

Data synthetization for V&V of ML-based systems

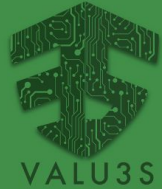
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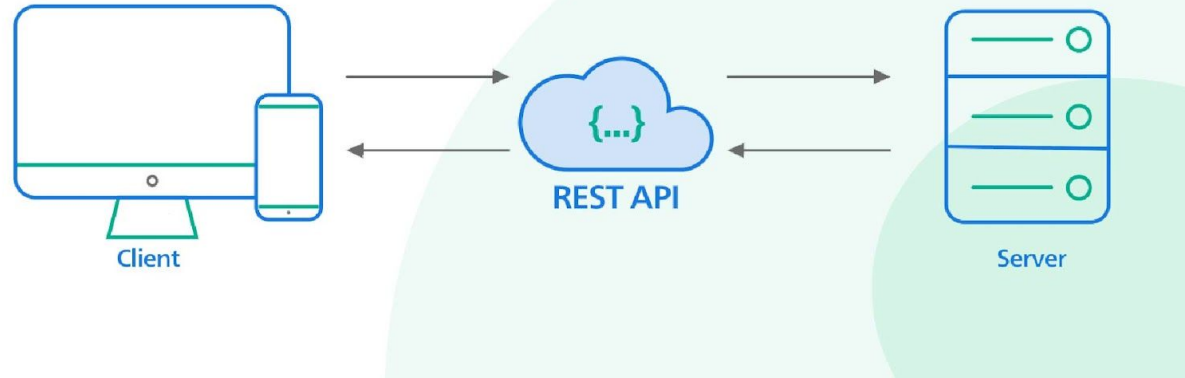
Berge



VALU3S:

Verification and Validation of
Automated Systems' Safety
and Security

CAMEA Traffic Control System



CAMEA

Assurance desiderata

The requirements for synthetic V&V data are structured based on the assurance desiderata proposed by (Ashmore, Calinescu, and Paterson, 2022), which are categorized into four key properties:

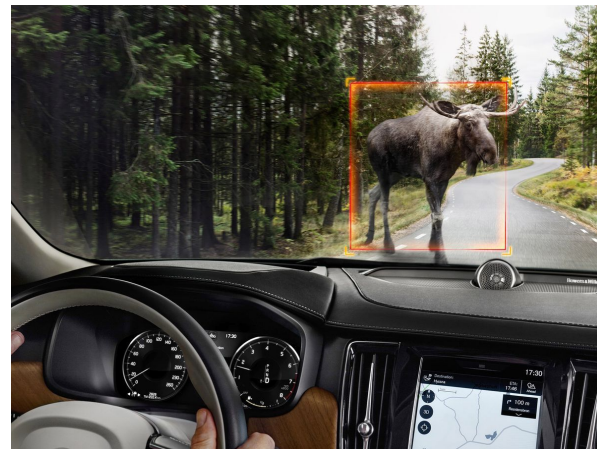
- Relevant (Berge simulator)
- Complete (Scenario Manipulator): range
- Balanced (Scenario Manipulator): distribution
- Accurate (Berge simulator)

BERGE Simulator (1)

- Generate realistic 3D environments by adjusting environmental parameters including
 - maps
 - weather
 - lighting
 - agents' movements
- Simulate different sensor outputs including
 - camera
 - radar
- Simulate virtual sensors to generate ground truth data
 - semantic segmentation (License plate)

BERGE Simulator (2)

- Åkareplatsen in Göteborg
- Swedish buildings
- Street lamp post
- Snow (CARLA: CVC, University of Barcelona)
- Trees, animals (e.g. Moose)
- Commercial reasons

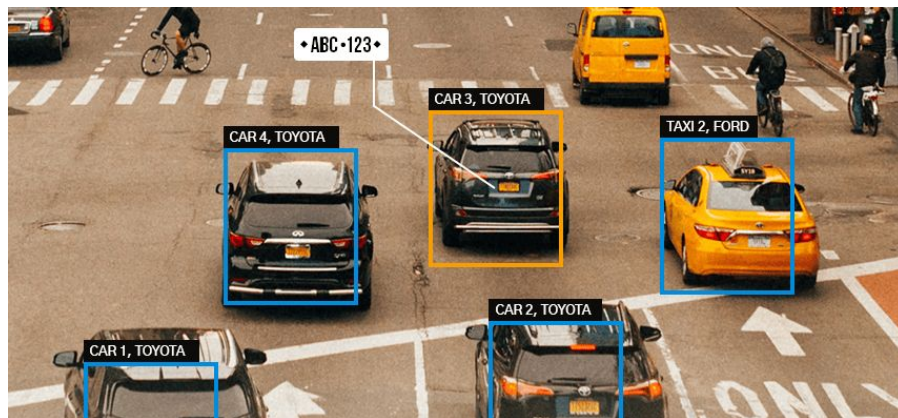




Video 1 : <https://www.youtube.com/watch?v=2LRw7jGvWLU>

Naive approach

- Randomly position agents (vehicles, pedestrians, objects, ...) to generate a scenario and evaluate how well the LP ML system works?



Problem with the naive approach

- This scene is not impossible but is it realistic?
- Which component is **not** working correctly? ML or simulator?
- Random testing usually doesn't perform well



Scenario Manipulator

Finding interesting scenarios

if an issue is caused by **minor** changes in a real benign scenario, it becomes an **interesting** case

Example: changing a car's color causes the ML system (e.g. LP detector) not to work correctly!

Scenario Manipulator

Better approach

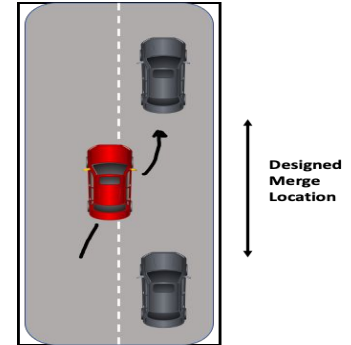
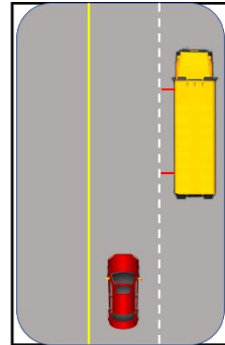
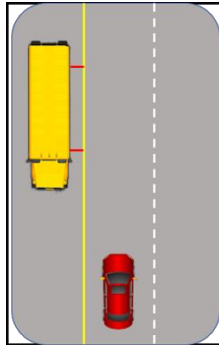
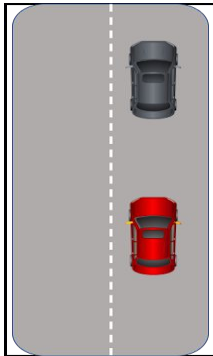
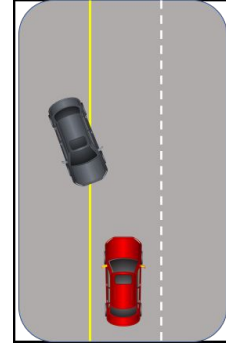
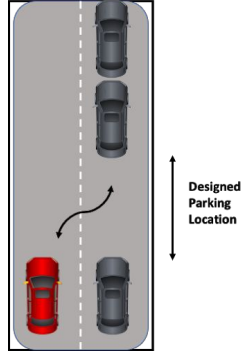
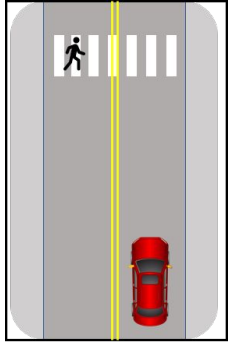
1. Create unit tests with **well-defined goals** to test **different aspects of driving**.
 - **Well-defined goals:** Measurable how the ML system behaves
 - **Different aspects of driving :** So the developer can identify the issue, fix the issue and test it again

A Framework for Automated Driving System Testable Cases and Scenarios”

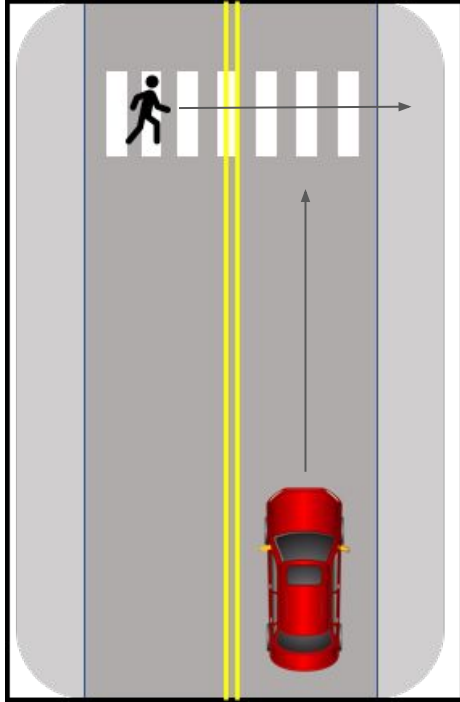
[The United States National Highway Traffic Safety Administration \(NHTSA\).](#)

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

Example of traffic scenario

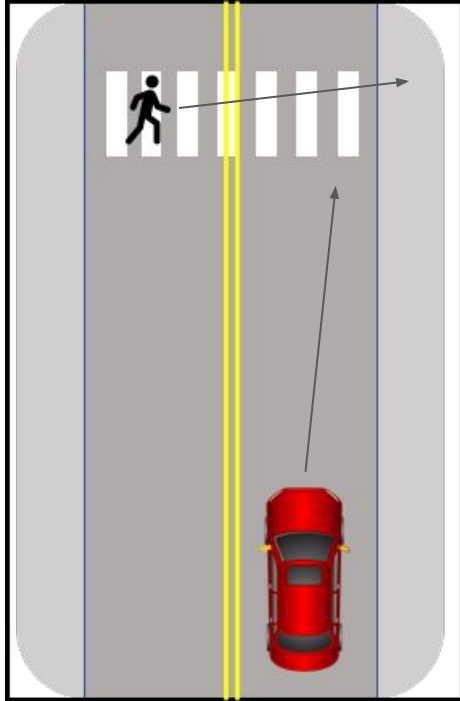


Basic scenario



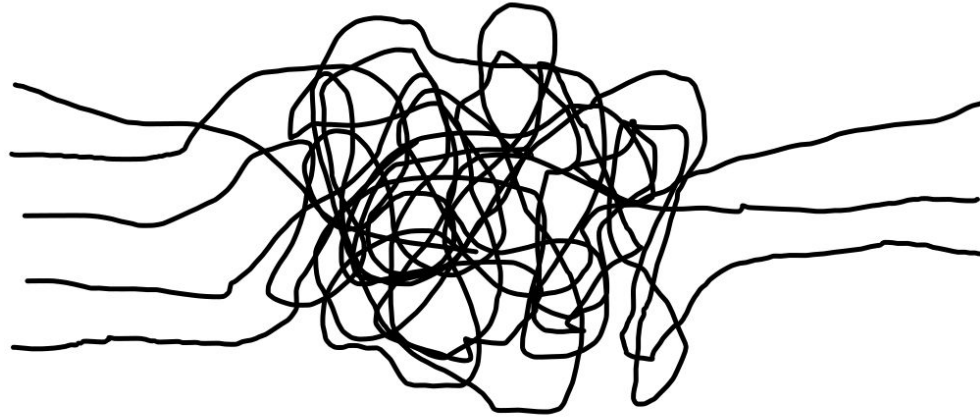
40 km/h

New scenario



42 km/h

Scenario
Parameters



Metrics

Scenario Parameters

- Positions (X,Y,Z), Rotation (Roll, Pitch, Yaw) for objects
- Positions (X,Y,Z), Rotation (Roll, Pitch, Yaw) for sensors
- Speeds of agents (including Initial, Max speed)
- Delays
- Object models (car, body type, gender, accessory)
- Plate number
- Camera properties (aperture, focal length, exposure, shutter speed, ISO, FOV)
- Time of day (effecting shadows)
- Precipitation (snow, rain)
- Weather (rainy, snowy, sunny, etc)

Metrics

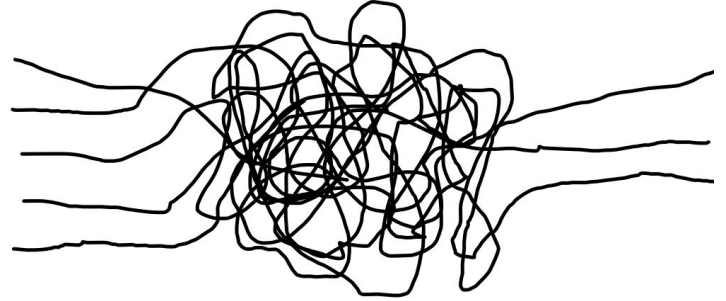
- Intersection of Union
- Levenshtein distance
- Box confidence score
- OCR confidence score



Video 2 : <https://www.youtube.com/watch?v=bLVjQXtlwP0>

Analysis

- Recursive Feature Elimination (RFE)
- Principal component analysis (PCA)



Conclusion

Assurance desiderata:

- Relevant (Berge simulator)
- Complete (Scenario Manipulator): range
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- Accurate (Berge simulator)

Questions



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.svl simulator.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/>