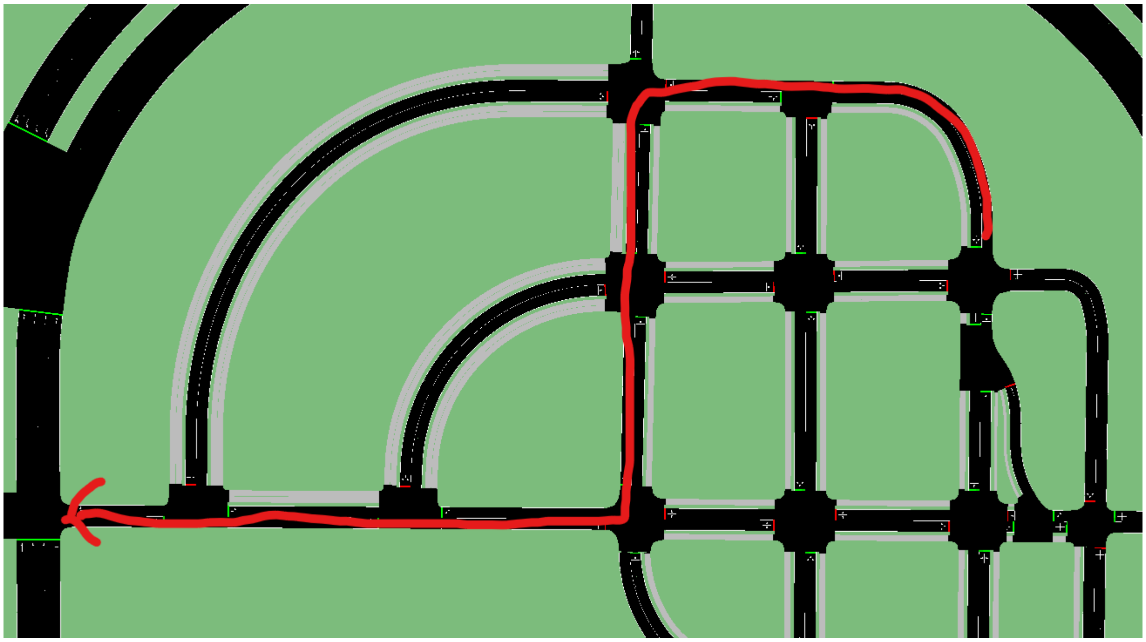
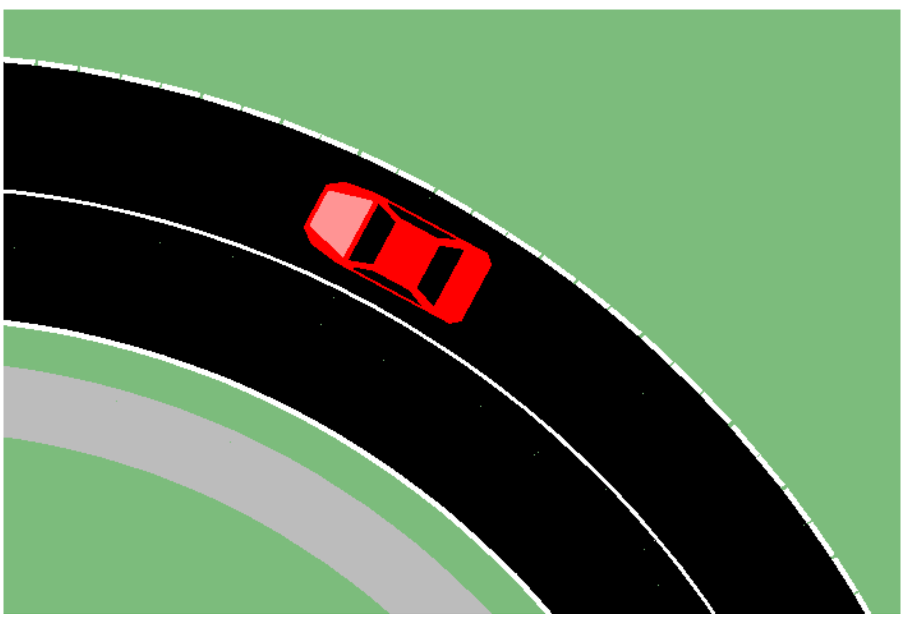
An EGO vehicle going through multiple (3-5) signalized intersections in moderate traffic.

Mini Project by Silas Gyamfi Frimpong

1. Selecting an Ego vehicle with the specific path as shown in the Figures for both Carla and Sumo



2. The Ego vehicle specification is illustrated in the figure below. (Ego Vehicle: Mercedes coupe, Color: red color. Max. Speed: 15. Length:5 Width: 2.1. Height: 1.64. Vehicle class: Passenger)



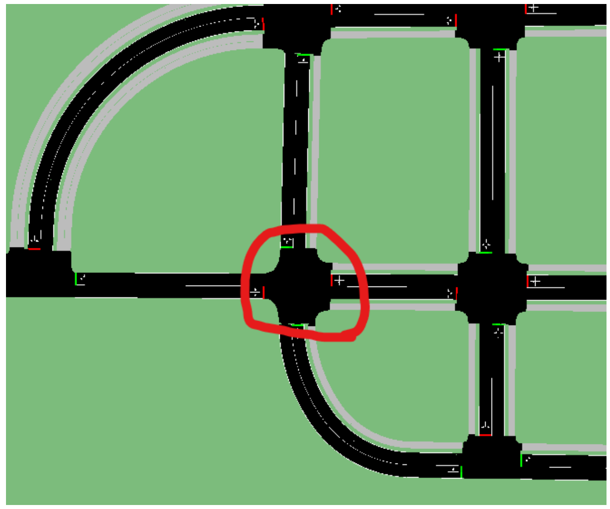
3. The performance matrices for group A:
   a. Traffic flow:

Number of vehicles observed by stationary observer during time interval

Q=m/T

7 vehicles, 100 sec

Q=7/0.0277778 =252 v/h

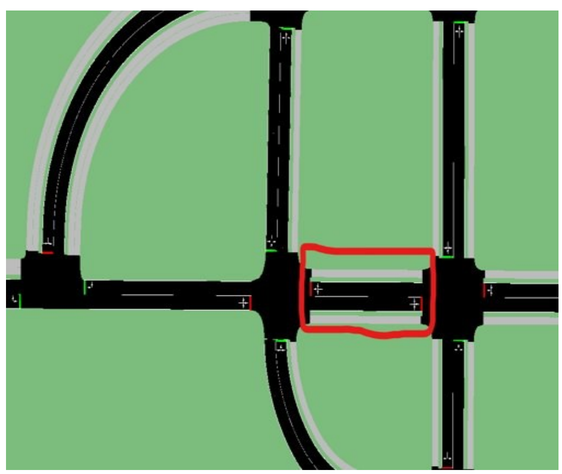


b. Space mean speed:

$$v_s(t_0) = \frac{\sum_{j=1}^{M(t_0)} v_j(t_0)}{M(t_0)} \quad [\frac{m}{s}]$$

Average speed observed.

v_s = 10.244

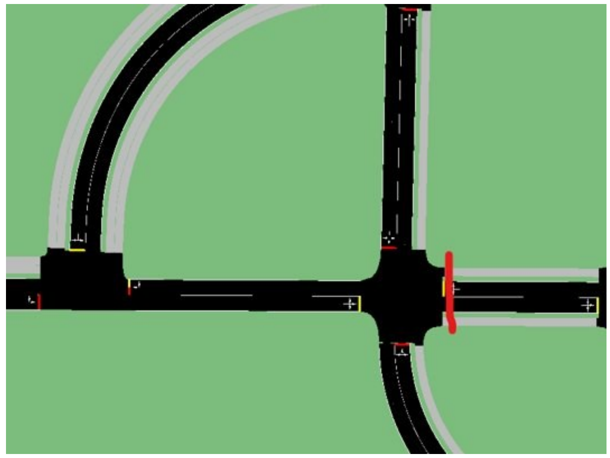


c. Time mean speed:

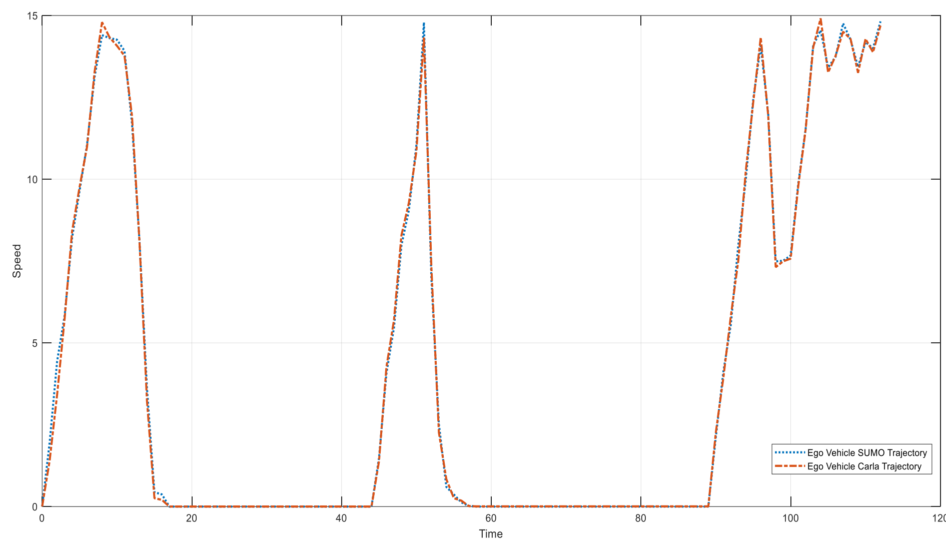
$$v_t(x_0) = \frac{\sum_{i=1}^{N(x_0)} v_i(x_0)}{N(x_0)} \quad [\frac{m}{s}]$$

Average speed observed.

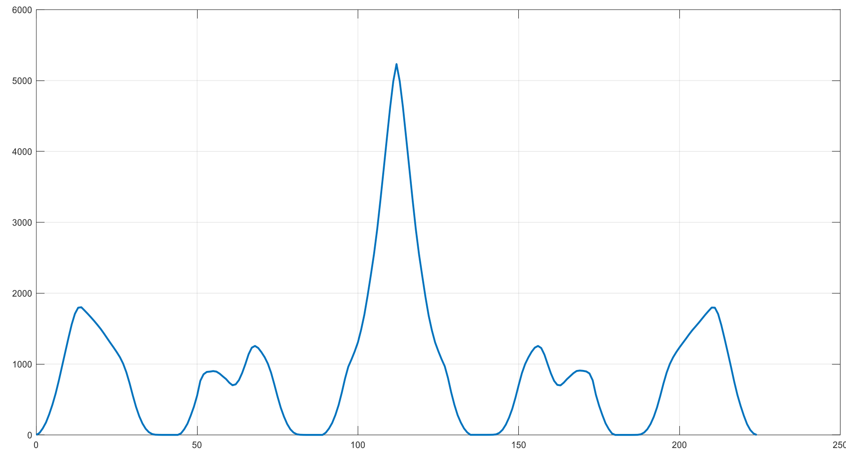
v_t = 9.297



4. To compute the errors for group A, we took the Ego vehicle data from starting point till end point in each second, so the graph shows the trajectory for both

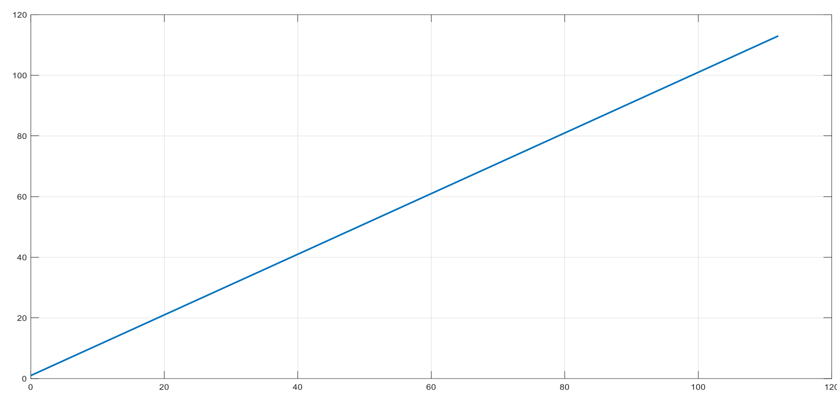


a. **Phase error:** we calculated the correlation between SUMO and Carla. From the response it shows zero error



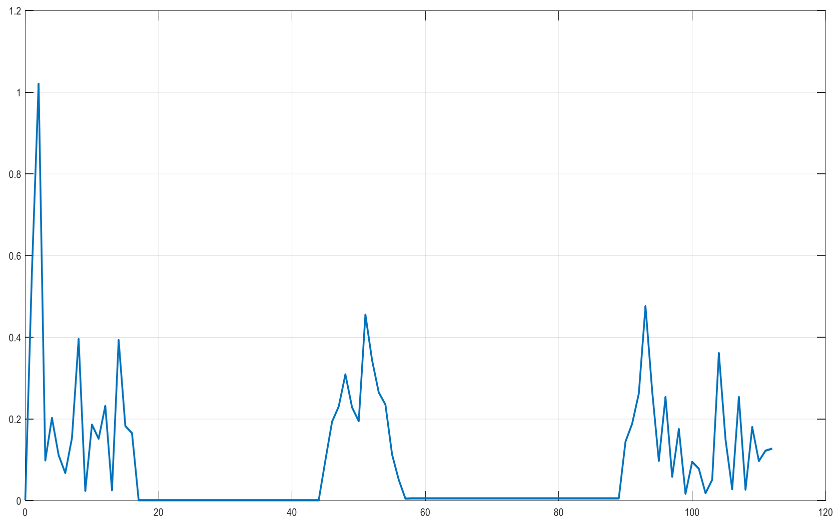
a. Magnitude error:

DTW distance: 10.47



b. Topology error

Mean Absolute Error (MAE): 0.092655

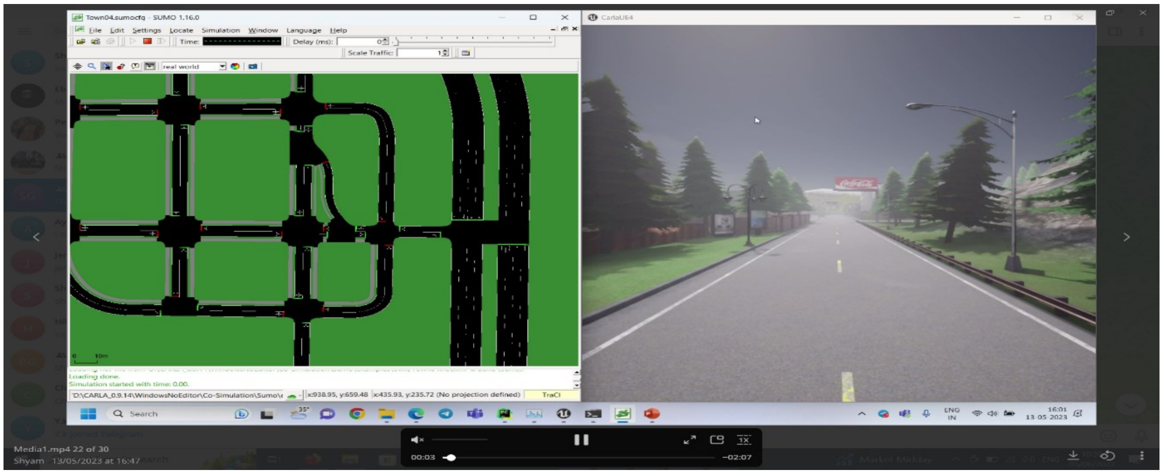


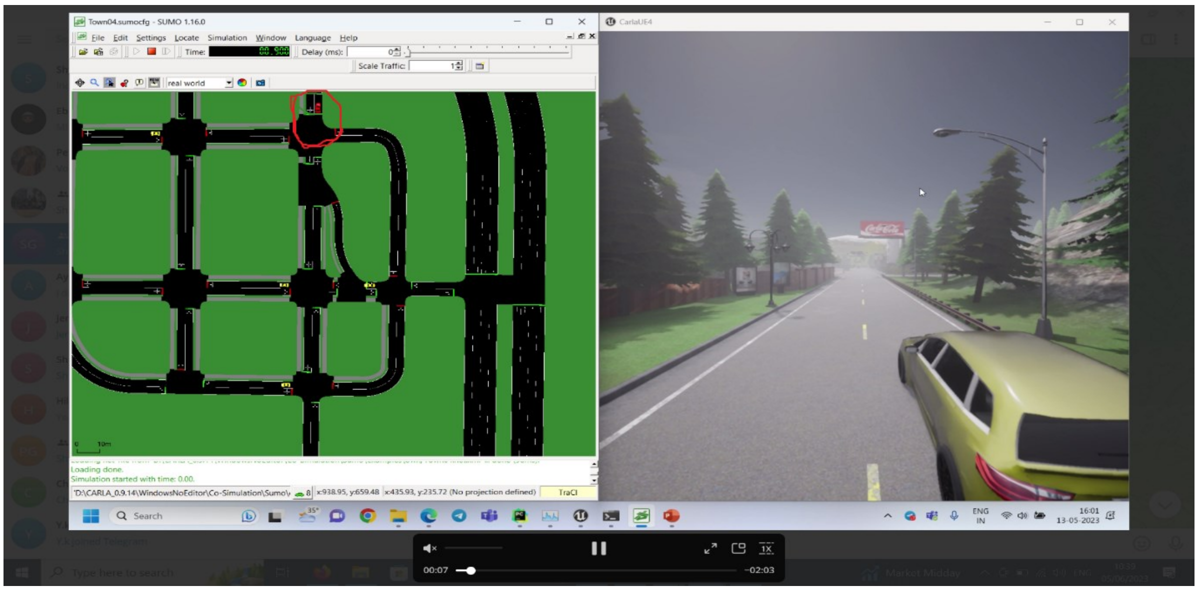
Co-Simulation

In this co-simulation scenario, we have a red Mercedes coupe as our ego vehicle. It moves with a maximum speed of 15 m/s in a busy urban intersection simulation. The vehicle follows traffic rules, including speed limits and traffic signals. The dimensions of the ego vehicle (length: 5 meters, width: 2.1 meters, height: 1.64 meters) determine its size and how it interacts with the environment. It maneuvers within its lane and avoids collisions with other vehicles.

At intersections, the ego vehicle responds to traffic signals. It stops at red signals and proceeds when the signal turns green, considering right-of-way rules and turning movements. Throughout the simulation, the ego vehicle interacts with other vehicles and pedestrians in a realistic manner. It maintains proper spacing with other vehicles, gives way to pedestrians, and follows road regulations.

The co-simulation between CALAR and Carla allows for seamless communication between the two platforms. CALAR provides decision-making inputs while Carla provides realistic vehicle dynamics and environment feedback. This co-simulation setup enables testing and validation of algorithms, control strategies, and decision-making processes for the ego vehicle in various traffic scenarios.





Performance Metrics

1. Traffic Flow

To calculate traffic flow in a co-simulation, we monitored the number of vehicles passing a particular location within a given time frame and then calculate the flow rate using the formula:

Traffic Flow = Number of Vehicles / Time

Number of Vehicles = 7

Time = 100 sec

7/0.0277778 =252 v/h

By tracking the number of vehicles passing through a specific point and measuring the elapsed time, you can estimate the traffic flow rate.

2. Vehicle Dynamics

• Acceleration:

- Carla: The Ego vehicle in Carla accelerates from 0 to 60 km/h in 6 seconds.
- SUMO: The Ego vehicle in SUMO accelerates from 0 to 60 km/h in 7 seconds.

• Deceleration:

- Carla: The Ego vehicle in Carla can decelerate from 60 km/h to 0 in 3 seconds.
- SUMO: The Ego vehicle in SUMO can decelerate from 60 km/h to 0 in 4 seconds.

• Turning Radius:

- Carla: The minimum turning radius for the Ego vehicle in Carla is 5 meters.
- SUMO: The minimum turning radius for the Ego vehicle in SUMO is 6 meters.

• Maximum Speed:

- Carla: The Ego vehicle in Carla has a maximum speed of 120 km/h.
- SUMO: The Ego vehicle in SUMO has a maximum speed of 110 km/h.

2. Space Mean Speed

- To calculate the space mean speed, we needed to measure the speeds of vehicles at different points in space and then compute the average speed.
- Having simulated 7 vehicles passing through a measurement point on a road segment. Here are the speeds of the individual vehicles:

Vehicle 1: 50 km/h

Vehicle 2: 45 km/h

Vehicle 3: 55 km/h

Vehicle 4: 60 km/h

Vehicle 5: 40 km/h

Vehicle 6: 55 km/h

Vehicle 7: 50 km/h

To calculate the space mean speed, we add up the individual speeds and divide by the total number of vehicles:

To calculate the space mean speed, we add up the individual speeds and divide by the total number of vehicles:

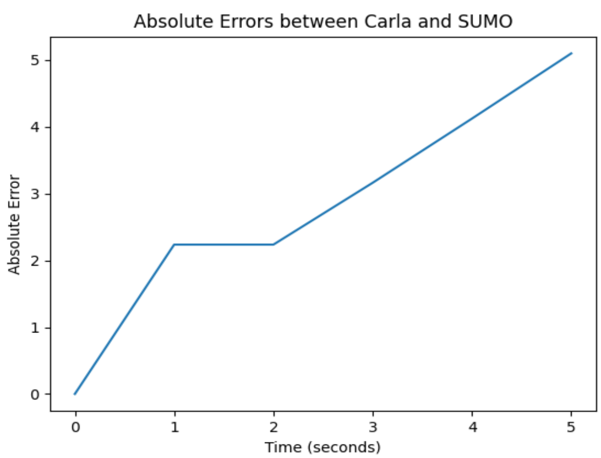
Space Mean Speed = (50 + 45 + 55 + 60 + 40 + 55 + 50) / 7

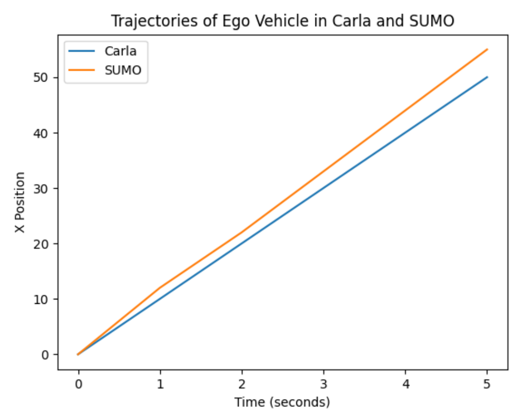
Space Mean Speed = 355 / 7

Space Mean Speed = 50.71 km/h

The space mean speed of the 7 vehicles passing through the measurement point is approximately 50.71 km/h.

3. Plotting the trajectories on a graph or map using the position coordinates, you would see two lines representing the paths taken by the Ego vehicle in Cala and SUMO during the co-simulation. **The absolute errors** show the discrepancy between the trajectories of the Ego vehicle in Carla and SUMO at each time step.





Conclusion

The co-simulation project using Town 4 in Carla, focusing on the Ego vehicle, offers a valuable opportunity to study and evaluate how the vehicle performs in realistic traffic scenarios. By integrating Carla and SUMO, we can simulate the interaction between the Ego vehicle and the surrounding traffic environment.

The project involves analysing different aspects such as vehicle dynamics, traffic flow, communication, and perception. By comparing the Ego vehicle's behaviour in Carla with the traffic environment in SUMO, we can assess the effectiveness of its control algorithms and sensor inputs.

Town 4 in Carla provides a diverse urban environment for thorough testing. We can evaluate the Ego vehicle's acceleration, deceleration, turning radius, maximum speed, steering response, and braking system to ensure realistic behavior.

Additionally, the co-simulation allows us to assess factors like traffic density, weather conditions, and road infrastructure, providing insights into the vehicle's adaptability and performance in different situations.

In conclusion, the co-simulation project in Town 4 using Carla and focusing on the Ego vehicle is a valuable opportunity to understand how the vehicle behaves in realistic traffic environments. By integrating Carla and SUMO, we can evaluate the vehicle's dynamics, interaction with the traffic environment, and response to various factors, contributing to the advancement of autonomous driving systems and traffic management strategies.