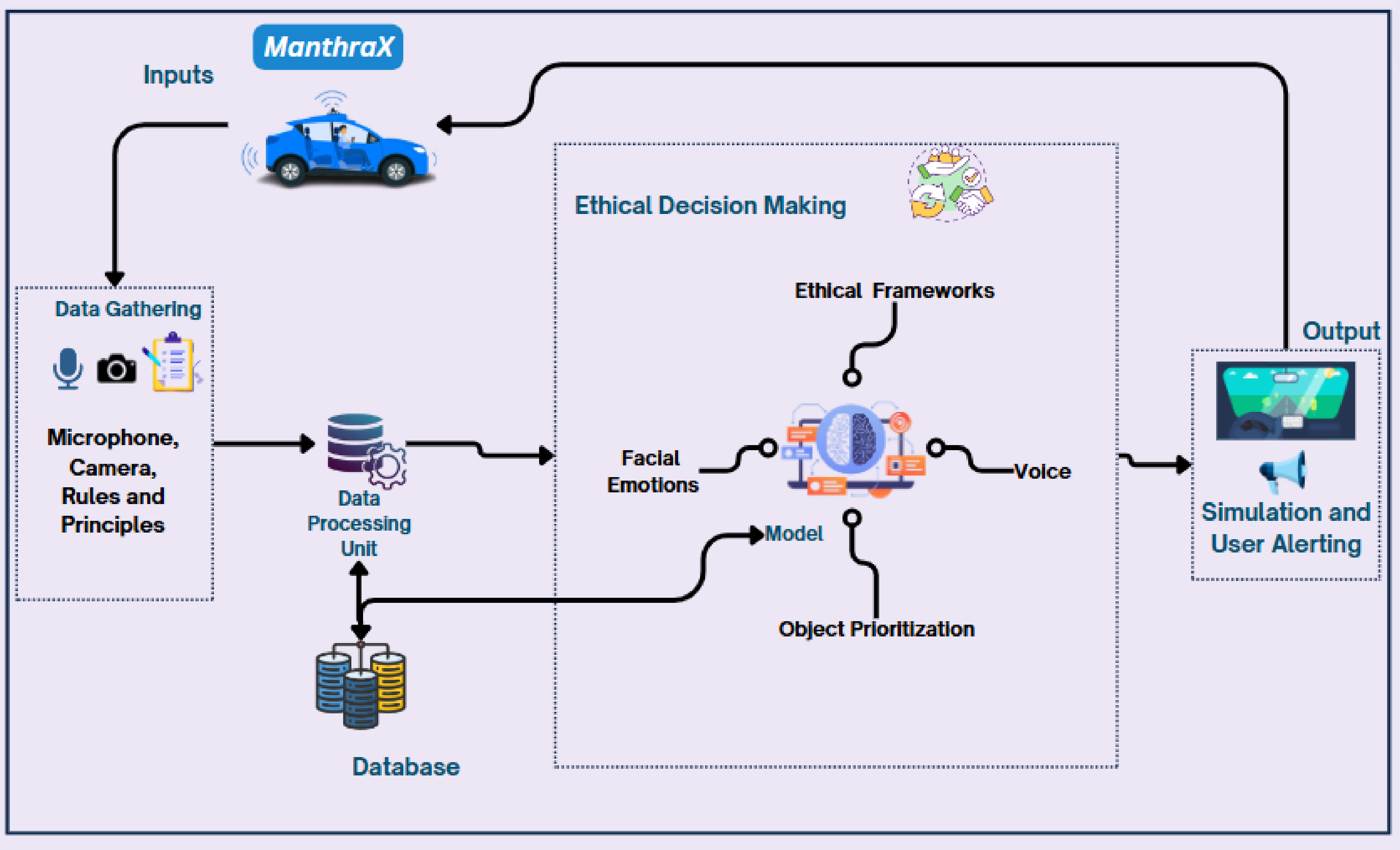
## SYSTEM DIAGRAM

## REQUIREMENT SPECIFICATION

- System Requirements
- Software Requirements
- Personal Requirements

## TECHNOLOGIES TO BE USED

# SYSTEM DIAGRAM



# REQUIREMENT SPECIFICATION

## System Requirements

- **High-performance Computing (HPC) Cluster or Workstations:** For processing complex algorithms related to ethical decision-making and real-time data analysis.
- **High-definition Cameras**: For capturing the driver's emotional state and external environment.
- **Microphones**: For capturing audio cues that may contribute to understanding the driver's state or external conditions.
- **High-speed Internet Connection:** For real-time data transfer, communication with external systems, and updates.
- **Cloud Storage**: For storing large datasets, including historical decision-making scenarios and real-time logs.

# REQUIREMENT SPECIFICATION

## Software Requirements

- **Development Tools:**
  IDEs: VSCode, PyCharm, Jupyter Notebook
  Version Control: Git(GitHub, GitLab)

- **Frameworks and Libraries:**
  AI/ML: Tensorflow, Pytorch, Keras
  Emotion Detection: OpenFace, Vokaturi
  Other : OpenCV

- **Cloud Services:**
  Microsoft Azure for Computing, storage, and machine Learning

- **Databases:**
  NoSQL Databases: MongoDB, Cassandra

- **Simulation Frameworks:**
  CARLA, AirSim, or Unity

# REQUIREMENT SPECIFICATION

## Personal Requirements

- Technical Proficiency
- Analytical Thinking
- Time Management Skills
- Commitment to Learning
- Teamwork and Communication
- Project Management
- Adaptability and Flexibility

# TECHNOLOGIES TO BE USED

AI/ML Freameworks:
Tensorflow, Pytorch, Keras

Development Tools:
IDEs: VSCode, PyCharm,
Jupyter Notebook

Cloud Services:
Microsoft Azure

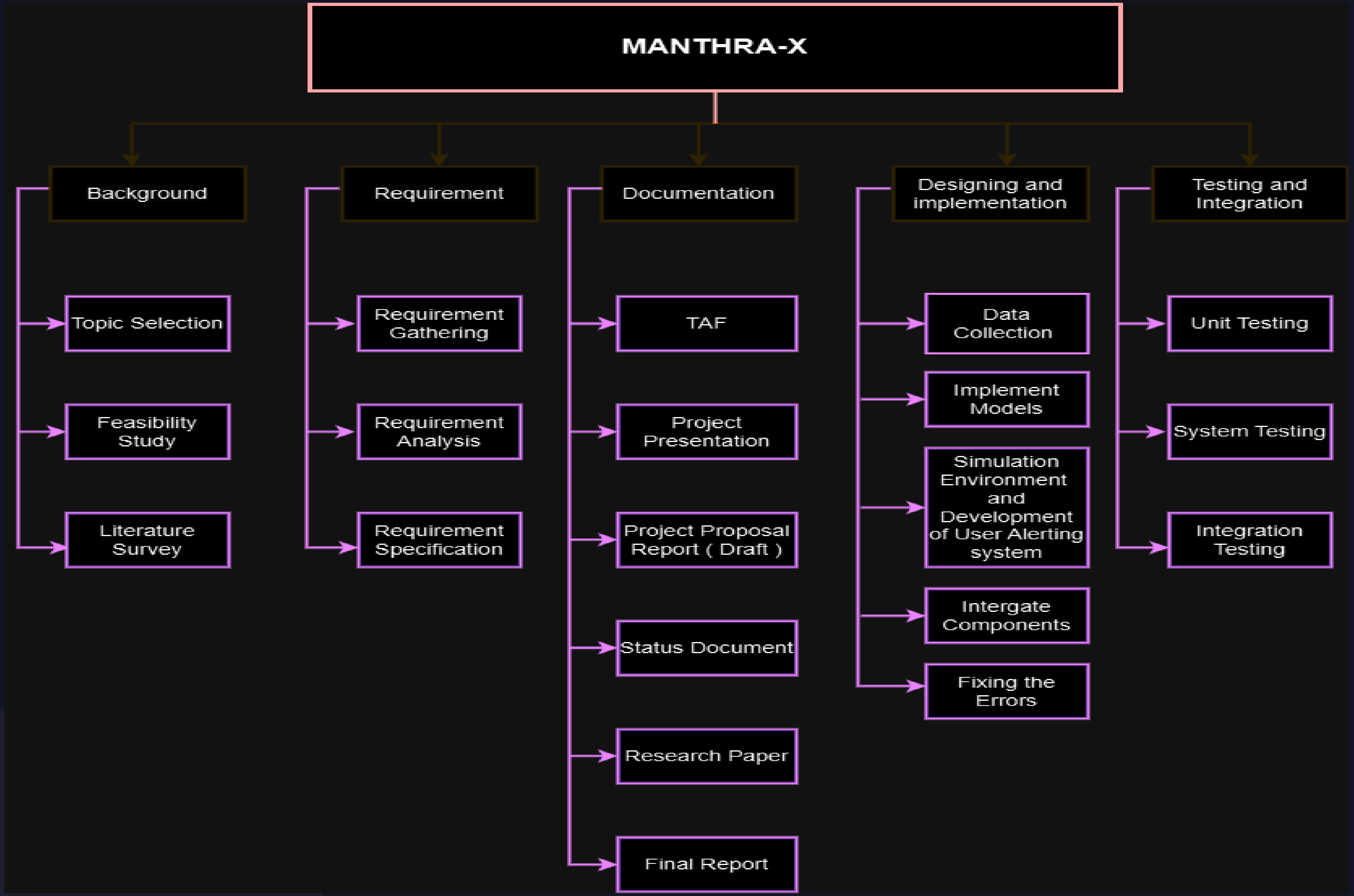
mongoDB

Databases:
NoSQL Databases:
MongoDB, Cassandra

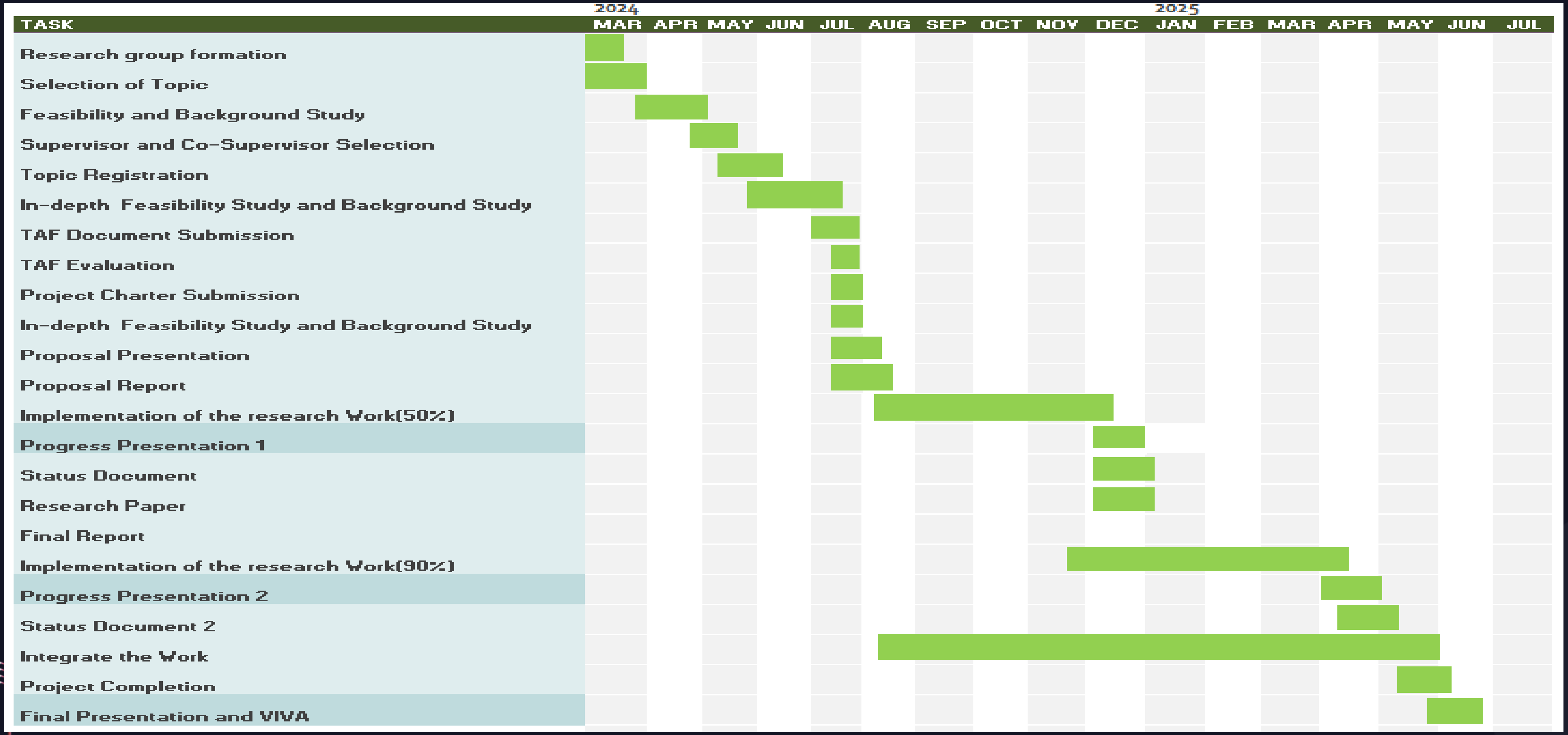
Simulation Frameworks:
CARLA, AirSim, or Unity

Web Frameworks: Node.js,
Flask, Django

# WORK BREAKDOWN CHART



# GANNT CHART



2024
2025
TASK
MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN JUL
Research group formation
Selection of Topic
Feasibility and Background Study
Supervisor and Co-Supervisor Selection
Topic Registration
In-depth Feasibility Study and Background Study
TAF Document Submission
TAF Evaluation
Project Charter Submission
In-depth Feasibility Study and Background Study
Proposal Presentation
Proposal Report
Implementation of the research Work(50%)
Progress Presentation 1
Status Document
Research Paper
Final Report
Implementation of the research Work(90%)
Progress Presentation 2
Status Document 2
Integrate the Work
Project Completion
Final Presentation and VIVA

# REFERENCES


- G. Goodall, "Incorporating Ethical Considerations Into Automated Vehicle Control," IEEE Intelligent Transportation Systems Magazine, vol. 9, no. 3, pp. 63-71, Fall 2017, doi: 10.1109/MITS.2017.2717543.

Incorporating Ethical Considerations Into Automated Vehicle Control | IEEE Journals & Magazine | IEEE Xplore

- Y. Shi, X. Ma, and B. Xu, "Decision-Making Technology for Autonomous Vehicles: Learning-Based Methods, Applications and Future Outlook," IEEE Transactions on Vehicular Technology, vol. 69, no. 9, pp. 9245-9261, Sept. 2020, doi: 10.1109/TVT.2020.3014587.

Decision-Making Technology for Autonomous Vehicles: Learning-Based Methods, Applications and Future Outlook | IEEE Conference Publication | IEEE Xplore

- A. Pan, J. Li, and Y. Wang, "Large Language Models for Autonomous Driving: Real-World Experiments," in Proc. of IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2022, pp. 12345-12354, doi: 10.1109/CVPR52688.2022.01234.

Large Language Models for Autonomous Driving: Real-World Experiments (arxiv.org)

- P. Lin, K. Abney, and G. Bekey, "Ethical Decision Making in Autonomous Vehicles: The AV Ethics Project," IEEE Intelligent Systems, vol. 30, no. 5, pp. 20-26, Sept.-Oct. 2015, doi: 10.1109/MIS.2015.60.

Ethical Decision Making in Autonomous Vehicles: The AV Ethics Project | Science and Engineering Ethics (springer.com)

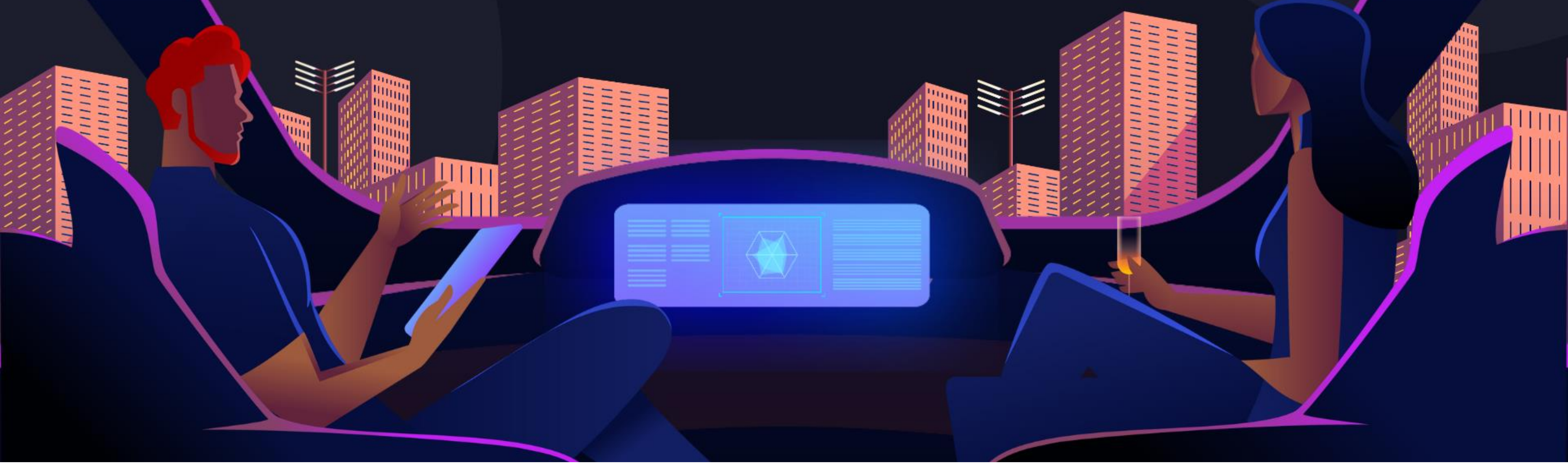
- J. Wang, S. Liu, and Y. Zhang, "Emotion Detection and Face Recognition of Drivers in Autonomous Vehicles in IoT Platform," IEEE Internet of Things Journal, vol. 7, no. 3, pp. 1858-1869, Mar. 2020, doi: 10.1109/JIOT.2020.2963784.

Emotion detection and face recognition of drivers in autonomous vehicles in IoT platform - ScienceDirect

# IT21174780|D.M.M.I.T.DISSANAYAKA

BSc (Hons) Degree in Information Technology (specialization in Data Science)

# Enhancing Autonomous Vehicle Safety in cabin



# Background

Identifying and monitor security risks such as weapons and unauthorized items in the car cabin.

- Image Recognition: Use deep learning models to process real-time camera feeds and detect unauthorized items.
- Voice Analysis: Analyze audio inputs to identify suspicious or unauthorized behaviors through voice patterns.

# Research Gap

Enhancing Low-Light Resolution for In-Cabin Security in Autonomous Vehicles

Addressing Voice Overlap Challenges in Multi-Occupant Autonomous Vehicle Cabins

Enhancing the speed and accuracy of real-time data processing

False Positives and False Negatives

There is a need for systems that ensure privacy while still providing effective monitoring.

# Competition comparison

| Features | In-Cabin Monitoring for Avs[6] | sensor fusion in autonomous vehicles[4] | Autonomous Vehicles [5] | Security strategy for autonomous vehicle[7] | MANTHRA-X (proposed System) |
|---|---|---|---|---|---|
| Integration of Image and Voice Recognition | ✗ | ✗ | ✗ | ✗ | ✓ |
| False Positive/Negative Reduction in Security Systems | ✗ | ✓ | ✗ | ✗ | ✓ |
| Advanced Convolutional Neural Networks for Vehicle Security | ✓ | ✓ | ✗ | ✓ | ✓ |
| Voice Tone and sounds in Security Systems | ✗ | ✗ | ✗ | ✗ | ✓ |
| Ethical and Privacy Considerations | ✓ | ✗ | ✓ | ✗ | ✓ |

# Research Problem

How to ensure accurate and reliable detection in autonomous vehicles to prevent security breaches ?

Synchronizing object and voice detection to accurately identify unauthorized activities.

How challenging is it to identify unauthorized items, such as weapons, in low-light scenarios?

Identifying unauthorized voices or keywords in an environment with multiple overlapping voices.

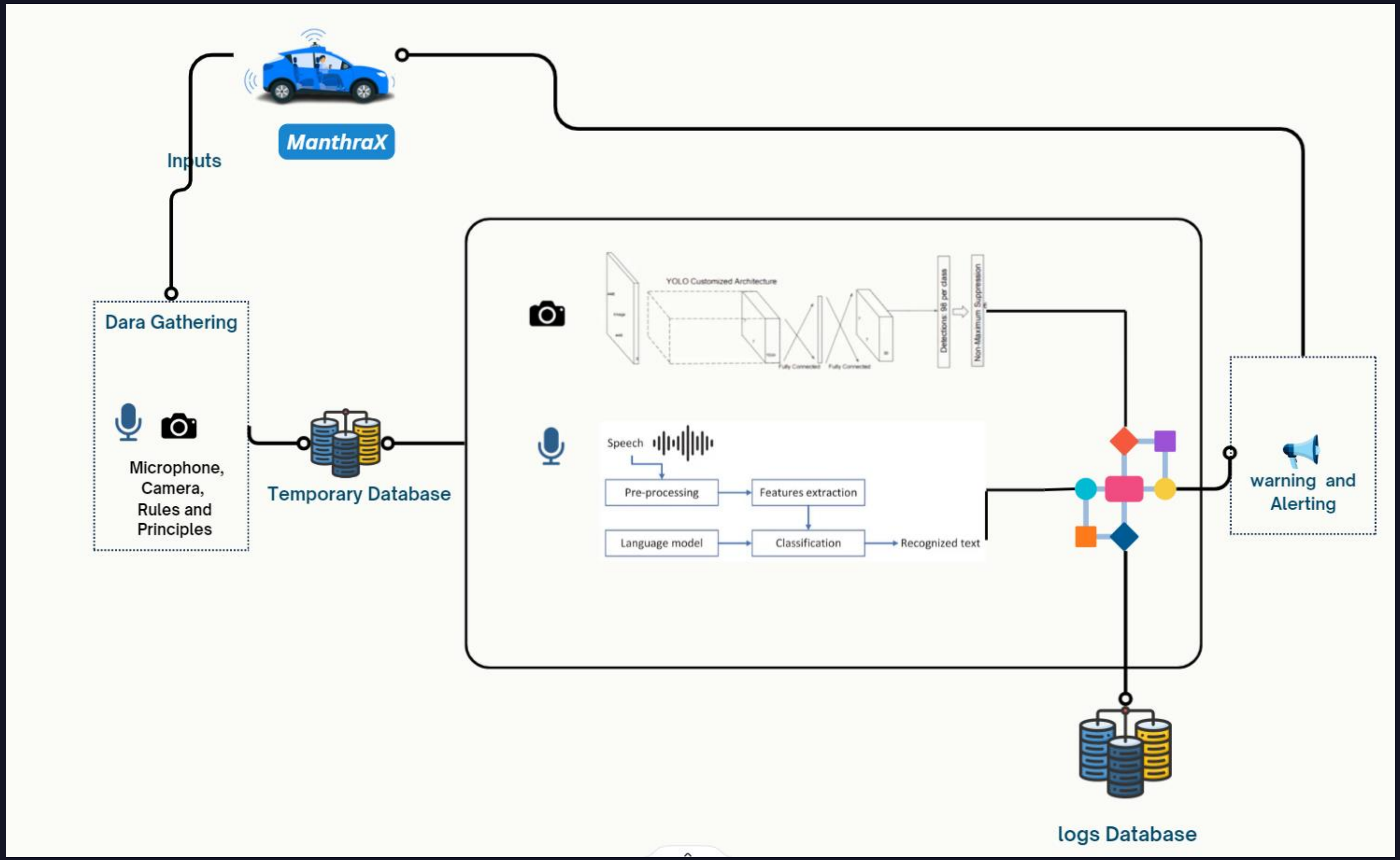
# SPECIFIC OBJECTIVE

Implement an application to accurately identify and monitor security risks, such as weapons and unauthorized items, in the car cabin by integrating real-time camera feeds and audio inputs, ensuring reliable performance in every condition.

# Sub Objectives

- Utilize advanced image and audio processing algorithms to analyze camera feeds and audio inputs continuously.
- Achieve high accuracy in detection while minimizing false positives.
- Protect the privacy and security of the data collected by the system.
- Design an intuitive and user-friendly interface for both drivers and passengers.

# Methodology



# Technologies to be Used

AI/ML Frameworks: TensorFlow, PyTorch, Keras.

Cloud Services: Microsoft Azure

Development Tools: IDEs: VSCode, PyCharm, Jupyter Notebook

Web Frameworks: Node.js, Flask, Django

Security: Encryption.

APIs: RESTful APIs

Databases: NoSQL Databases: MongoDB, Cassandra

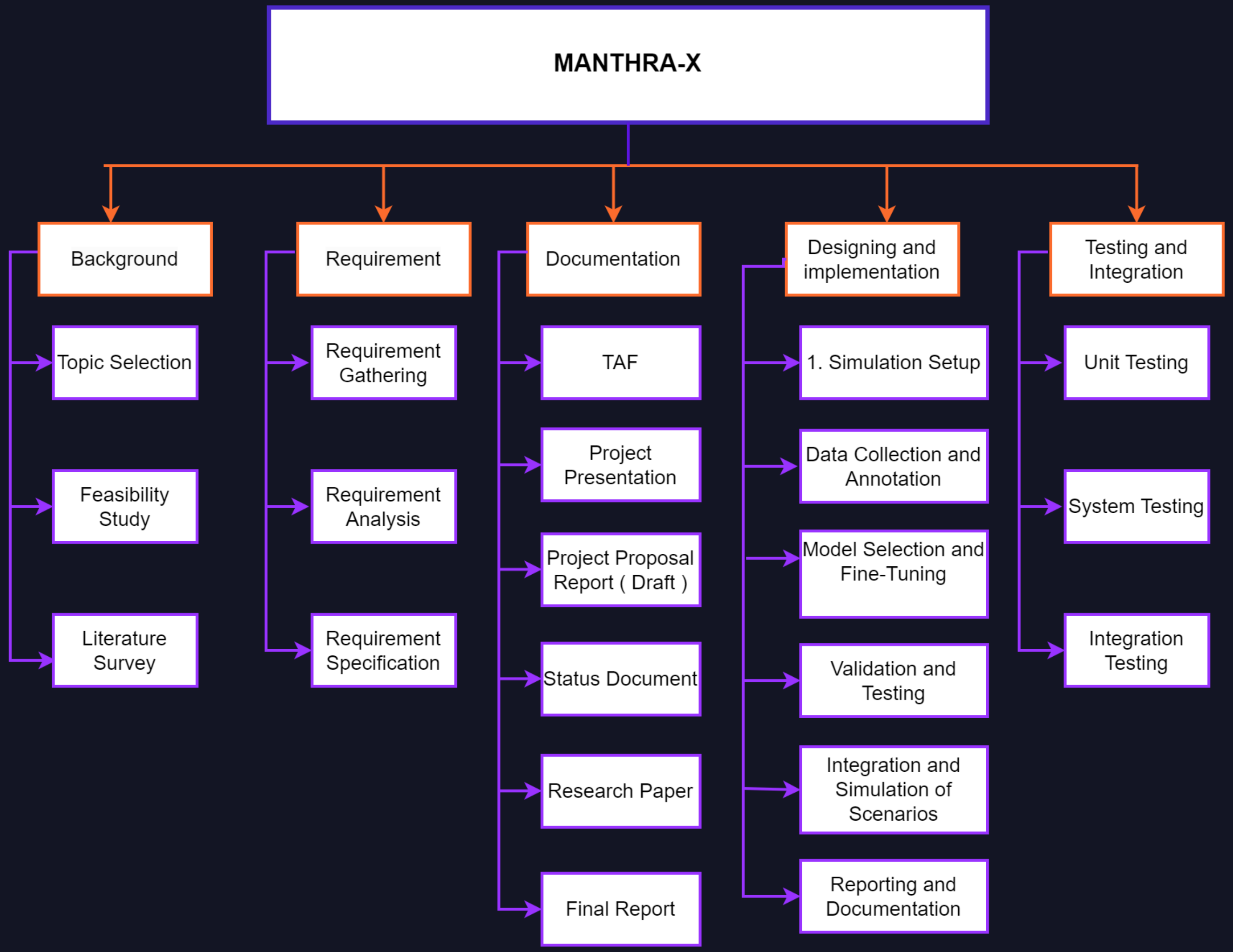
Simulation Frameworks: CARLA, AirSim, or Unity

# REQUIREMENT SPECIFICATION

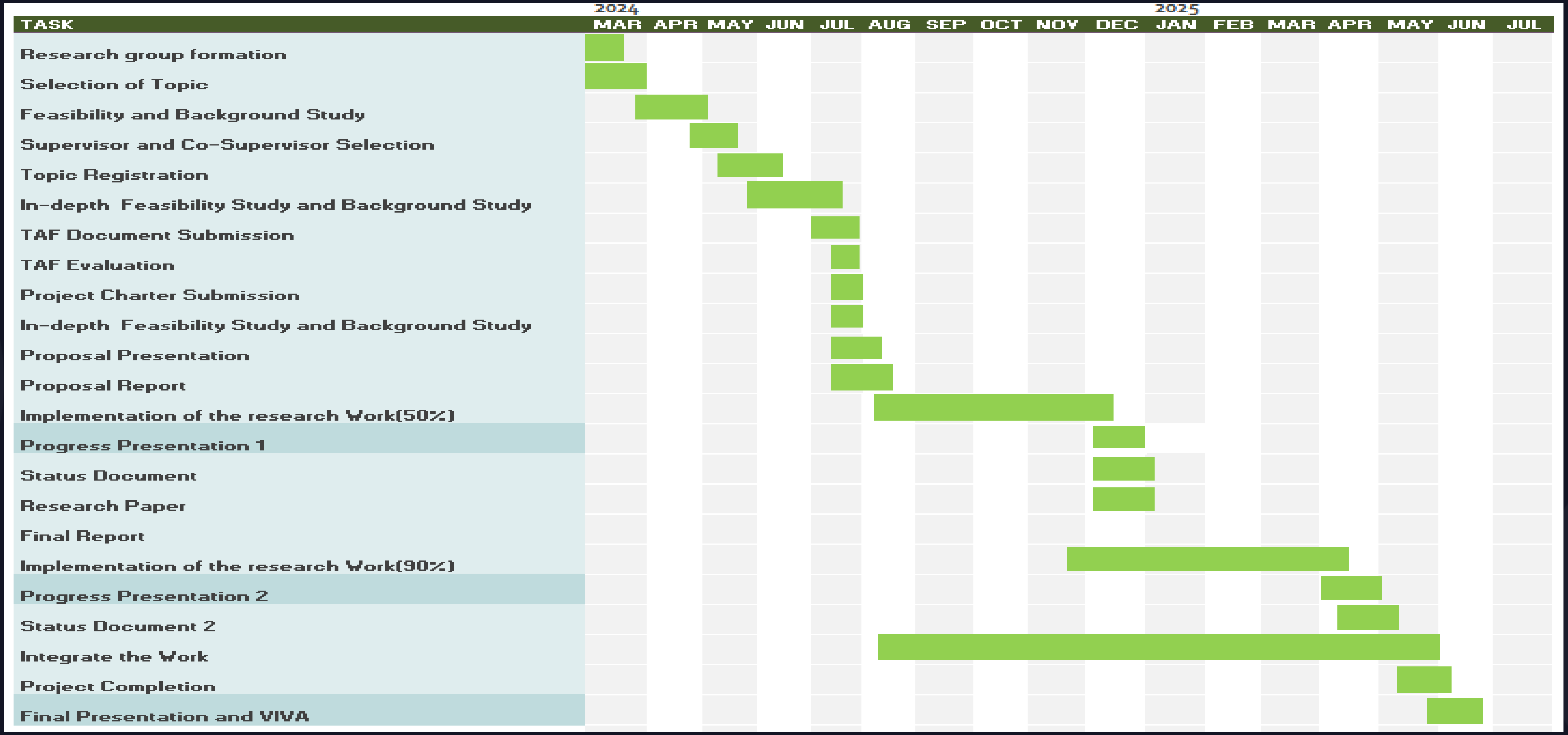
## System Requirements

- **High-performance computing (HPC) cluster or workstations:** For model training, simulation, and real-time processing.
- **High-resolution cameras:** For capturing detailed visual information.
- **Microphones: High-quality microphones are essential for capturing clear audio input.**

# Work Breakdown Structure (WBS)



# GANNT CHART


2024
2025
TASK
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
Research group formation
Selection of Topic
Feasibility and Background Study
Supervisor and Co-Supervisor Selection
Topic Registration
In-depth Feasibility Study and Background Study
TAF Document Submission
TAF Evaluation
Project Charter Submission
In-depth Feasibility Study and Background Study
Proposal Presentation
Proposal Report
Implementation of the research Work(50%)
Progress Presentation 1
Status Document
Research Paper
Final Report
Implementation of the research Work(90%)
Progress Presentation 2
Status Document 2
Integrate the Work
Project Completion
Final Presentation and VIVA

# References


- [1] Gun Detection in Real-Time Video Streams Using Convolutional Neural Networks. (n.d.). Gun Detection in Real-Time Video Streams Using Convolutional Neural Networks | IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/8681234
- [2] Real-Time Object Detection with Deep Learning for Autonomous Vehicles. (n.d.). Real-Time Object Detection with Deep Learning for Autonomous Vehicles | IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9073802
- [3] Voice Recognition Systems for Security Applications: A Survey. (n.d.). Voice Recognition Systems for Security Applications: A Survey | IEEE Journal Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/8847891
- [4] Multimodal Sensor Fusion for Enhanced Security and Comfort in Autonomous Vehicles. (n.d.). Multimodal Sensor Fusion for Enhanced Security and Comfort in Autonomous Vehicles | IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9354376
- [5] D. Garikapati and S. S. Shetiya, "Autonomous Vehicles: Evolution of Artificial Intelligence and Learning Algorithms," in IEEE International Conference on Autonomous Systems, Tokyo, Japan, Feb. 2024, pp. 1-10.
- [6] A. Mishra, S. Lee, D. Kim, and S. Kim, "In-Cabin Monitoring System for Autonomous Vehicles," Sensors, vol. 22, no. 12, pp. 4360
- [7] A. A. Alsulami, Q. Abu Al-Haija, B. Alturki, A. Alqahtani, and R. Alsini, "Security strategy for autonomous vehicle cyber-physical systems using transfer learning," Journal of Cloud Computing: Advances, Systems and Applications, vol. 12, no. 1, pp. 1-18, 2023.

# SUB OBJECTIVES

- Incorporate and Operationalize Ethical Principles and Frameworks-

Identify and integrate relevant ethical principles (e.g., utilitarianism, deontological ethics) into the system's decision-making processes to ensure alignment with established ethical standards.

- Develop and Integrate Driver Emotion Recognition-

Create and implement a system using voice and facial recognition technologies to accurately monitor and interpret the driver's emotional state, ensuring this information is effectively used in ethical decision-making.

- Establish Object and Road User Prioritization Techniques-

Develop methods for prioritizing objects and vulnerable road users based on ethical considerations and contextual information, ensuring decisions are aligned with safety and ethical standards.

- Ensure System Adaptability to Dynamic and Diverse Environments –

Design mechanisms that allow the system to adapt to varying driving conditions, societal values, and situational demands, maintaining ethical and safety standards.

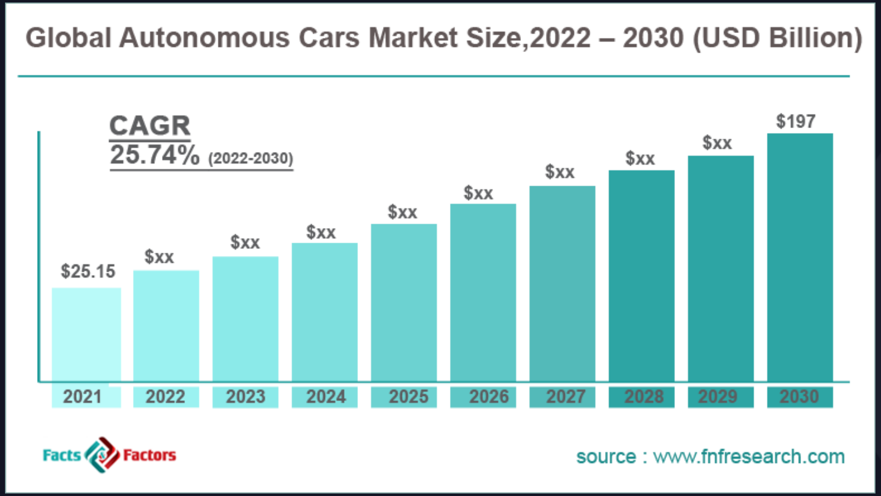
- Enhance Transparency and User Trust-

Create features that provide clear explanations of the system's decision-making processes, improving transparency and fostering trust among users regarding the ethical decisions made by the vehicle.

# Market Analysis

**1. Autonomous Vehicle Market Overview:**

- The global autonomous vehicle market is projected to grow significantly, with a CAGR of 25.74% from 2022 to 2030. The demand is driven by technological advancements, increased safety concerns, and the potential for reducing traffic congestion.
- Key players in the market include Tesla, Waymo, Cruise, and Uber, with significant investments in R&D and collaborations to improve autonomous driving technologies.



# Commercialization

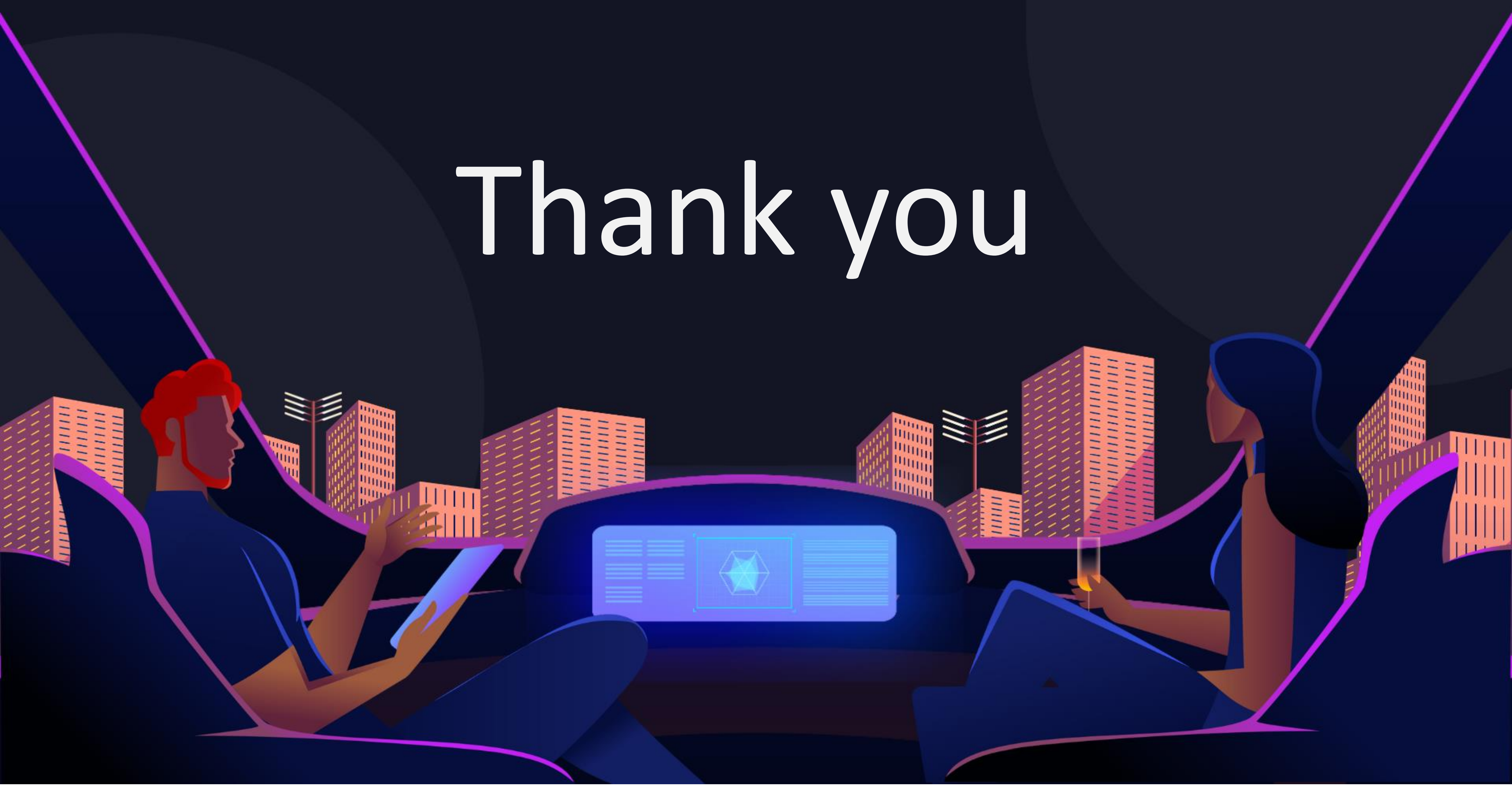
**Market Potential**

- **Demand Drivers**: Increased safety and efficiency in traffic management.
- **Urban Mobility**: Rising demand for advanced transportation solutions.
- **Emerging Economies**: High growth potential in developing countries.

# Commercialization

## Partnerships

- **Local Governments**: Collaborate on pilot programs and regulatory approvals.
- **Automotive Manufacturers**: Partner for technology integration and scaling production.
- **Tech Companies**: Work with AI and sensor technology firms for innovation and development.
- **Academic Institutions**: Engage with universities for research support and testing in real world scenarios.


Thank you