Truck Platooning Safety Scenarios: Emergency Stop Lane Changing

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Abstract: Truck platooning is a driving technology that allows multiple complicated vehicles to travel in close formation, improving fuel efficiency, and reducing road congestion. However, safety always becomes an important factor when considering this model, this paper talks about safety features based on the scenario of there being stationary obstacles on the road. Two primary scenarios are addressed. Scenario 1 considers a stationary obstacle is detected within 35 meters, the lead truck then initiates a coordinated lane change maneuver, followed by the platoon trucks. Scenario 2 involves a sudden appearance of a stationary obstacle detected less than 15 meters away, for which an emergency braking procedure is executed by all vehicles in the platoon. The analysis of the system requirements, including vehicle to vehicle (V2V) communication and inter-vehicle spacing, creating a high level decision making model for ensuring safety and coordination under these scenarios.

1 Motivation

- Safety challenges in real world deployment of platooning.

- Realistic accident risks and importance of responsive maneuvers.

- Critical role of low-latency coordination in preventing collisions.

2 Scenario Description

2.1 Scenario A: Lane Change

- Trigger: Obstacle detected <= 35 meters ahead.

- Action : Lead Truck initiates lane change.

- Coordination: Follower trucks replicate the maneuver.

2.2 Scenario B: Emergency Stop

- Trigger: Object Detected <= 15 meters ahead.

- Action : Lead Truck performs emergency stop.

- Reaction : Follower Trucks follow synchronized braking command.

3 System Requirements

3.1 Reliable V2V Communication

- Low-Latency, high reliability.

3.2 Safe Vehicle Distance

- Adaptive cruise control.

3.3 Real-Time Obstacle Detection and Classification

∗ Lidar, Radar, and camera on the lead truck.

4 Scenario Models using SYSML/UML

This section highlights the different SYSML and UML diagrams to model the safety scenarios of the platoon, focusing on the structure, behavior, and interactions. The diagrams shown include the Activity Diagram, Block Definition Diagram, Sequence Diagram, Requirements Diagram, and State Machine Diagram.
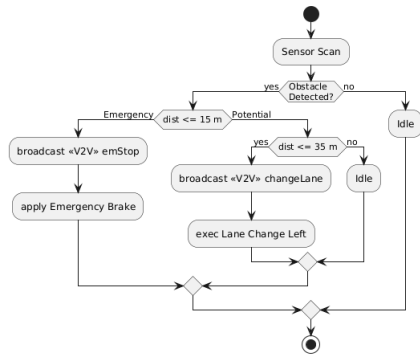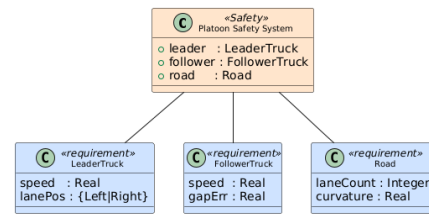
Fig. 1: Activity Diagram
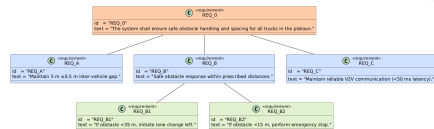
Fig. 2: Block Definition Diagram
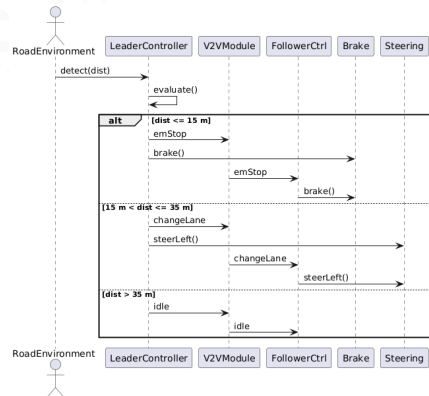
Fig. 3: Requirements Diagram
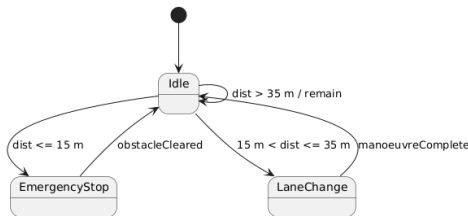
Fig. 4: Sequence Diagram

Fig. 5: State Machine Diagram

5 Formal Modeling with UPPAAL

This Section of the project highlights the UPPAAL model that was created in order to simulate and test this scenario. Where like previously mentioned, all trucks remain idle until an obstacle has been detected, once an obstacle has been detected, if it is over 35 meters away, the trucks remain idle, if the obstacle is between 15 and 35 meters away, the lead truck performs a lane change, and the follower trucks repeat the process, and the state is returned back to idle. Finally, if the obstacle is less than 15 meters away, the leader truck performs an emergency break, forcing the follower trucks to do the same.
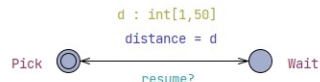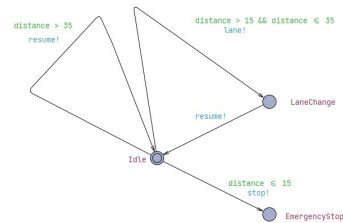
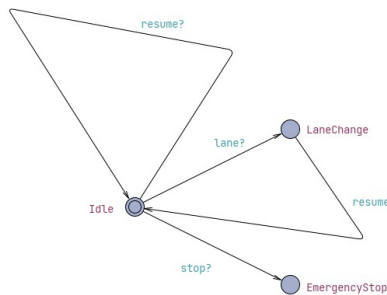Fig. 6: Activity Diagram

Fig. 7: Block Definition Diagram

Fig. 8: State Machine Diagram

6 Conclusion

7 Declaration of Originality

I, Arya Karimi Jafari, herewith declare that I have composed the present paper and work by myself and without the use of any other than the cited sources and aids. Sentences or parts of sentences quoted literally are marked as such; other references with regard to the statement and scope are indicated by full details of the publications concerned. The paper and work in the same or similar form have not been submitted to any examination body and have not been published. This paper was not yet, even in part, used in another examination or as a course performance. I agree that my work may be checked by a plagiarism checker.

05,09,2025 - Arya Karimi Jafari

Bibliography