Search-based Software Testing of Apollo Baidu in SVL simulator

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About us

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Background

- "2021 IEEE Autonomous Driving AI Test Challenge"
  - Sponsored By "IEEE AI Test Conference 2021"
- Use **LGSVL** simulator to generate and evaluate test cases to test **Baidu Apollo** autonomous driving platform.

SVL Simulator

- Unity-based autonomous vehicle simulator
- Developed by LG Electronics America R&D Center.
- Generate various realistic 3D environments by adjusting environmental parameters including
  - Maps
  - Weather
  - Traffic
  - pedestrians
- Simulate different sensor outputs including
  - Camera
  - Lidar
  - Radar
  - Ultrasonic
- Simulate virtual sensors to generate ground truth data
  - Depth
  - semantic/instance segmentation
  - 2D/3D bounding box.
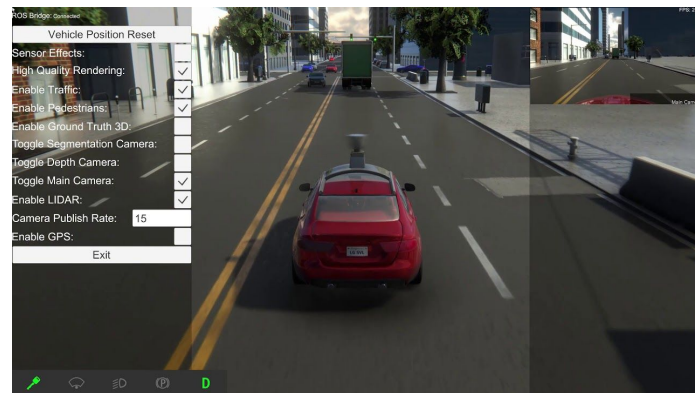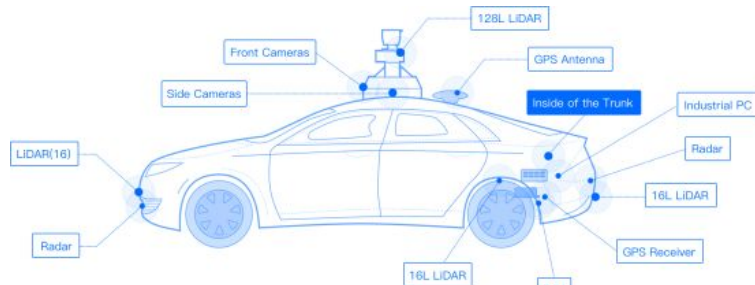
Baidu Apollo Autonomous Drive

Apollo is a high performance, flexible architecture which accelerates the development, testing, and deployment of Autonomous Vehicles.
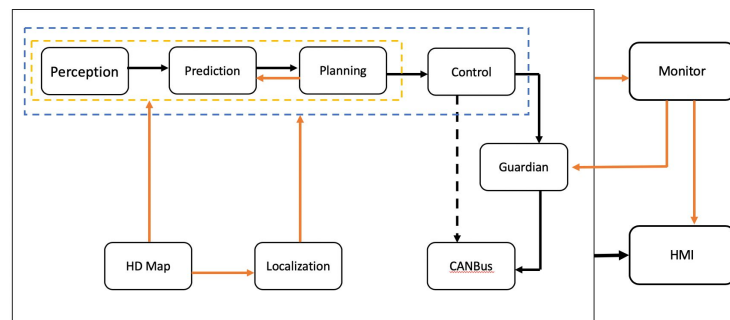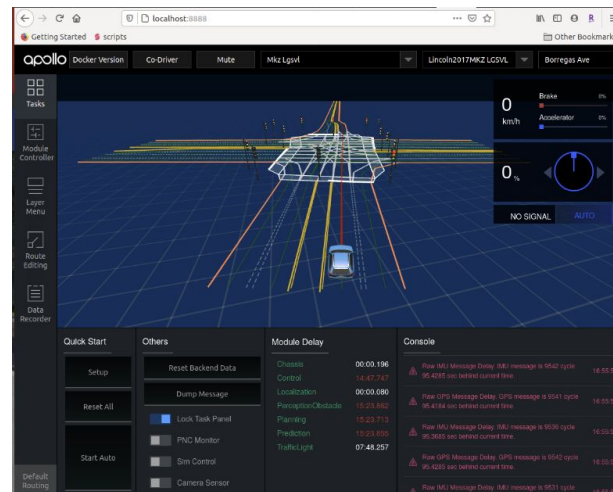
- Robotaxi
- Minibus

Baidu Apollo

Hardware Stack

Software Stack

LGSVL together with Apollo (instead of actual HW))
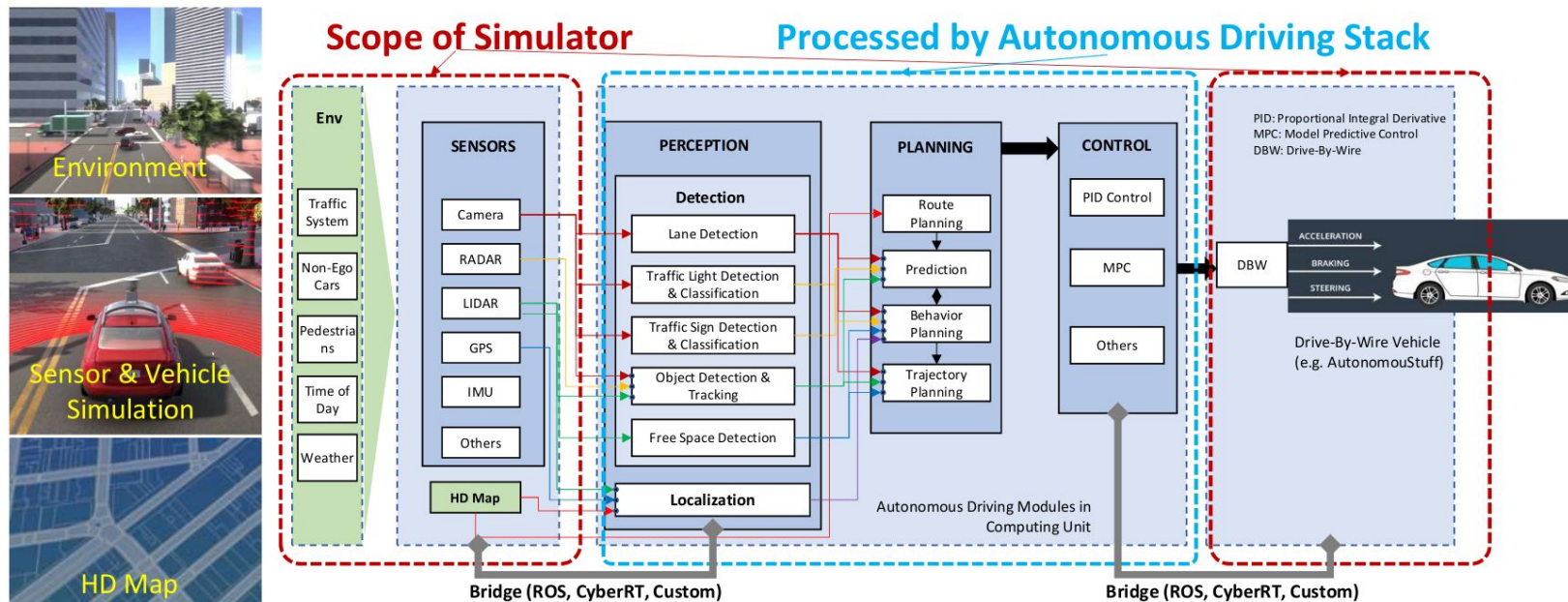

Fig. 4.   High-level architecture of autonomous driving system and the roles of the simulation engine

Challenge Goals

- Generate diverse AV simulation test scenarios and scripts.
- There are two major objectives:
  - Achieve good scenario diversity
  - Detect AV problems in the simulation environment.

Evaluation Criteria

- Test simulation automation in test simulation modeling, auto-script generation, auto-result validation, auto-coverage analysis, and auto-report
- Models and methodology
- Simulation demos based on specified routes, scenarios, and rules
- The number of test simulation scenarios

Naive V&V Solution

Randomly position agents (vehicles, pedestrians, objects, ...) generate a scenario and see how the ADS works?

Problem with the naive solution

- What the right response by the white?
- The car has crashed into many cars, but did it drive bad?
- This scene is not impossible but is it realistic?

Better Solution

1. Create unit tests with **well-defined goals** to test **different aspects of driving**.
   - **Well-defined goals:** Measurable, is the goal achieved?
   - **Different aspects of driving:** So the developer can identify the issue, fix the issue and be able to test the fix

   A Framework for Automated Driving System Testable Cases and Scenarios"

   [The United States National Highway Traffic Safety Administration (NHTSA)](#).

2. Create more similar scenario based on the basic test case

Creating a basic scenario

Pedestrian passing a street

Mutating (changing) the basic scenario

- Changing weather
- Changing the colors of vehicle
- Changing the way points (routes)
- Time of the day
- Road surface
- etc

- Measure the scenario score.
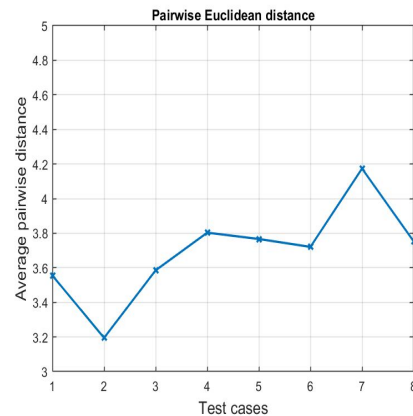- Improve the scenario score
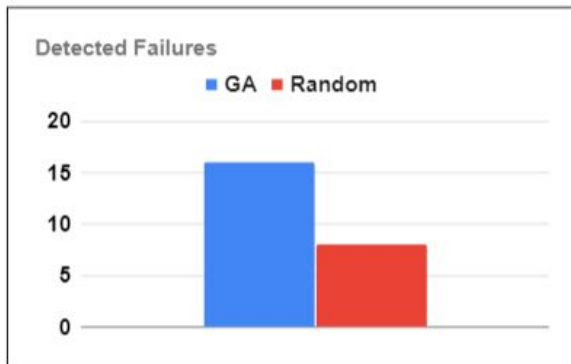 - Random
  - Genetic Algorithm

Results

Efficient and Effective Generation of Test Cases for Pedestrian Detection – Search-based Software Testing of Baidu Apollo in SVL presented at AITest 2021 : The IEEE Third International Conference On Artificial Intelligence Testing in the Autonomous Driving AI Test Challenge track
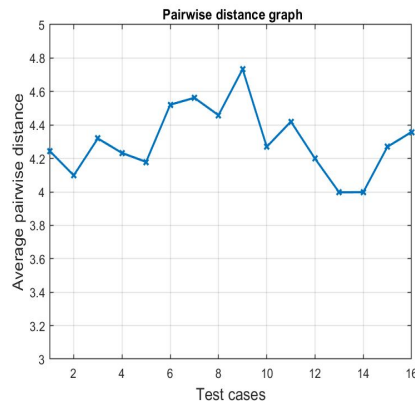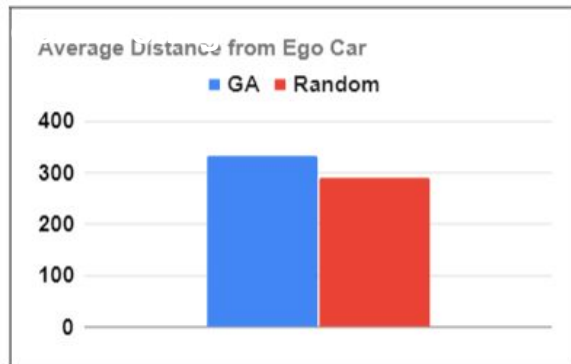

GA Testing

Random testing

(a) Number of detected failures.

(b) Objective values for the average journey distance during failure-revealing test cases.

(c) Objective values for average distance from ego car during failure-revealing test cases.

References

- ScenarioGenerator https://github.com/ebadi/ScenarioGenerator
- 2021 IEEE Autonomous Driving AI Test Challenge: http://av-test-challenge.org
- VALU3S research project: https://valu3s.eu
- SVL end-to-end autonomous vehicle simulation platform: https://www.svlsimulator.com
- The Apollo open autonomous driving platform: https://apollo.auto
- "Efficient and Effective Generation of Test Cases for Pedestrian Detection – Search-based Software Testing of Baidu Apollo in SVL"
- LGSVL Simulator: A High Fidelity Simulator for Autonomous Driving, https://arxiv.org/abs/2005.03778
- GTA Picture, https://libertycity.net/files/page5610/