Task report:

Carla simulation to generate Odometry & sensor data

Developed by: Saad Waqar

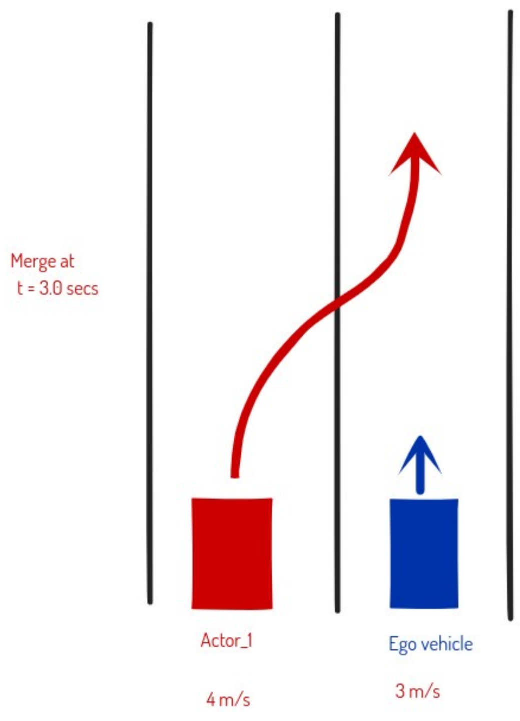
Project Demo: Screen recording can be viewed here.

Summary:

This package contains a ROS2 package (ament cmake type), which holds a single “executor_node”. This executor node is responsible to simulate a driving scenario in Carla simulator through interaction over carla-ROS bridge. This package was built & tested with ROS2 humble. This node will simulate an ego-vehicle and an actor vehicle, and then save the sensor data from ego vehicle (GPS, IMU, lidar & camera) in an mcap file.

Scenario:

I have selected a scenario of **“ego-vehicle being over-taken, and cut-in by a passing actor vehicle”.**
Ego-car (Blue) will be moving with speed 3m/s, while actor_1 will be moving with 4m/s. At time = 3.0 secs, the **actor_1** car will cut & merge into the ego-car’s lane with lateral speed of 0.6m/s. After merging, the leading vehicle will also slow down to 3m/s, followed by ego-vehicle running at similar speed.



Note: For the sake of simplicity, the driving models are not selected to be Ackerman, hence, lateral motion is possible. Although, merging speed has been set very low to mimic the behavior of a proper Ackerman car.

Control

Both ego-car and actor_1 are being controlled directly by setting their transforms directly using ROS2 executor node, over a rate of 10 frames per sec. These transforms are being controlled directly from topics:

- carla/ego_vehicle/control/set_transform
- carla/actor_1/control/set_transform (`geometry_msgs::msg::Pose`)

Executor node calculates the positions of both cars over time at the rate of 10 updates per second, and then publish the updated positions of the cars in the corresponding set_transform topics, hence simulating the motion of these cars over a desired set-speed. (Assuming a constant-velocity model)

Along with control, the node also subscribes to topics to receive:

• GPS	(carla/ego_vehicle/gnss)
• Lidar	(carla/ego_vehicle/lidar)
• IMU	(carla/ego_vehicle/imu)
• Camera	(carla/ego_vehicle/rgb_front/image)

The received data is saved in a MCAP file at location:
`"/home/saad/pro_ws/src/merge_simulation/data/latest_data_dump"`
(It can be changed by passing an argument as “dump_path” in the ros2 run command.)

Steps to run

Assuming that the user has installed the Carla simulator, ROS-bridge, and ROS2 humble already on the computer, the steps would be:

1) Add the package in ros workspace:

Add the package “**merge_simulation”** in the active ros workspace /src directory. Build the workspace using “colcon build”.

2) Run Carla & initialize ros-bridge connection:

Run Carla simulator in a terminal, and start ros-carla bridge in a new terminal window using command:
“ros2 launch carla_ros_bridge carla_ros_bridge.launch.py host:=localhost port:=2000 timeout:=5000 town:=Town03 synchronous_mode:=True”

This will start a ros_bridge instance at port 2000 with a timeout of 5 secs. Please wait until the connection is successfully completed.

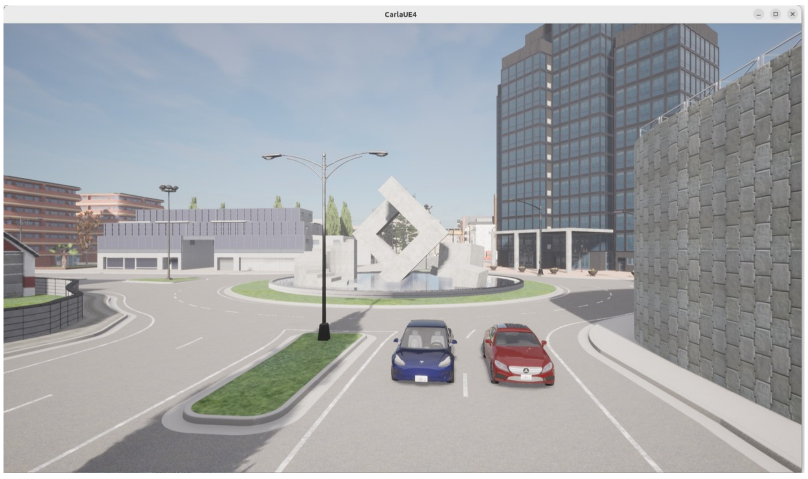
3) Spawn ego-vehicle and actor_1:

In a new terminal, launch:

“ros2 launch carla_spawn_objects carla_example_ego_vehicle.launch.py spawn_sensors_only:=False objects_definition_file:=/home/saad/pro_ws/src/merge_simulation/config/objects.json”

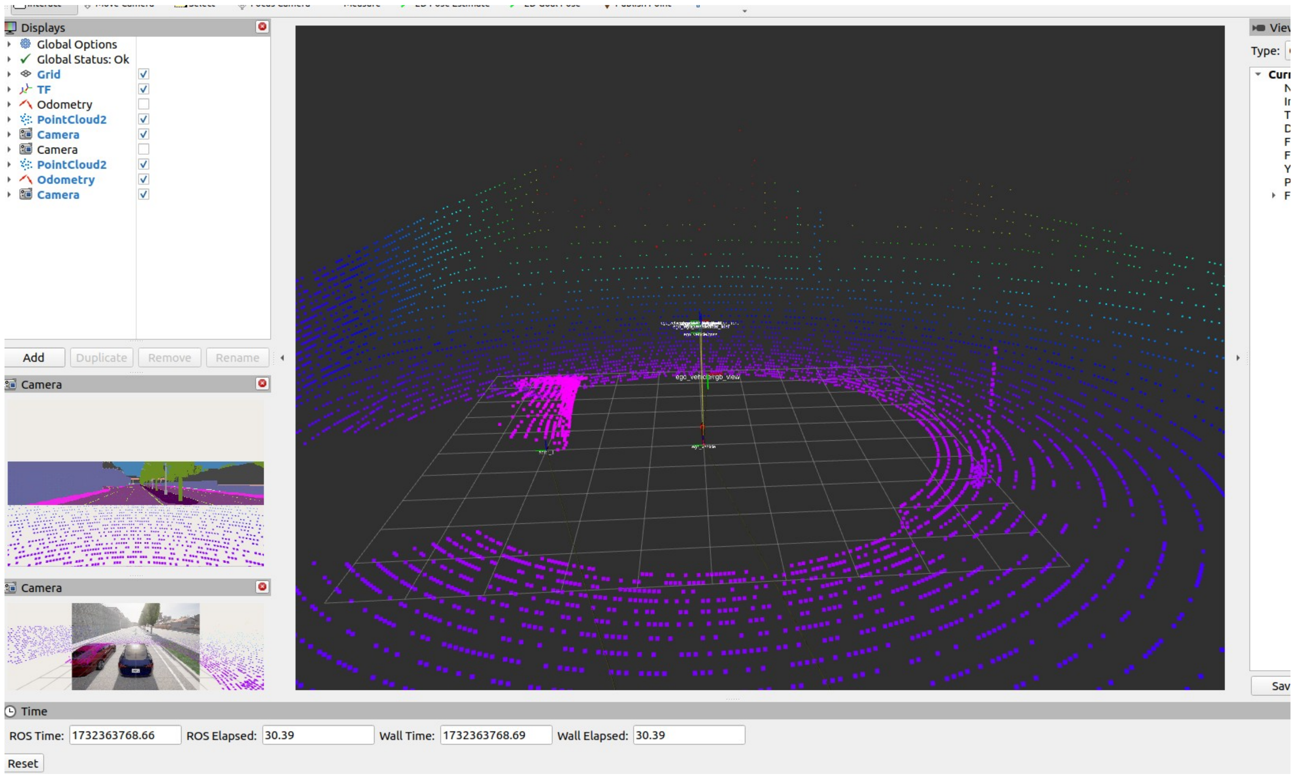
(Note: Please change the path according to your workspace. The desired objects.json file is present in the config directory of the merge_simulation package.)

This **object.json** file will spawn Ego_vehicle and an actor_1 vehicle at predefined positions.



4) Launch Rviz for visualization:

Launch rviz using command “rviz2” and open config “rviz_config.rviz” in “rviz” directory of our package.



ROS Time: 1732363768.66 ROS Elapsed: 30.39 Wall Time: 1732363768.69 Wall Elapsed: 30.39

Ego vehicle is set as reference frame. (Actor vehicle can be seen in the point cloud on the left side).

5) Launch executor node:

Finally, launch the executor node:

“ros2 run merge_simulation executor --ros-args -p dump_path:=sensor_data_dump”

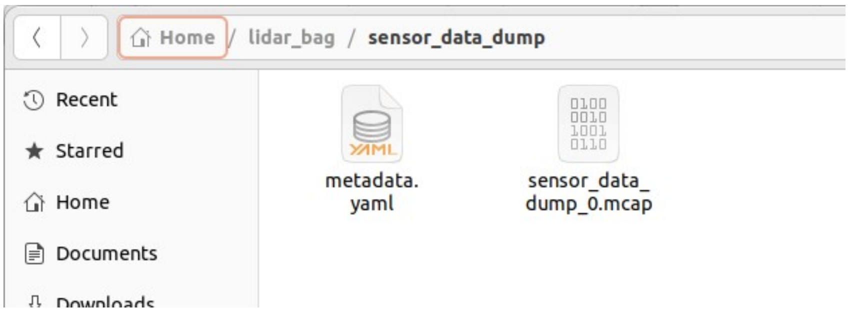
The node will start and show msgs like:

```
[INFO] [1732363957.820805315] [ego_vehicle_control_node]: Ego vehicle control node has started
[INFO] [1732363957.835663167] [ego_vehicle_control_node]: Received GNSS data: latitude=0.000045,
longitude=0.000278, altitude=2.001481
[INFO] [1732363957.840251675] [ego_vehicle_control_node]: Received IMU data: orientation=(-0.000024, -
0.000026, -0.000000, 1.000000), angular_velocity=(-0.000000, 0.000000, -0.000000), linear_acceleration=(0.000513, -
0.000470, 9.810000)
[INFO] [1732363957.967321885] [ego_vehicle_control_node]: Received image data: width=800, height=600,
encoding=bgra8
[INFO] [1732363958.006772068] [ego_vehicle_control_node]: Received LIDAR data: width=8226, height=1, point
step=16
[INFO] [1732363958.058246589] [ego_vehicle_control_node]: Received GNSS data: latitude=0.000045,
longitude=0.000278, altitude=2.001481
```

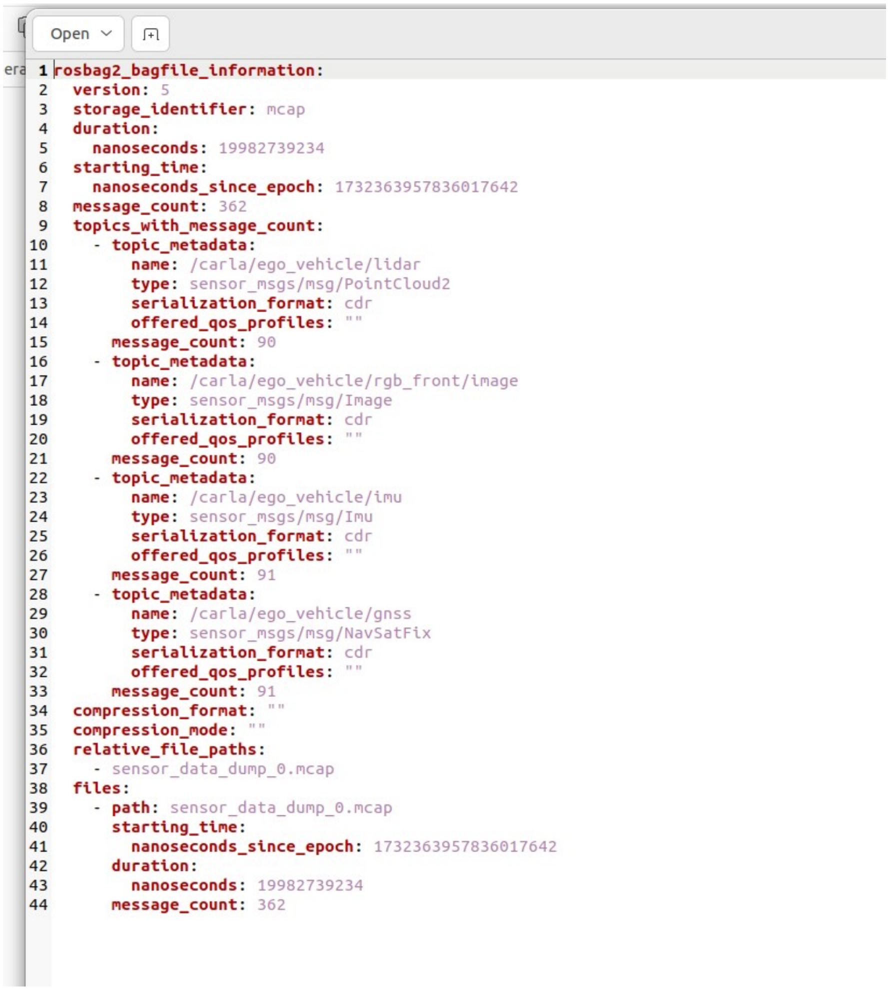
This node will run for 20 secs by default. User can stop the node at any time by sending CTRL+C in the terminal as well.

The user should see the red car swerving in the lane of ego-vehicle and then ego-vehicle will keep following the lead vehicle. The RVIZ screen should also show the motion in the camera view and lidar point cloud as well.

After the execution, please go to the dump path directory:
/home/saad/lidar_bag/sensor_data_dump/ (in my case)



The details can be checked in the metadata.yaml file:



```yaml
rosbag2_bagfile_information:
  version: 5
  storage_identifier: mcap
  duration:
    nanoseconds: 19982739234
  starting_time:
    nanoseconds_since_epoch: 1732363957836017642
  message_count: 362
  topics_with_message_count:
    - topic_metadata:
        name: /carla/ego_vehicle/lidar
        type: sensor_msgs/msg/PointCloud2
        serialization_format: cdr
        offered_qos_profiles: ""
      message_count: 90
    - topic_metadata:
        name: /carla/ego_vehicle/rgb_front/image
        type: sensor_msgs/msg/Image
        serialization_format: cdr
        offered_qos_profiles: ""
      message_count: 90
    - topic_metadata:
        name: /carla/ego_vehicle/imu
        type: sensor_msgs/msg/Imu
        serialization_format: cdr
        offered_qos_profiles: ""
      message_count: 91
    - topic_metadata:
        name: /carla/ego_vehicle/gnss
        type: sensor_msgs/msg/NavSatFix
        serialization_format: cdr
        offered_qos_profiles: ""
      message_count: 91
  compression_format: ""
  compression_mode: ""
  relative_file_paths:
    - sensor_data_dump_0.mcap
  files:
    - path: sensor_data_dump_0.mcap
      starting_time:
        nanoseconds_since_epoch: 1732363957836017642
      duration:
        nanoseconds: 19982739234
      message_count: 362
```