Evaluating the Impact of Autonomous Vehicle Motion Planning in Diverse Traffic Scenarios Using SumoWare

Master‘s Thesis of Shahnam Ahmad Noor

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1. Background & Motivation

Autonomous vehicles (AVs) are expected to significantly influence future traffic systems.
While many studies evaluate AV behaviour at the **individual vehicle level**, the **system-level effects on traffic flow and congestion remain unclear**. Understanding these effects is critical because traffic dynamics emerge from interactions between many vehicles.

This research investigates how a **full-stack autonomous vehicle motion planner affects overall traffic performance** using a co-simulation framework integrating **Autoware and SUMO**.

2. Research Question

How does an autonomous vehicle motion planner perform in terms of efficiency, safety, and behavioural compliance across different traffic scenarios using the SumoWare framework?

- Performance across traffic geometries
- Safety and rule compliance
- Adaptation to dynamic traffic environments

3. Methodology

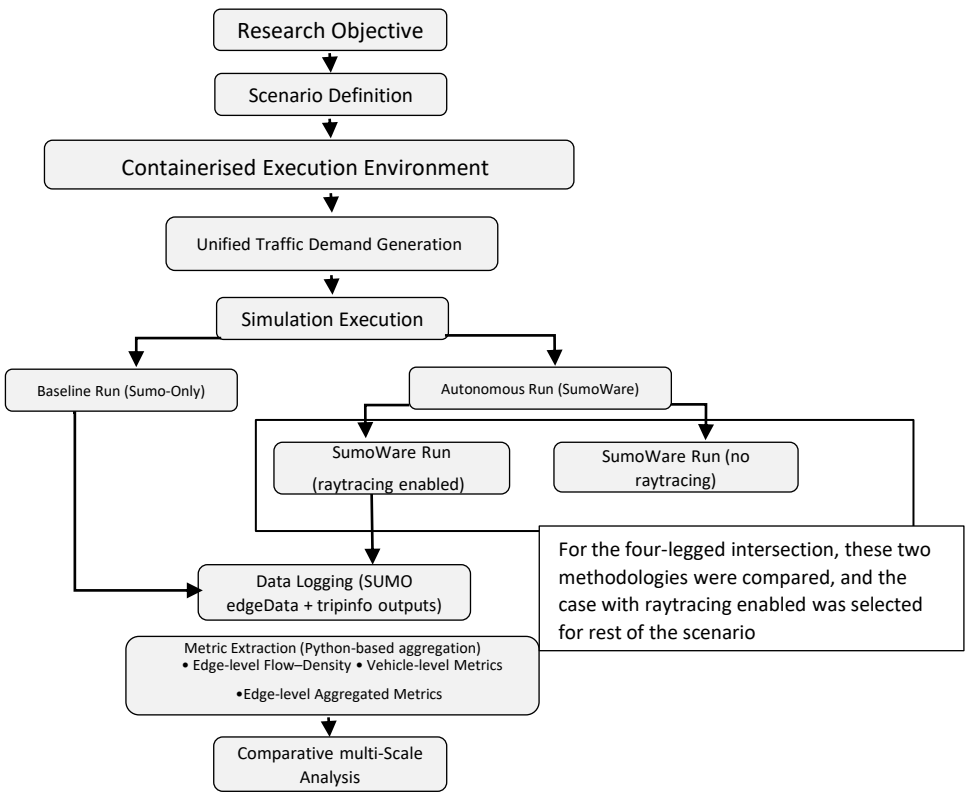

Figure 1. Methodology flow diagram

4. Evaluated Traffic Scenarios

- **Highway** – longitudinal traffic flow
- **Four-Legged Intersection** – high conflict interactions
- **Roundabout** – continuous yield-based merging
- **Major–Minor Staggered access road** – gap acceptance behaviour

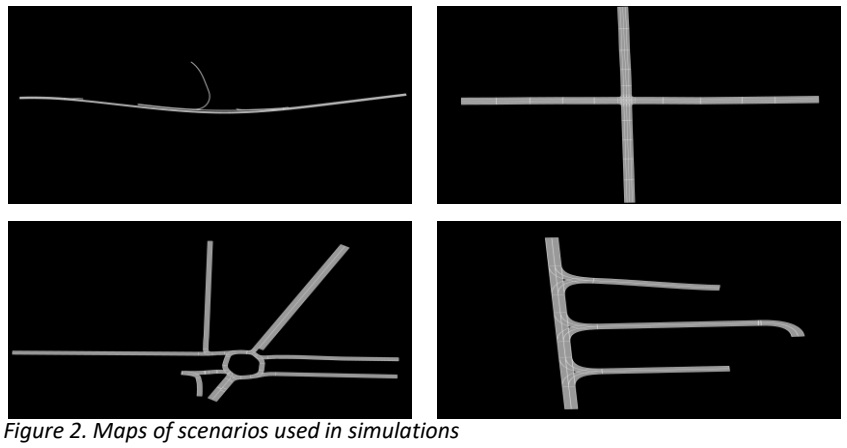

Figure 2. Maps of scenarios used in simulations

5. Key Results

The simulation results reveal that the impact of autonomous motion planning strongly depends on roadway geometry.
Major Findings
• Intersections show the largest sensitivity to autonomous vehicle behaviour
• Autonomous vehicles may reduce capacity in high-conflict environments
• Highway scenarios show stable flow with minor capacity changes
• Even a single autonomous vehicle can measurably influence traffic dynamics
These results highlight the importance of geometry-specific evaluation when assessing AV deployment.

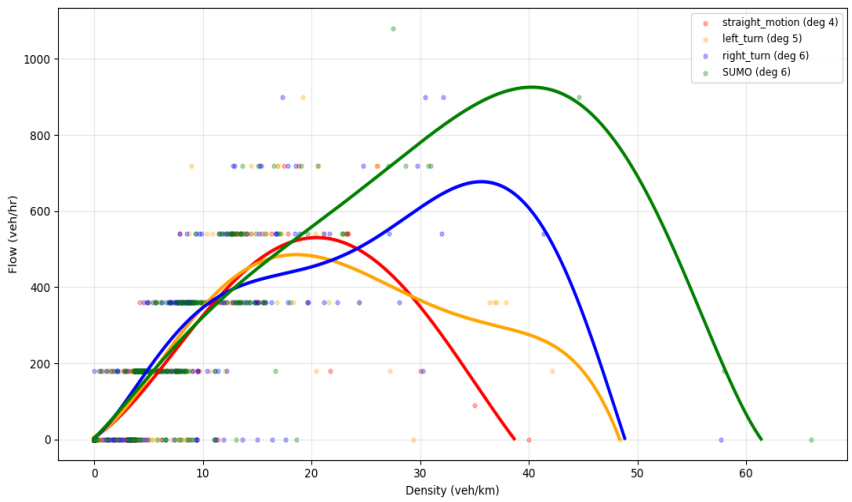

Figure 3. Edge-level Flow-density graphs of AV making different turning manoeuvres for a four-legged intersection compared with the baseline SUMO

6. Conclusions

This study demonstrates that autonomous motion planning can influence traffic systems beyond individual vehicle behaviour.
Key insights include:

- Autonomous vehicle motion planning reduces traffic efficiency in conflict-heavy environments
- Traffic flow remains stable, indicating safe system behaviour
- Autonomous motion planner follows priority and merging rules, demonstrating behavioural compliance
- SUMO safety indicators show only occasional emergency braking events by the Autonomous Vehicle, suggesting stable overall traffic behaviour
- Simulation frameworks like SumoWare enable the evaluation of AV behaviour across multiple traffic scenarios

Future Work
Future research should investigate:
• Higher autonomous vehicle penetration rates
• Larger urban traffic networks