Requirements Gathering Documentation for Autonomous Vehicle Project

Introduction

In order to develop a robust and effective autonomous vehicle system, it is essential to gather detailed and accurate requirements. These requirements were gathered using a variety of techniques, including interviewing a domain expert and conducting documentation analysis. The approach involved reviewing existing documentation, research papers, industry standards, and guidelines related to autonomous vehicle navigation.

Interview with Domain Expert

Personal Information

- **Name:** Mr. M Tahir Anis
- **Role:** Software Engineer
- **Organization:** Maanz AI
- **Years of Experience:** 2

Interview Questionnaire

Introduction: We are conducting an interview to gather insights for our final year project on autonomous vehicle navigation. Your expertise will help us understand the key requirements and challenges in this field.

Initial Technical Questions:

1. What are the key components essential for autonomous vehicle navigation?
2. How do you approach obstacle detection and avoidance in autonomous systems?
3. Can you describe the process of path planning in complex environments?
4. What industry standards and guidelines do you consider most critical for autonomous vehicle safety?

Opinion-Based Questions:

1. What do you see as the biggest challenge in autonomous vehicle development?
2. In your experience, what technologies or methods have proven most effective for improving navigation precision and safety?
3. How do you foresee the future of autonomous vehicle navigation evolving in the next five years?

Interview Summary

Interview Period: Jan 8, 2024 – March 15, 2024

Key Insights:

1. **Essential Components:** M. Tahir emphasized the importance of vehicle control, path planning, obstacle detection and avoidance, sensor integration, and user interface as key components for autonomous vehicle navigation.
2. **Obstacle Detection and Avoidance:** He highlighted the use of advanced sensor fusion techniques and real-time processing algorithms for effective obstacle detection and avoidance.
3. **Path Planning:** He discussed the need for dynamic path planning that can adapt to changing environments and unexpected obstacles, utilizing both global and local path planning strategies.
4. **Industry Standards:** He pointed out several critical standards, including ISO 26262 for functional safety and ISO 21448 for safety of the intended functionality (SOTIF).

Challenges: He identified the biggest challenge as achieving reliable perception in diverse and unpredictable environments.

Effective Technologies: He noted that Different algorithms, use of ROS, Carla and ROS bridge and high-definition mapping have significantly improved navigation precision and safety.

Consent Form

Consent Form for Participation in Interview

I, M. Tahir, consent to participate in the interview conducted by the **Students of Riphah International University** for the purpose of gathering requirements for the autonomous vehicle project. I understand that my responses will be used in the project documentation and report.

Signature: _____*Tahir*_____

Questions designed to gather detailed information and ensure the completeness and accuracy of each requirement.

Vehicle Control

Autonomous Navigation

1. What specific conditions must the system be able to handle during autonomous navigation (e.g., weather, road types, traffic)?
2. How will the system handle navigation failures or deviations from the planned path?
3. What are the expected response times for the system to start navigating autonomously after receiving the destination?

Acceleration Control

1. What are the speed limits or acceleration thresholds for the system?
2. How will the system adjust acceleration in response to dynamic changes in the environment (e.g., traffic, obstacles)?
3. What mechanisms are in place to ensure smooth acceleration and passenger comfort?

Emergency Stop

1. What are the conditions under which the emergency stop mechanism should be triggered?
2. How will the system communicate an emergency stop to the driver and surrounding vehicles?
3. What are the fail-safe measures if the emergency stop mechanism fails?

Throttle Control

1. What parameters will the system use to regulate the throttle?
2. How will the system integrate throttle control with other control mechanisms like braking and steering?
3. What safety measures are in place to prevent throttle control failures?

Steering Control

1. What algorithms will be used for precise steering control?
2. How will the system ensure steering accuracy at different speeds and road conditions?

3. What redundancy mechanisms are in place for steering control?

Braking Control

1. What are the braking distance requirements for different speeds?
2. How will the system ensure safe braking in emergency situations?
3. How does the system handle braking coordination with other control systems (e.g., throttle, steering)?

Path Planning

Route Calculation

1. What factors will the system consider when calculating the most efficient route (e.g., distance, traffic, road conditions)?
2. How frequently will the system update the calculated route?
3. What data sources will be used for route calculation (e.g., maps, real-time traffic data)?

Lane Assignment

1. What criteria will the system use to assign lanes?
2. How will the system handle lane changes and merging?
3. How will lane assignment be communicated to the vehicle's control systems?

Waypoint Generation

1. What is the frequency of waypoint generation along the route?
2. How will the system ensure waypoints are accurately placed?
3. How will waypoints be updated in response to dynamic environmental changes?

Map Reading

1. What types of digital map data will the system use?
2. How will the system handle discrepancies or errors in map data?
3. What are the procedures for updating map data in the system?

Dynamic Obstacle Avoidance

1. What sensors and algorithms will the system use for real-time obstacle detection?
2. How will the system prioritize obstacle avoidance over other tasks?

3. What are the criteria for determining when to avoid an obstacle and when to stop?

Path Following

Path Smoothing

1. What techniques will be used to smooth the path?
2. How will the system balance path smoothness with responsiveness to dynamic changes?
3. What metrics will be used to evaluate path smoothness?

Lateral Control

1. What methods will be used to minimize lateral deviation?
2. How will the system measure and correct lateral deviations in real-time?
3. What are the acceptable limits for lateral deviation?

Longitudinal Control

1. How will the system control longitudinal deviation?
2. What factors will influence longitudinal control (e.g., traffic flow, road conditions)?
3. How will the system integrate longitudinal control with other control mechanisms?

Speed Control

1. What parameters will determine the vehicle's speed at different points in the journey?
2. How will the system adapt speed control in response to dynamic changes (e.g., obstacles, traffic signals)?
3. What safety measures are in place for speed control failures?

Waypoint Following

1. What precision is required for following waypoints?
2. How will the system handle deviations from waypoints?
3. How frequently will waypoints be updated during navigation?

Sensor Integration

Inertial Measurement Unit (IMU) Utilization

1. What data will the IMU provide, and how will it be used?
2. How will the system integrate IMU data with other sensor data?
3. What are the accuracy requirements for the IMU?

Global Positioning System (GPS) Utilization

1. What level of accuracy is required from the GPS system?
2. How will GPS data be used for vehicle navigation and control?
3. What are the backup mechanisms in case of GPS signal loss?

Radar/Lidar Utilization

1. What types of objects will radar/lidar sensors detect?
2. How will the system integrate radar/lidar data with other sensor data?
3. What are the accuracy and range requirements for radar/lidar sensors?

Trajectory Planning

Trajectory Generation

1. What factors will influence the trajectory generation (e.g., route, obstacles, vehicle dynamics)?
2. How frequently will the trajectory be updated?
3. What algorithms will be used for optimal trajectory generation?

Obstacle Detection

Detection Using Sensors

1. What types of obstacles will the sensors detect?
2. How will the system differentiate between static and dynamic obstacles?
3. What are the detection range and accuracy requirements for the sensors?

Environmental Awareness

1. What methods will the system use to maintain situational awareness?
2. How will the system integrate data from multiple sensors for environmental awareness?
3. How will the system handle false positives and negatives in obstacle detection?

Dynamic Obstacle Tracking

1. What algorithms will be used for tracking moving obstacles?
2. How will the system predict the movement of dynamic obstacles?
3. What are the response times required for dynamic obstacle tracking?

Distance Estimation

1. How will the system estimate the distance to obstacles?
2. What accuracy is required for distance estimation?
3. How will distance estimation data be used for obstacle avoidance?

Obstacle Avoidance

Re-Plan Path

1. What triggers will cause the system to re-plan the path?
2. How will the system ensure the new path is safe and efficient?
3. What algorithms will be used for path re-planning?

Trajectory Adjustment

1. How will the system dynamically adjust the trajectory to avoid obstacles?
2. What criteria will determine the need for trajectory adjustment?
3. How will trajectory adjustments be communicated to the vehicle's control systems?

Multi-Obstacle Handling

1. How will the system manage the avoidance of multiple obstacles simultaneously?
2. What priority rules will the system follow for obstacle avoidance?
3. What are the performance requirements for multi-obstacle handling?

Steering Control

1. How will the system adjust steering angles in response to detected obstacles?
2. What are the accuracy requirements for steering adjustments?
3. How will the system ensure steering adjustments are smooth and safe?

Maneuver Execution

1. What types of avoidance maneuvers will the system execute?
2. How will the system ensure maneuvers are executed safely and efficiently?
3. What algorithms will be used for maneuver execution?

Destination Arrival

Destination Approach

1. How will the system approach the driver-specified destination?
2. What accuracy is required for destination approach?
3. How will the system handle obstacles or changes near the destination?

Stop at Destination

1. How will the system ensure a smooth and safe stop at the destination?
2. What are the criteria for determining the stopping point?
3. How will the system communicate the arrival and stopping process to the driver?

User Input

Ride Initiation

1. How will the driver initiate the journey?
2. What interfaces will be used for ride initiation?
3. How will the system confirm that the ride has been initiated successfully?

Destination Setting

1. How will the driver input the desired destination?
2. What interfaces will be used for destination setting?
3. How will the system confirm and validate the input destination?

System Integration

ROS Integration

1. How will ROS facilitate communication between different software components?
2. What specific ROS packages and nodes will be utilized?
3. How will data exchange and synchronization be managed within ROS?

Simulation Environment

1. How will the CARLA simulator be used for development and testing?
2. What scenarios and environments will be simulated in CARLA?
3. How will simulation results be validated and applied to real-world deployment?