

Scenario Factory: Creating Traffic Scenarios For Automated Vehicles

■ Advanced seminar: Simulation-based Testing of Autonomous Cars ■

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Overview

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- Background
- Scenario Factory
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Introduction

- Virtual testing is an important tool for validating the safety of automated vehicles.
- Even though the number of publicly-available datasets has increased, they usually feature only a small number of maps and require much effort to record.
- The framework generates a set of database, safety-critical scenarios for testing of motion planning algorithms for automated vehicles (AV).

Introduction

- The safety validity of motion planning algorithm for AV's need large amount of data for Virtual Testing(VT), so they have collected data from real test drivers which is **costly and in-efficient**, also they considered the minority of traffic scenarios posing challenges to motion planners.
- To overcome all this critical issues, In the paper they have introduced 3 major studies as follows:
 - 1) Open Street Map (OSM).
 - 2) Traffic SUMO Simulator.
 - 3) Non-Linear Optimization.

Architecture

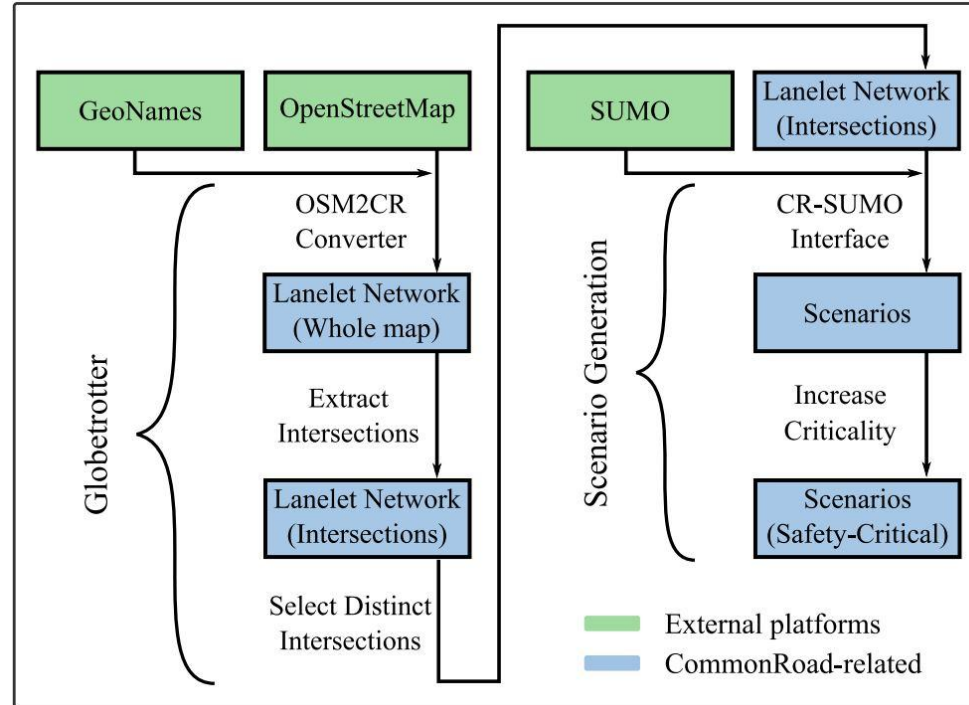


Figure 1. Architecture Process [1].

Inputs

```
{  
  "base-path": "./scenarios/interactive/NGSIM/US101",  
  "scenario-name": "USA/US101-27-4-1-1-1",  
  "base-path": "./scenarios/interactive/SUMO/",  
  "scenario-name": "USA/US101-27-47I-1-1",  
  "output-path": "./outputs",  
  "gui": true,  
  "ego-vehs": {  
    "veh0": {  
      "wid": 1.6,  
      "length": 4.3,  
      "departSpeed": 0,  
      "pos": [0, 0, -0.68]  
    }  
  }  
}
```

Inputs

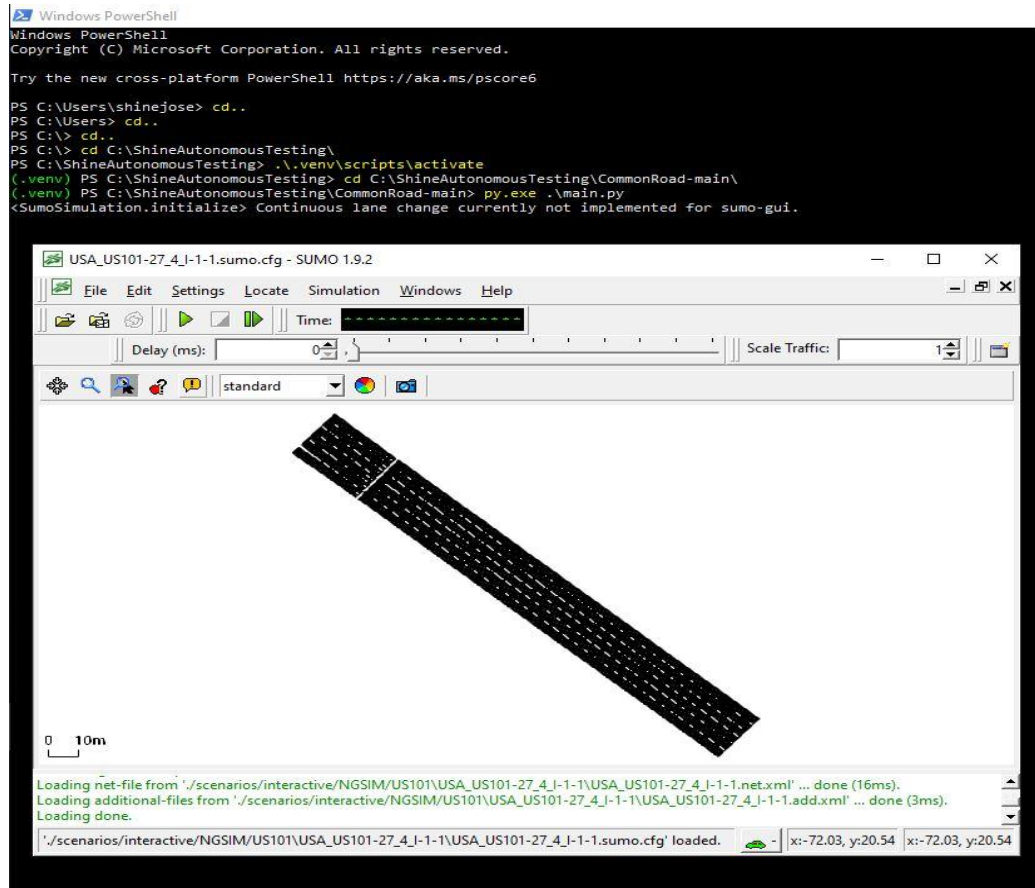


Figure 2. SUMO Inputting [2].

Output Generated

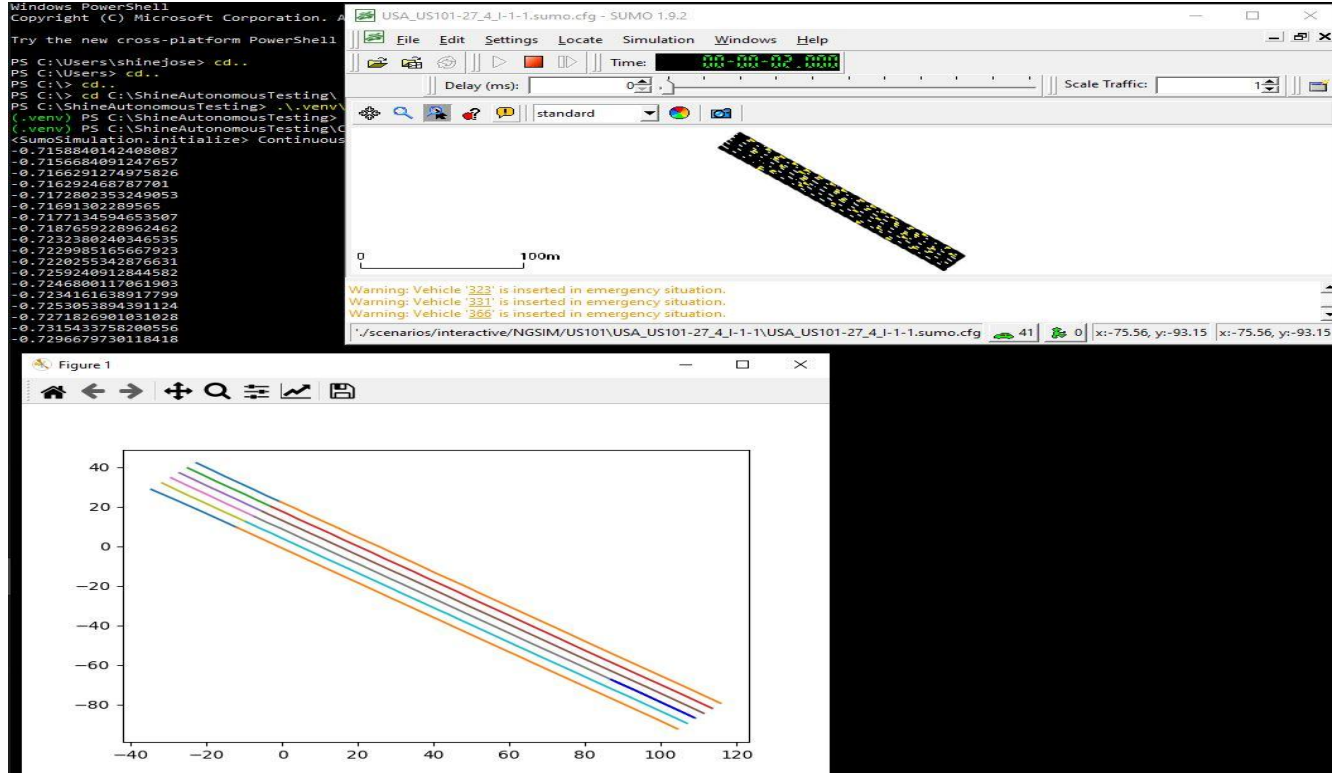


Figure 3. SUMO Simulation Of Given Map Inserted [3].

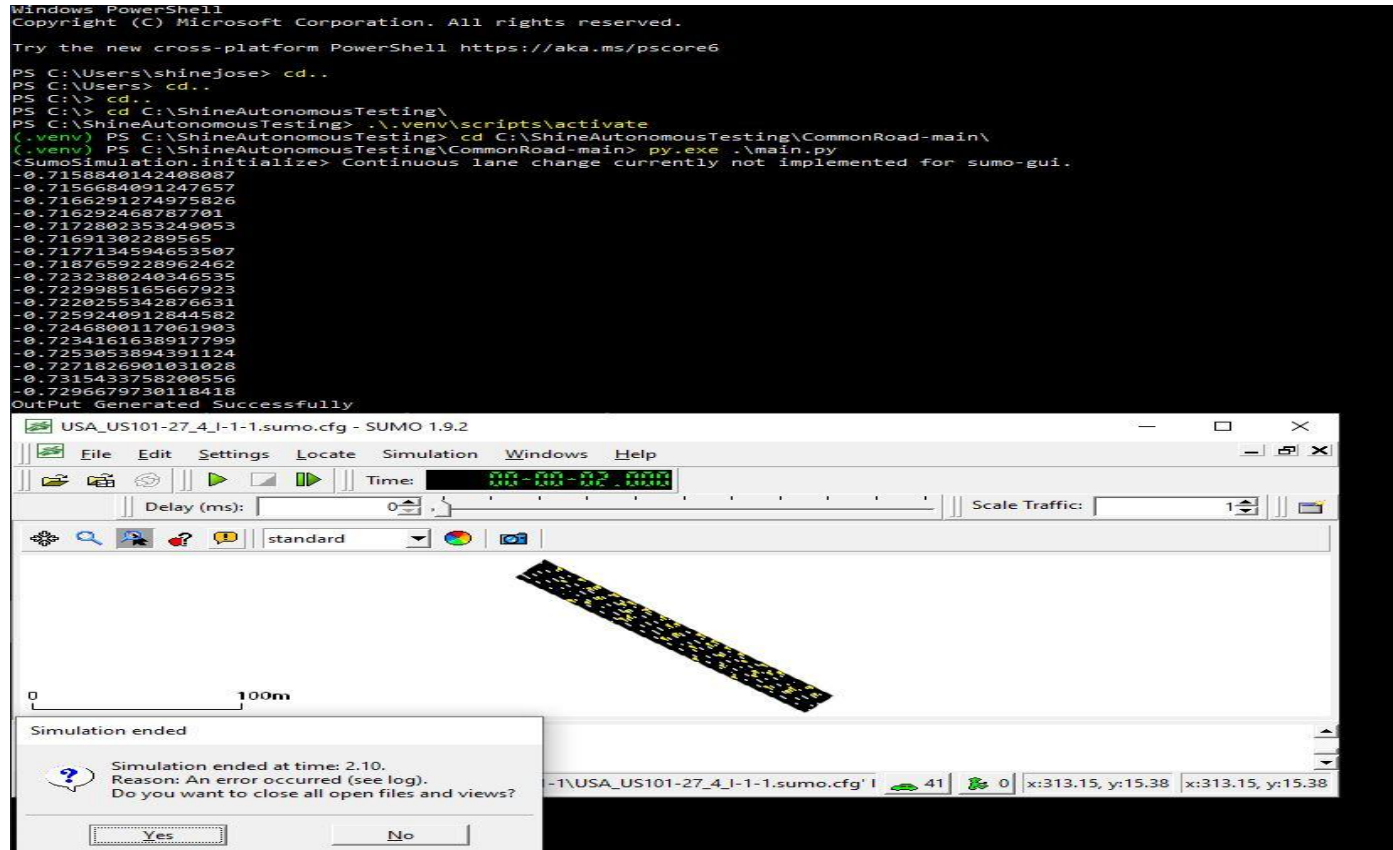


Figure 4. To add a new map [4].

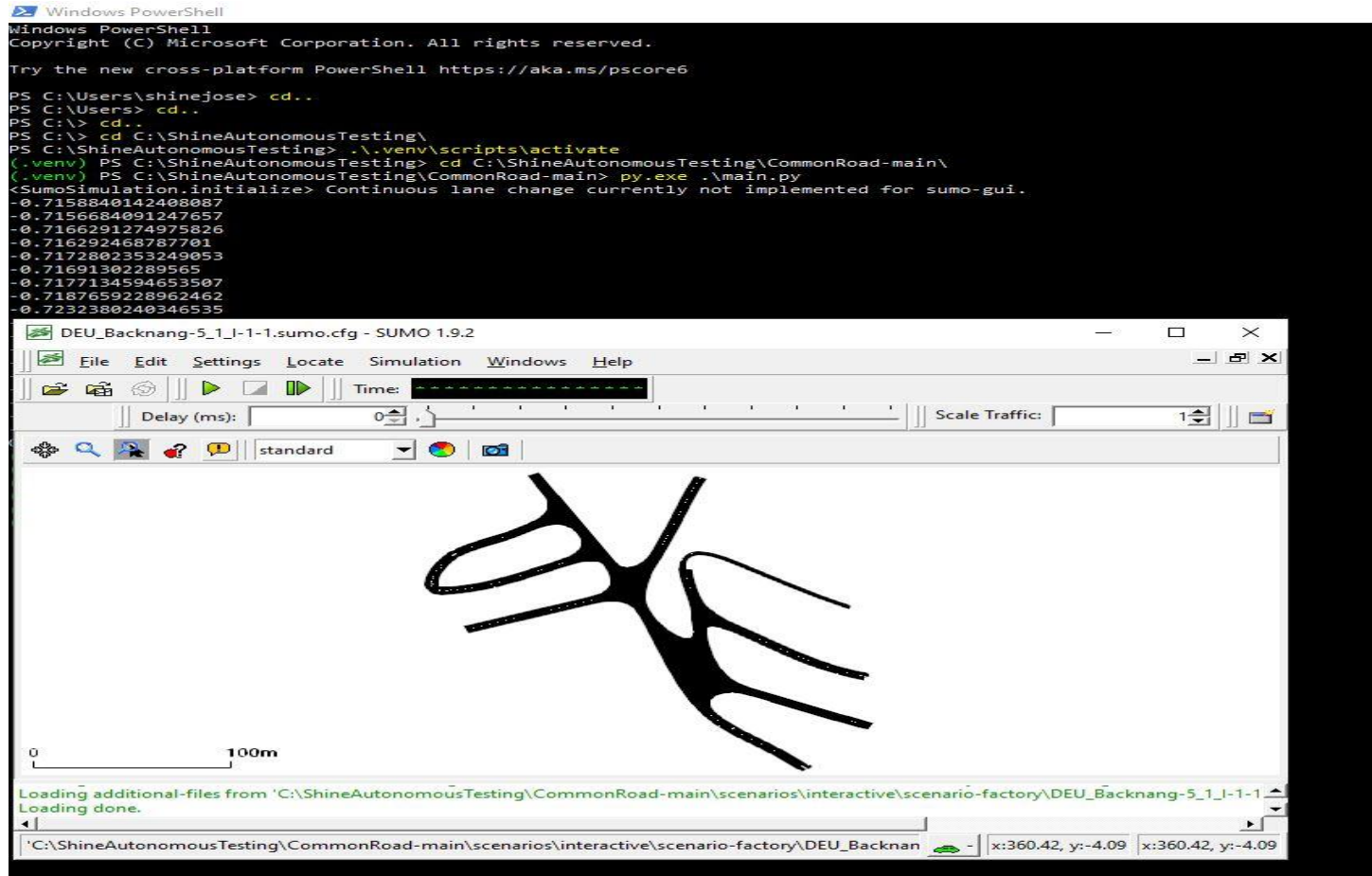


Figure 5. New Map & Features Added [5].

Output Generated

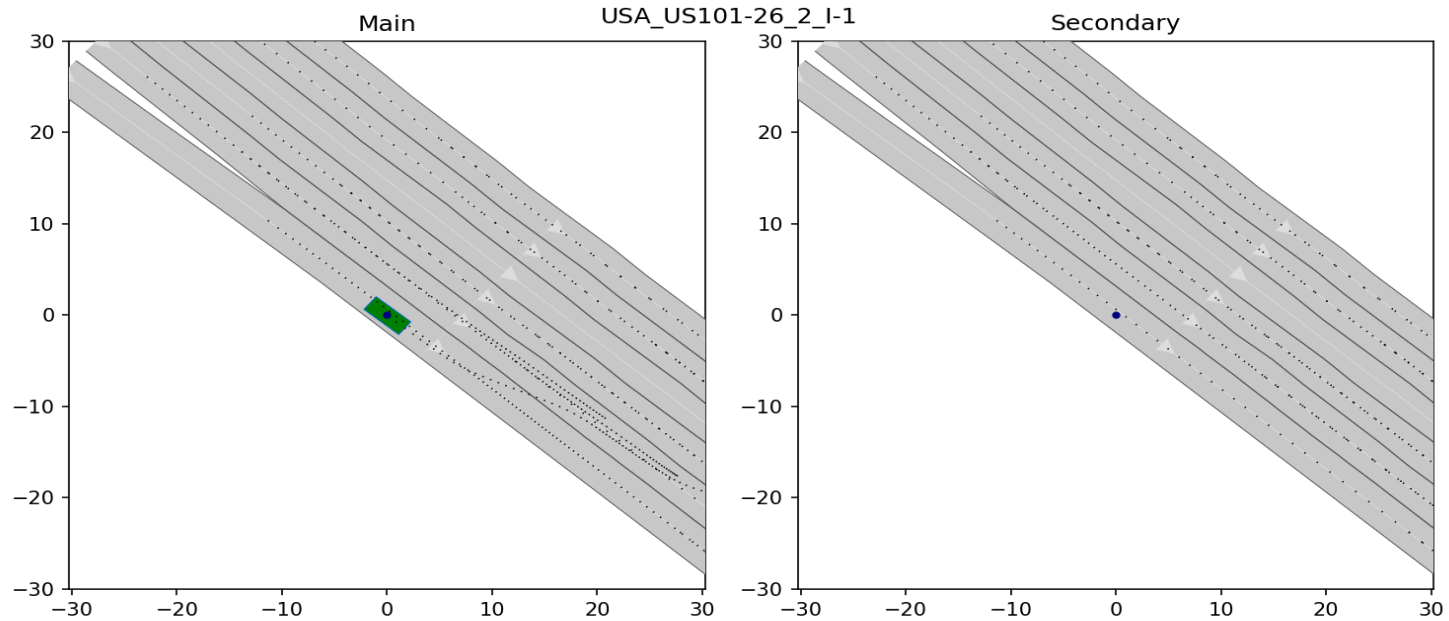


Figure 6. SUMO Simulation Of Given Map Inserted [6].

Results

- This approach can significantly decrease the drivable area, and thus it increases the criticality.
- And the second image shows the reduction of critical area.

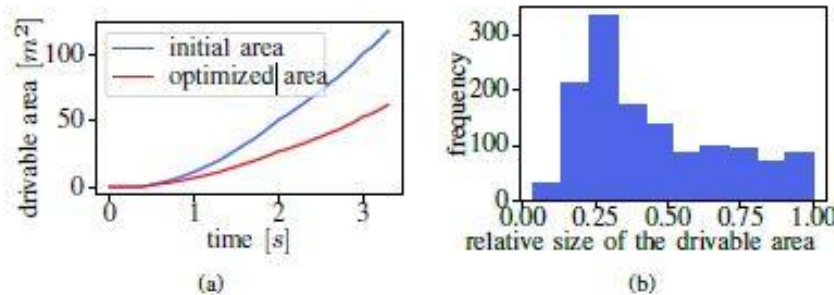


Figure 7. SUMO Simulation Of Given Map Inserted [7].

BeamNG.Tech

- The same Scenarios what we tested before are going to test in BeamNG tech simulator.
- Roads, Vehicles are created and placed using the same old files from Scenario Factory.
- We must extract the XML file format to JSON file format and to test the simulation successfully.
- Let's get into the simulator testing.

Inputs

```
from beamngpy import BeamNGpy, Scenario, Road
```

```
# Specify location of BeamNG home and BeamNG user folders
```

```
BNG-HOME = "C:/ShineAutonomousTesting/BeamNG.tech"
```

```
BNG-USER = "C:/ShineAutonomousTesting/sbst-2021-tutorial\Code"
```

```
beamng = BeamNGpy('localhost',  
64256, home=BNG/HOME, user=BNG/USER)
```

```
# Start BeamNG by setting launch to True
```

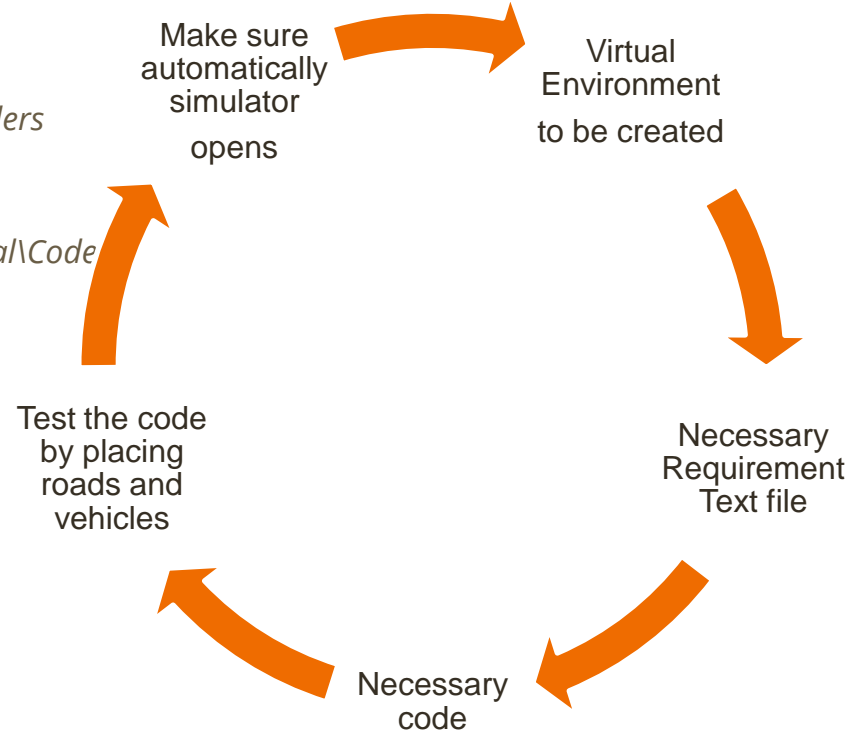
```
bng = beamng.open(launch=True)
```

```
try:
```

```
input('Press enter when done...')
```

```
finally:
```

```
bng.close()
```



Evaluation

```
BeamNG.tech console - LV errors - / warnings
6.172 [I] LoadingManager | LevelInfo [ 1] in 0.186 s | 0.186 s/item
6.242 [I] LoadingManager | CameraBookmark [ 1] in 0.037 s | 0.037 s/item
6.260 [I] LoadingManager | total 0.275 s
6.267 [I] LoadingManager | ===== Terrain =====
7.068 [W] TerrainBlock::onAdd | Terrain file is outdated (version 7 vs 8): levels/tig/terr
9.878 [I] LoadingManager | TerrainBlock [ 1] in 3.584 s | 3.584 s/item
0.067 [I] LoadingManager | total 3.763 s
0.150 [I] LoadingManager | ===== Environment =====
0.309 [I] LoadingManager | CloudLayer [ 2] in 0.073 s | 0.037 s/item
0.447 [I] LoadingManager | ScatterSky [ 1] in 0.086 s | 0.086 s/item
0.466 [I] LoadingManager | total 0.236 s
0.485 [I] LoadingManager | ===== Forest =====
0.595 [W] Forest::reloadData | == Old forest file format detected. Please resave the fo
0.814 [W] Forest::reloadData | no forest files loaded
0.913 [I] LoadingManager | Forest [ 1] in 0.371 s | 0.371 s/item
0.918 [I] LoadingManager | total 0.376 s
0.923 [I] LoadingManager | ===== Meshes =====
0.932 [I] LoadingManager | total 0.000 s
0.957 [I] LoadingManager | ===== Prefabs =====
1.149 [I] LoadingManager | Prefab [ 1] in 0.174 s | 0.174 s/item
1.151 [I] LoadingManager | total 0.180 s
1.154 [I] LoadingManager | ===== Roads =====
1.155 [I] LoadingManager | total 0.000 s
1.157 [I] LoadingManager | ===== Audio =====
1.158 [I] LoadingManager | total 0.000 s
1.161 [I] SceneStaticManagerRender::onObjectsReady | *** Built static data in 0.003s
1.163 [I] LoadingManager::loadLevelJsonObjects | * loading took 5.188 s
1.171 [I] GELua.levelLoading | *** Level loaded: /levels/tig/info.json
1.173 [I] GELua.levelLoading | *** Loaded objects in 5.312 s
1.175 [I] GELua.levelLoading | *** Loaded ai.map in 0.002 s
1.188 [I] GELua.levelLoading | *** Loaded decals in 0.013 s
1.190 [I] BeamNGPhysicsPlugin::enableSimulation | RELOADING COLLISION
1.224 [I] BeamNGPhysicsPlugin::reload | *** generated physics collision in 0.030s
1.226 [I] BeamNGPhysicsPlugin::reload | *** reloaded physics in 0.031s
1.227 [I] GELua.levelLoading | *** Started physics in 0.039 s
1.237 [W] GELua.spawn.lua | No SpawnPointName in mission file vehicle spawn in the default
1.244 [W] GELua.spawn.lua | No SpawnPointName in mission file vehicle spawn in the default
1.246 [W] SimNameDictionary::insert | Warning! You have a duplicate datablock name of Def
this object) 7847 and 7845 are conflicting.
1.247 [W] GELua.spawn.lua | No SpawnPointName in mission file vehicle spawn in the default
1.252 [I] GELua.levelLoading | *** Loaded player and camera in 0.025 s
1.265 [I] BeamNGVehicle::spawnObject | *** Loaded player and camera in 0.025 s
```

Figure 8. Given Prefabs, Meshes & Roads are Loading [8].

```
(.venv) PS C:\ShineAutonomousTesting\sbst-2021-tutorial\Code> py.exe .\xmlvisualization.py
<Element 'commonRoad' at 0x000001B1C15844A0>
commonRoad {'timeStepSize': '0.1', 'commonRoadVersion': '2020a', 'author': 'Edmond Irani Liu, Fabian Höltnke, Moritz Klischat', 'affiliation': 'Technical University of Muni
ch, Germany', 'source': 'Scenario Factory (OpenStreetMaps, SUMO Traffic Simulator)', 'benchmarkID': 'ARG_Carcarana-4_1_T-1', 'date': '2020-08-23'}
location {}
scenarioTags {}
lanelet {'id': '7223'}
lanelet {'id': '6255'}
lanelet {'id': '7238'}
lanelet {'id': '6259'}
lanelet {'id': '7890'}
lanelet {'id': '7945'}
lanelet {'id': '5847'}
lanelet {'id': '7237'}
lanelet {'id': '5843'}
lanelet {'id': '7222'}
lanelet {'id': '7891'}
lanelet {'id': '7946'}
lanelet {'id': '7239'}
lanelet {'id': '7224'}
lanelet {'id': '7892'}
lanelet {'id': '7944'}
lanelet {'id': '7240'}
lanelet {'id': '7241'}
lanelet {'id': '7242'}
lanelet {'id': '5846'}
lanelet {'id': '6258'}
lanelet {'id': '7225'}
lanelet {'id': '7226'}
lanelet {'id': '7227'}
lanelet {'id': '7888'}
lanelet {'id': '7889'}
lanelet {'id': '6256'}
lanelet {'id': '5844'}
```

Figure 9. Features Extracted From XML File Format [9].


```

1  {"commonRoad": {"@timeStepSize": "0.1", "@commonRoadVersion": "2020a", "@author": "Edmond Irani Liu, Fabian
H\u00c3\u00b6ltke, Moritz Klischat", "@affiliation": "Technical University of Munich, Germany", "@source": "Scenario Factory
(OpenStreetMaps, SUMO Traffic Simulator)", "@benchmarkID": "ARG_Carcarana-4_1_T-1", "@date": "2020-08-23", "location":
{"geoNameId": "3862655", "gpsLatitude": "-32.85679", "gpsLongitude": "-61.15331"}, "scenarioTags": {"intersection": null,
"simulated": null, "critical": null}, "lanelet": [{"@id": "7223", "leftBound": {"point": [{"x": "-181.86926", "y":
"-361.9372"}, {"x": "-162.89669", "y": "-365.94017"}, {"x": "-143.90609", "y": "-369.9469"}]}, "rightBound": {"point": [{"x":
"-182.59263", "y": "-365.36171"}, {"x": "-163.61907", "y": "-369.36481"}, {"x": "-144.64514", "y": "-373.36624"}]}},
"predecessor": {"@ref": "6258"}, "successor": {"@ref": "6255"}, "adjacentLeft": {"@ref": "7890", "@drivingDir": "opposite"},
"laneletType": "urban"}, {"@id": "6255", "leftBound": {"point": [{"x": "-143.90609", "y": "-369.9469"}, {"x": "-99.343027",
"y": "-379.3454"}, {"x": "-54.770778", "y": "-388.74862"}]}, "rightBound": {"point": [{"x": "-144.64514", "y": "-373.36624"},
{"x": "-100.06537", "y": "-382.77005"}, {"x": "-55.49401", "y": "-392.16957"}]}}, "predecessor": [{"@ref": "7946"}, {"@ref":
"7239"}, {"@ref": "7223"}], "successor": [{"@ref": "7888"}, {"@ref": "7889"}], "adjacentLeft": {"@ref": "6256",
"@drivingDir": "opposite"}, "laneletType": "urban"}, {"@id": "7238", "leftBound": {"point": [{"x": "-167.01567", "y":
"-384.80907"}, {"x": "-166.43747", "y": "-381.1844"}, {"x": "-166.29296", "y": "-378.74132"}, {"x": "-166.39259", "y":
"-376.33568"}, {"x": "-166.79928", "y": "-373.93389"}, {"x": "-167.11848", "y": "-372.80443"}, {"x": "-167.52381", "y":
"-371.71008"}, {"x": "-168.0150", "y": "-370.65007"}, {"x": "-168.50508", "y": "-369.65740"}, {"x": "-169.00508", "y":
"-368.65468"}, {"x": "-169.50508", "y": "-367.65196"}]}, "rightBound": {"point": [{"x": "-167.01567", "y": "-384.80907"},
{"x": "-166.43747", "y": "-381.1844"}, {"x": "-166.29296", "y": "-378.74132"}, {"x": "-166.39259", "y": "-376.33568"},
{"x": "-166.79928", "y": "-373.93389"}, {"x": "-167.11848", "y": "-372.80443"}, {"x": "-167.52381", "y": "-371.71008"},
{"x": "-168.0150", "y": "-370.65007"}, {"x": "-168.50508", "y": "-369.65740"}, {"x": "-169.00508", "y": "-368.65468"},
{"x": "-169.50508", "y": "-367.65196"}]}}, "predecessor": [{"@ref": "7239"}, {"@ref": "7223"}], "successor": [{"@ref":
"7239"}, {"@ref": "7223"}], "adjacentLeft": {"@ref": "7239"}, "adjacentRight": {"@ref": "7239"}, "laneletType": "urban"}]}

```

Figure 10. Features Extracted From XML File Format To JSON [10].



Figure 11. Simulator Loaded With ShineTest [11].



Figure 12. Simulator Loaded With ShineTest Result [12].

Conclusion

- By shinetest generator, I tried to implement the scenario factory by creating roads and placing Vehicle.
- Tracks are created using the given end points and visualized it.
- Obstacles are created as a parking bus.
- Successfully tested them in the virtual environment by the discussed paper in the meeting.

References

1. M. Klischat, E. I. Liu, F. Holtke and M. Althoff, "Scenario Factory: Creating Safety-Critical Traffic Scenarios for Automated Vehicles," *2020 IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC)*, 2020, pp. 1-7, doi: 10.1109/ITSC45102.2020.9294629.
2. <https://commonroad.in.tum.de/>
3. <https://www.geonames.org/>
4. A. Gambi, M. Mueller, and G. Fraser, "Automatically testing self driving cars with search-based procedural content generation," in *Proc. of the 28th ACM SIGSOFT Int. Symposium on Software Testing and Analysis*, 2019, pp. 318–328.
5. N. Kalra and S. M. Paddock, "Driving to safety: How many miles of driving would it take to demonstrate autonomous vehicle reliability?" *Transp. Res. Part A: Policy Pract.*, vol. 94, pp. 182–193, 2016.
6. <https://beamng.tech/>
7. <https://sumo.dlr.de/docs/index.html>
8. <https://github.com/shinejose0007/AutonomousCarTesting>
9. <https://gitlab.lrz.de/tum-cps/commonroad-io>
10. <https://commonroad-io.readthedocs.io/en/latest/>
11. <https://github.com/se2p/sbst-2021-tutorial/>

Thank You...