Some Papers about Autonomous Vehicles

two papers from ICSE 19' and one from FSE 19'

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Contents

Introduction

Title: Software Engineering for Automated Vehicles: Addressing the Needs of Cars That Run on Software and Data

Author: Krzysztof Czarnecki (Leader)

Organization: Waterloo Intelligent Systems Engineering (WISE) Lab

Research: Safety of intelligent system, ML, simulation, architecture and requirements

Introduction

The paper is a technical report on ICSE 19, which reviews automated vehicles' current challenges, industry practices and opportunities for future research.

Key Points

Requirement Engineering:

- Driving is a simple task, but hard to specify!
- No general driving rule due to open environment!
- Data-driven, continuous and allowing expert-assisted.
- RE should know what data to collect and how to collect (auto RE).

Architecture:

- highly-modular;
- reconfigurable according to environment (easy runtime reconfiguration);
- robust.

Key Points

Improve the safety of ML (hybrid approaches combined learning with manually crafted policies)

Test design:
deciding what tests to perform at each stage, and deciding how much testing is enough.
Billions of kilometers due to the openness of road.
Find effective and efficient ways to test!

Paper Information

Title: ASFAULT: Testing Self-Driving Car Software Using Search-based Procedural Content Generation

Author: Alessio Gambi[1], Marc Muller[2], Gordon Fraser[1]

Organization:1. University of Passau, Germany; 2.BeamNG

Link: https://github.com/alessiogambi/AsFault and https://youtu.be/lJ1sa42VLDw

Problem and Motivation

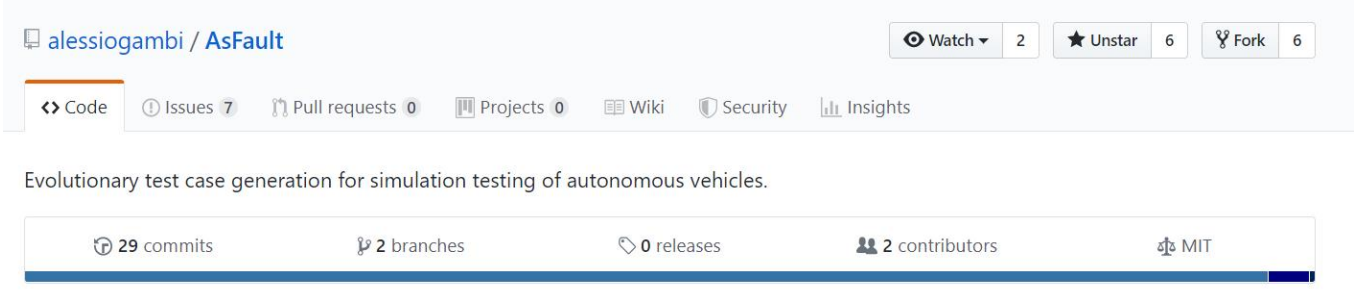
In order to ensure the safety of self-driving cars, we need to settle a standard way to test them. Unfortunately, neither industry and authorities do this.

In regular traffic? Costly, risk and unefficiently! $\rightarrow$ Simulator!

Then, how to cover the huge number of driving situations?

Manually design test cases? $\rightarrow$ Impossible!

A tool for automatically generating virtual tests $\rightarrow$ AsFault!



Platform

How to verify the effectiveness of test cases generated by AsFault?

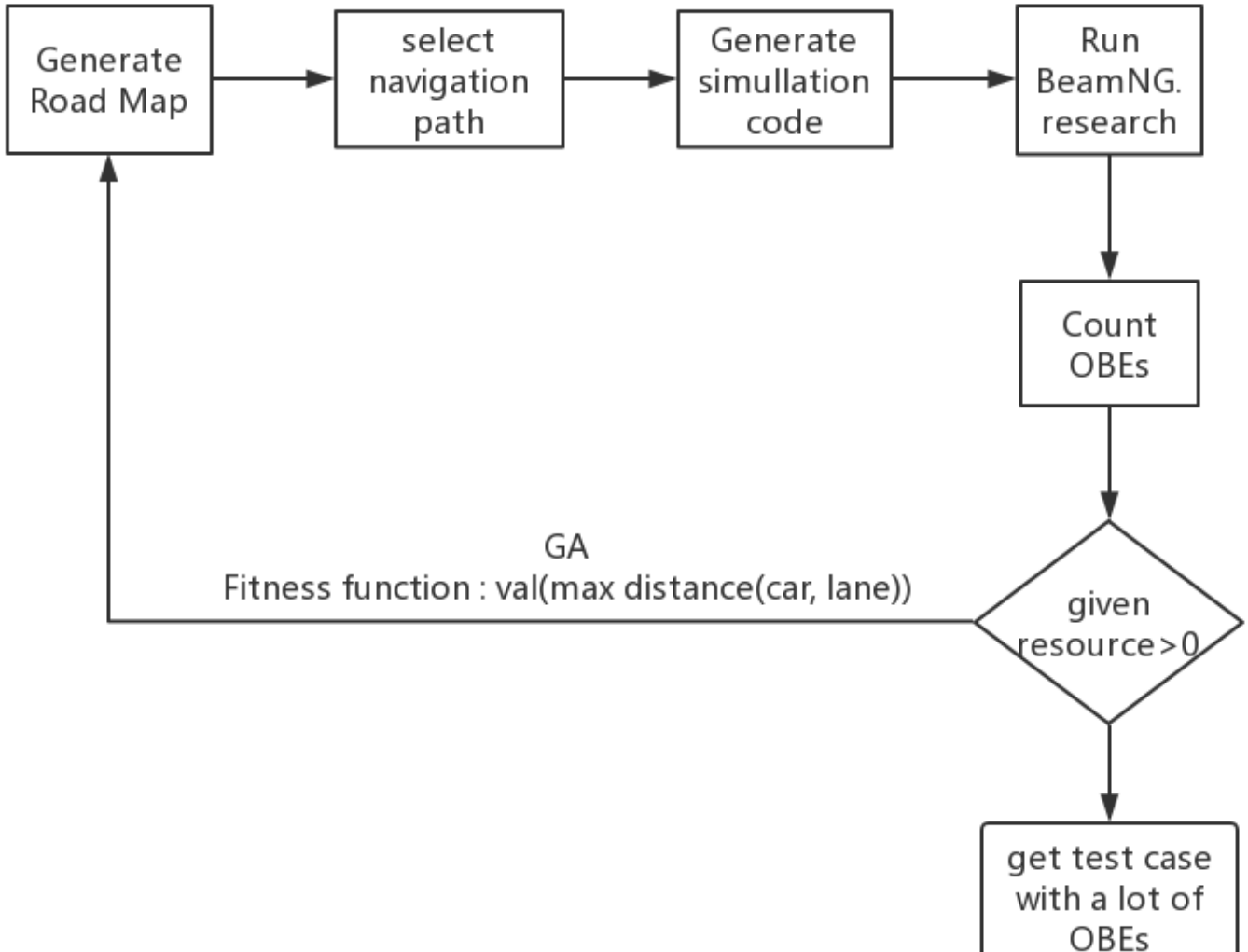
Take BeamNG.research as the simulator to test.

Why BeamNG?
→Exposes APIs for programmatically generating roads.
PS: BeamNG.research is only allowed in Windows.

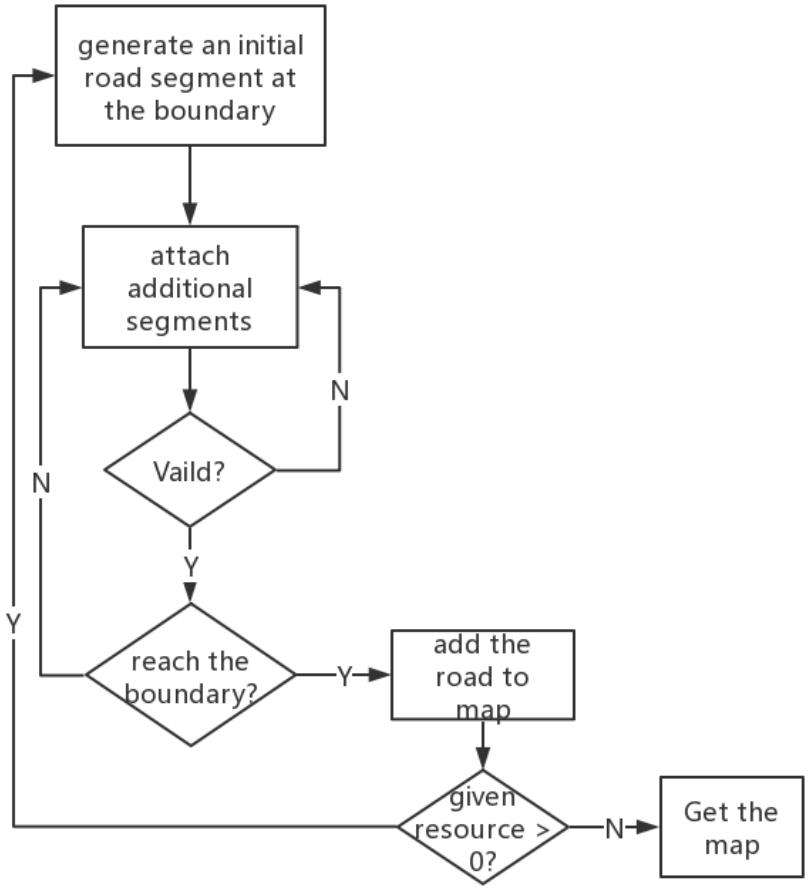
Technology

Python 3, OpenSource, Random, GA!

The core idea is generating virtual road networks which expose OBE (out of bound episodes).



Generate road map

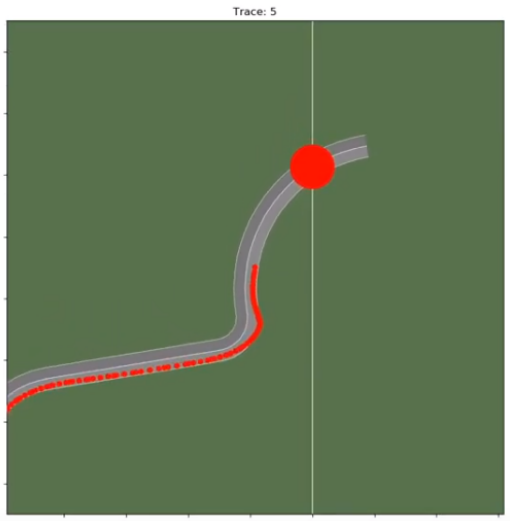


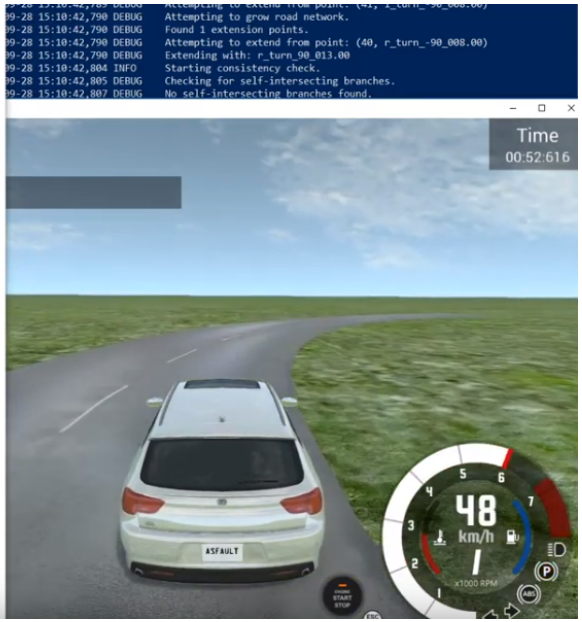
where invalid segment means overlap or self-intersect

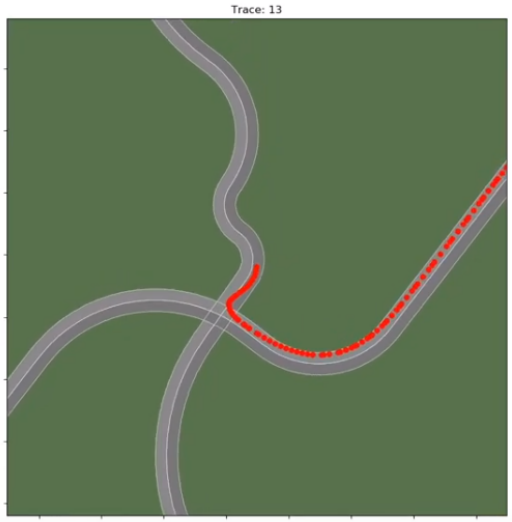
Other Tips

- Select the navigation path: Randomly sample roads, chose the longest one as the path! Fast!
- Run BeamNG.research: Create a new process. 250ms as interval to record the position of ego-car.
- Why max-distance as fitness function? We want more OBEs!!
- Always invalid segment? Once create an invalid segment, increase the probability of discarding the road.

Picture

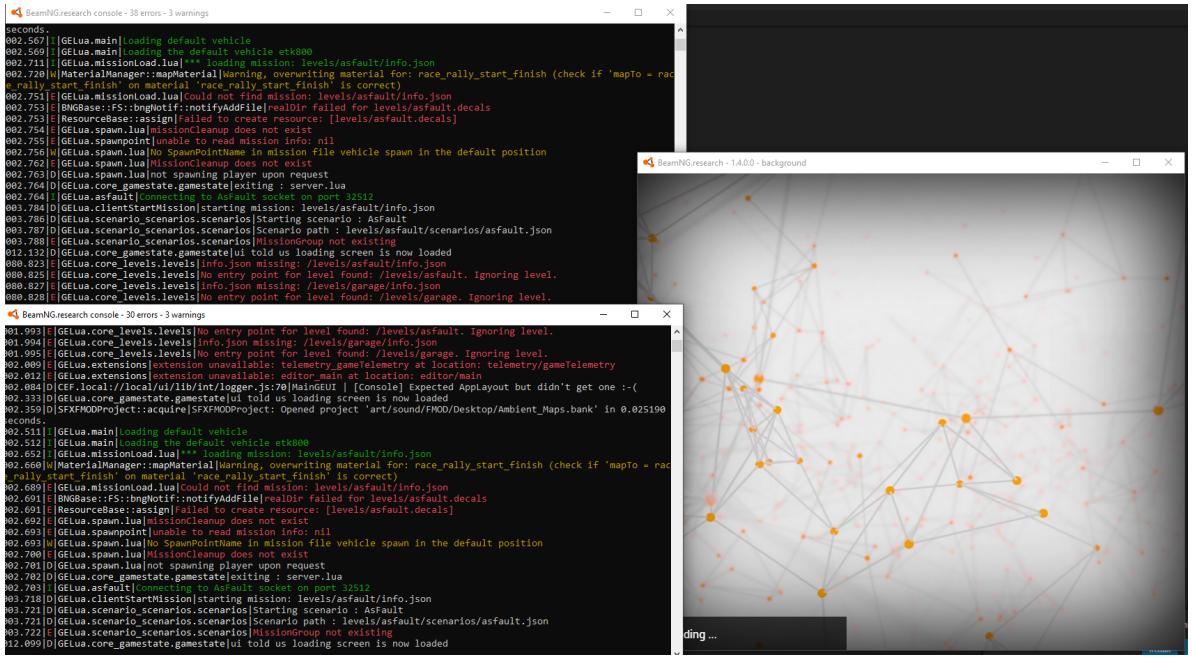

Trace: 5


09-28 15:10:42,790 DEBUG Attempting to grow road network.
09-28 15:10:42,790 DEBUG Found 1 extension points.
09-28 15:10:42,790 DEBUG Attempting to extend from point: (40, r_turn_-90_008.00)
09-28 15:10:42,790 DEBUG Extending with: r_turn_90_013.00
09-28 15:10:42,804 INFO Starting consistency check.
09-28 15:10:42,805 DEBUG Checking for self-intersecting branches.
09-28 15:10:42,807 DEBUG No self-intersecting branches found.
Time
00:52:616
48
km/h
ASPHALT


Trace: 13


09-28 15:16:10,776 INFO Got score estimation: 15
09-28 15:16:10,777 INFO Checking candidate: ((2, straight_30.0), (45, straight_50)), 6/12
09-28 15:16:10,778 INFO Path has length: 17
09-28 15:16:10,782 INFO Got polyline.
09-28 15:16:10,782 INFO Got score estimation: 17
09-28 15:16:10,783 DEBUG Got start, goal, and path for network.
Time
01:03:083

Picture

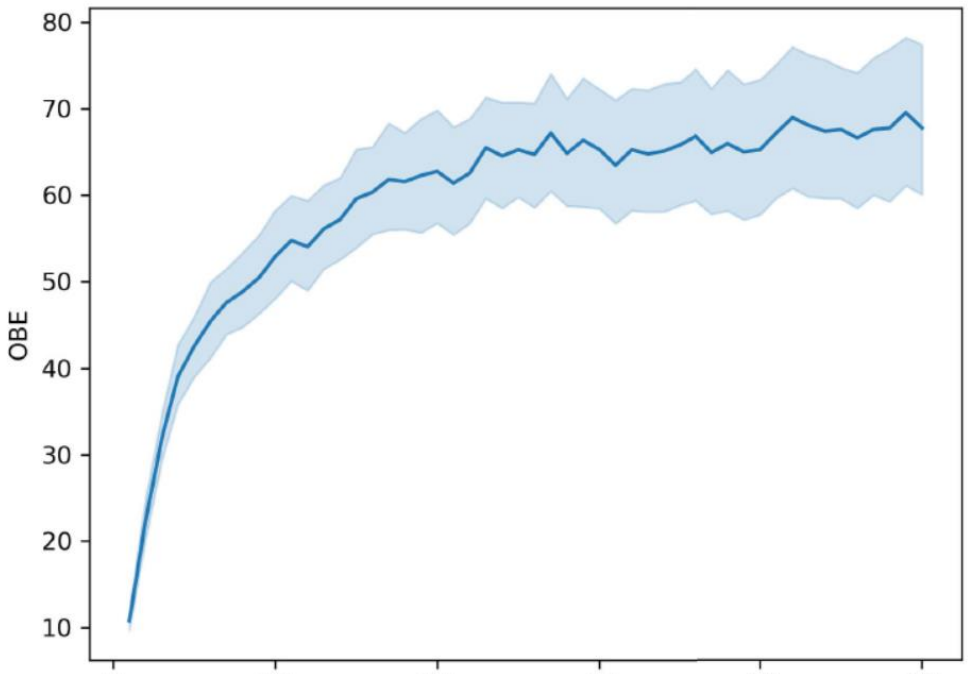

BeamNG.research console - 38 errors - 3 warnings
seconds.
002.567|I|GELua.main|Loading default vehicle
002.569|I|GELua.main|Loading the default vehicle etk800
002.711|I|GELua.missionLoad.lua|*** loading mission: levels/asfault/info.json
002.720|W|MaterialManager::mapMaterial|Warning, overwriting material for: race_rally_start_finish (check if 'mapTo = rac
e_rally_start_finish' on material 'race_rally_start_finish' is correct)
002.751|E|GELua.missionLoad.lua|Could not find mission: levels/asfault/info.json
002.753|E|BNGBase::FS::bngNotif::notifyAddFile|realDir failed for levels/asfault.decals
002.753|E|ResourceBase::assign|Failed to create resource: [levels/asfault.decals]
002.754|E|GELua.spawn.lua|missionCleanup does not exist
002.755|E|GELua.spawnpoint|unable to read mission info: nil
002.756|W|GELua.spawn.lua|No SpawnPointName in mission file vehicle spawn in the default position
002.762|E|GELua.spawn.lua|MissionCleanup does not exist
002.763|D|GELua.spawn.lua|not spawning player upon request
002.764|D|GELua.core_gamestate.gamestate|exiting : server.lua
002.764|I|GELua.asfault|Connecting to AsFault socket on port 32512
003.784|D|GELua.clientStartMission|starting mission: levels/asfault/info.json
003.786|D|GELua.scenario_scenarios.scenarios|Starting scenario : AsFault
003.787|D|GELua.scenario_scenarios.scenarios|Scenario path : levels/asfault/scenarios/asfault.json
003.788|E|GELua.scenario_scenarios.scenarios|MissionGroup not existing
012.132|D|GELua.core_gamestate.gamestate|ui told us loading screen is now loaded
080.823|E|GELua.core_levels.levels|info.json missing: /levels/asfault/info.json
080.825|E|GELua.core_levels.levels|No entry point for level found: /levels/asfault. Ignoring level.
080.827|E|GELua.core_levels.levels|info.json missing: /levels/garage/info.json
080.828|E|GELua.core_levels.levels|No entry point for level found: /levels/garage. Ignoring level.
BeamNG.research - 1.4.0.0 - background
BeamNG.research console - 30 errors - 3 warnings
001.993|E|GELua.core_levels.levels|No entry point for level found: /levels/asfault. Ignoring level.
001.994|E|GELua.core_levels.levels|info.json missing: /levels/garage/info.json
001.995|E|GELua.core_levels.levels|No entry point for level found: /levels/garage. Ignoring level.
002.009|E|GELua.extensions|extension unavailable: telemetry_gameTelemetry at location: telemetry/gameTelemetry
002.012|E|GELua.extensions|extension unavailable: editor_main at location: editor/main
002.084|D|CEF.local://local/ui/lib/lint/logger.js:70|MainGEUI | [Console] Expected Applayout but didn't get one :-(
002.333|D|GELua.core_gamestate.gamestate|ui told us loading screen is now loaded
002.359|D|SFXFMODProject::acquire|SFXFMODProject: Opened project 'art/sound/FMOD/Desktop/Ambient_Maps.bank' in 0.025190
seconds.
002.511|I|GELua.main|Loading default vehicle
002.512|I|GELua.main|Loading the default vehicle etk800
002.652|I|GELua.missionLoad.lua|*** loading mission: levels/asfault/info.json
002.660|W|MaterialManager::mapMaterial|Warning, overwriting material for: race_rally_start_finish (check if 'mapTo = rac
e_rally_start_finish' on material 'race_rally_start_finish' is correct)
002.689|E|GELua.missionLoad.lua|Could not find mission: levels/asfault/info.json
002.691|E|BNGBase::FS::bngNotif::notifyAddFile|realDir failed for levels/asfault.decals
002.691|E|ResourceBase::assign|Failed to create resource: [levels/asfault.decals]
002.692|E|GELua.spawn.lua|missionCleanup does not exist
002.693|E|GELua.spawnpoint|unable to read mission info: nil
002.693|W|GELua.spawn.lua|No SpawnPointName in mission file vehicle spawn in the default position
002.700|E|GELua.spawn.lua|MissionCleanup does not exist
002.701|D|GELua.spawn.lua|not spawning player upon request
002.702|D|GELua.core_gamestate.gamestate|exiting : server.lua
002.703|I|GELua.asfault|Connecting to AsFault socket on port 32512
003.718|D|GELua.clientStartMission|starting mission: levels/asfault/info.json
003.721|D|GELua.scenario_scenarios.scenarios|Starting scenario : Asfault
003.721|D|GELua.scenario_scenarios.scenarios|Scenario path : levels/asfault/scenarios/asfault.json
003.722|E|GELua.scenario_scenarios.scenarios|MissionGroup not existing
012.099|D|GELua.core_gamestate.gamestate|ui told us loading screen is now loaded
ding ...


Test: 54

Evaluation

Road environment → AsFault
Simulator → BeamNG.research
Lane Keeping → BeamNG.AI
SETTING:

- a map of 400 hectare;
- 25 tests, each one repeats 30 times;
- compute the cumulative number of OBEs



Evaluation

- Only consider the question of driving out of the lane;
- add more obstacles, weather and traffic factors;
- add pedestrians to environment.

Paper Information

Title: Generating Effective Test Cases for Self-Driving Cars from Police Reports

Author: Alessio Gambi[1], Tri Huynh[2], Gordon Fraser[1]

Organization:1. University of Passau, Germany; 2. Saarland University/CISPA

Problem and Motivation

Promise: eliminate most accidents
Reality: not as safe as promoted
$\rightarrow$ defective of softwares!
Then, $\rightarrow$ how to test them?

- naturalistic field operational test $\times$;
- simulator $\checkmark$.

Then, $\rightarrow$

- what constitutes good test scenarios?
- how to generate them?

Proposes AC3R to recreate the car crashes from policy report and take it as critical scenarios to generate test case.

Platform

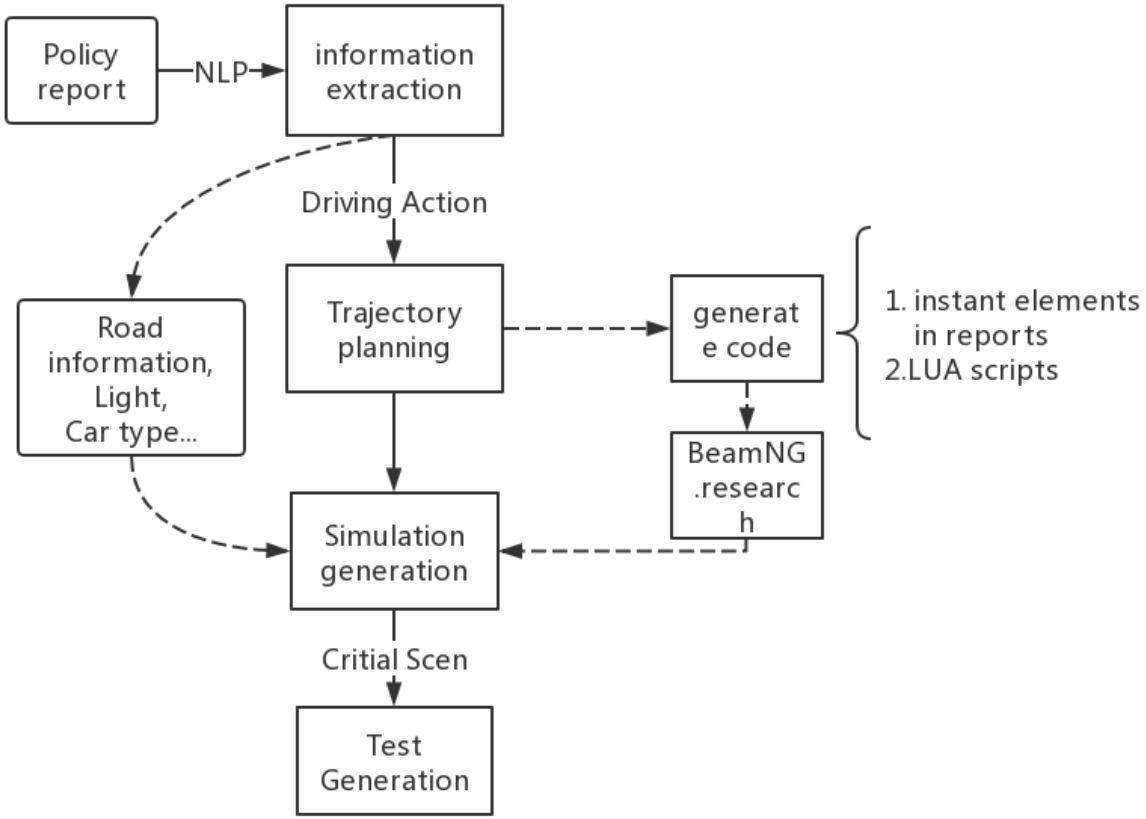
BeamNG.research + DeepDriving + 80 NHTSA* reports

DeepDriving: use a CNN to predict driving indicators(speed, direction and so on) from the images captured by a forward facing camera attached to the front of car.

*National Highway Traffic Safety Administration

Technology

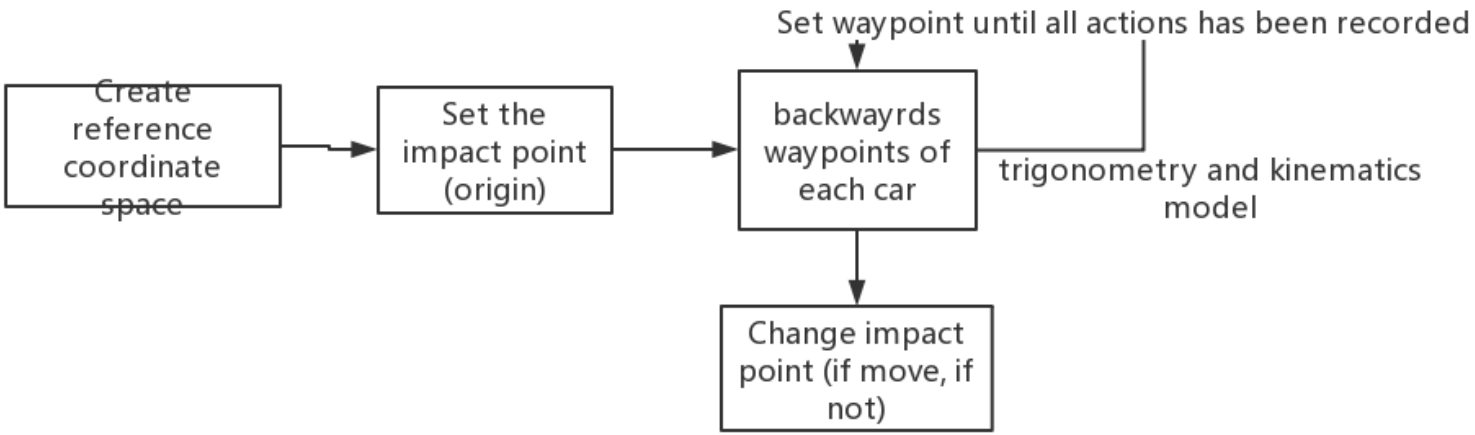
Four step:

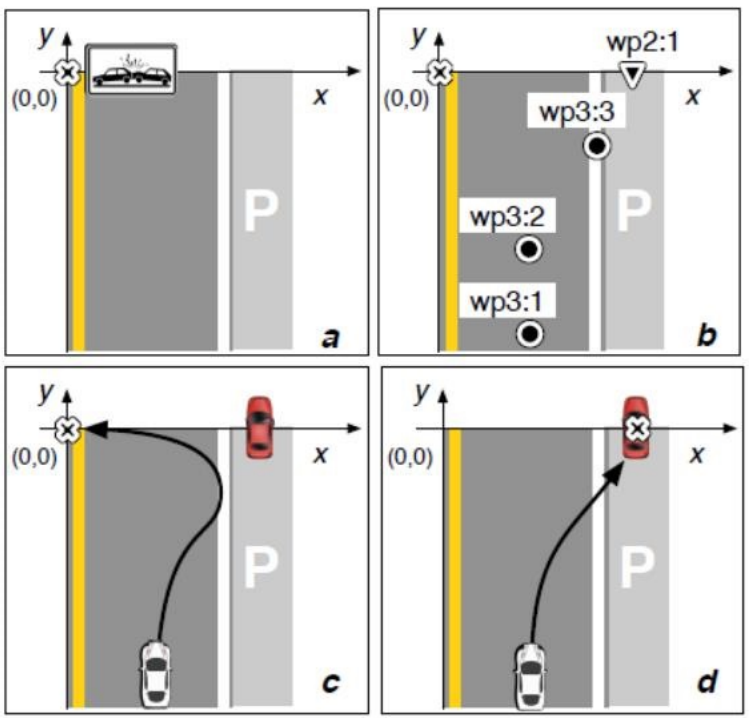


Example

The crash occurred on a two-way, two-lane straight, level, bituminous residential street with a speed limit of 25mph. Conditions at the time of the weeknight crash were cloudy, dark, and dry. V1, a 2001 Kia Sephia, driven by a 28 year-old female, was driving southbound on the road when it left the travel lane and the front of V1 struck the back of a legally parked, unoccupied vehicle on the right side of the road.

Trajectory planning





Impact point:Crash
wp2:1 Stop
wp3:3 Leave the road
wp3:1-3:2 Drive

Evaluation

- Effectiveness at producting simulations of the Impact
- Accuracy of the Overall Simulations
- Efficiency of AC3R
- Effectiveness of AC3R Test Cases

These questions evaluate three aspects of AC3R:
red– how closely the simulations generated by AC3R;
blue– how efficient;
black– whether critical scenarios are suitable as test scenarios.

Q1

Q1:

Method: Compare the crash impact recorded in report with the impact reported by BeamNG.

two variables: $\mathcal{P}$ stands for front-rear of cars and $\mathcal{S}$ stands for left-right.

- Total: both $\mathcal{P}$ and $\mathcal{S}$ (front-left and front-left)
- Partially: only $\mathcal{P}$ or $\mathcal{S}$ (front-left and front-right)
- NO: neither $\mathcal{P}$ or $\mathcal{S}$
- Unverified: the report cannot be processed by AC3R

Explain: Not follow MMUCC and AC3R's NLP is simple.

Label	**Frequency**	
	#	%
Total Match	39	48.8
Partially Match	7	8.8
No Match	4	5.0
Unverified	30	37.4
Total	80	100

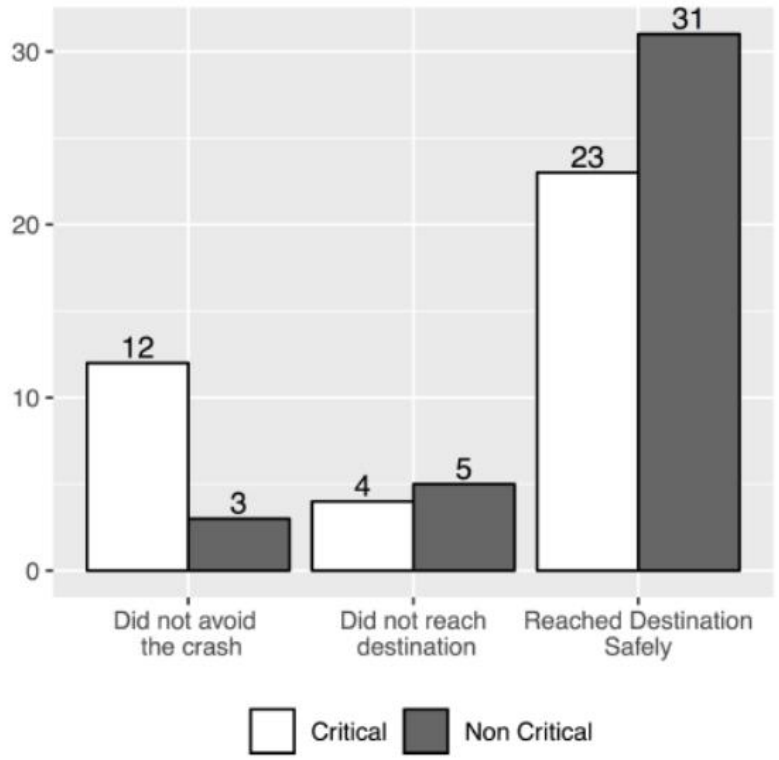
Q2 and Q3

Q2:
Method: online survey– read the policy report, watch recreate video and then rate them.
Result: accurately reflected the descriptions.

Q3:
Result: 44s for initialization of the Stanford NLP libraries + 1s for reconstruction + 22s for simulation;

Q4

Q4: 39cases (only total matched, find 16 vs 8)



Introduction

Title: AirSim

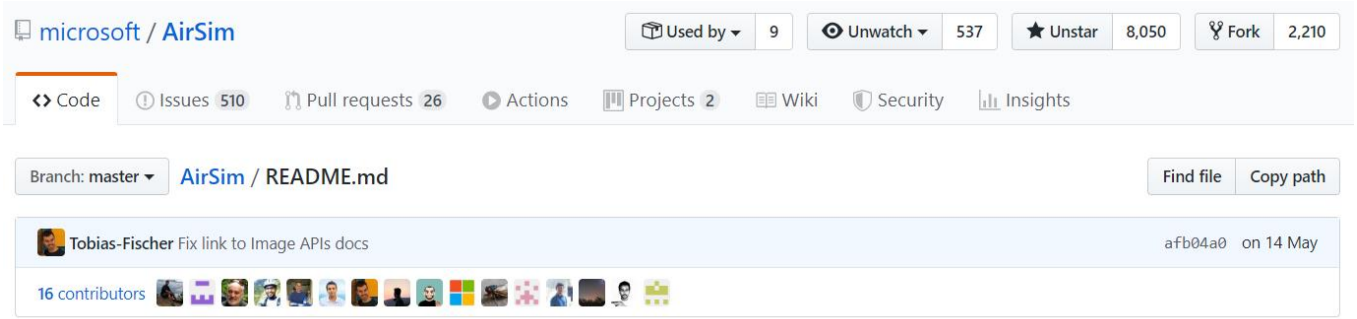
Author: MicroSoft

Link: https://github.com/microsoft/AirSim

Introduction

AirSim (C++) is a simulator built on Unreal Engine.

- OpenSource
- Cross-platform (BeamNG.research only Windows)
- APIs to get data and control vehicles (Python, C++, Java and so on)
- Gather environment data
- Hard to change the road environment

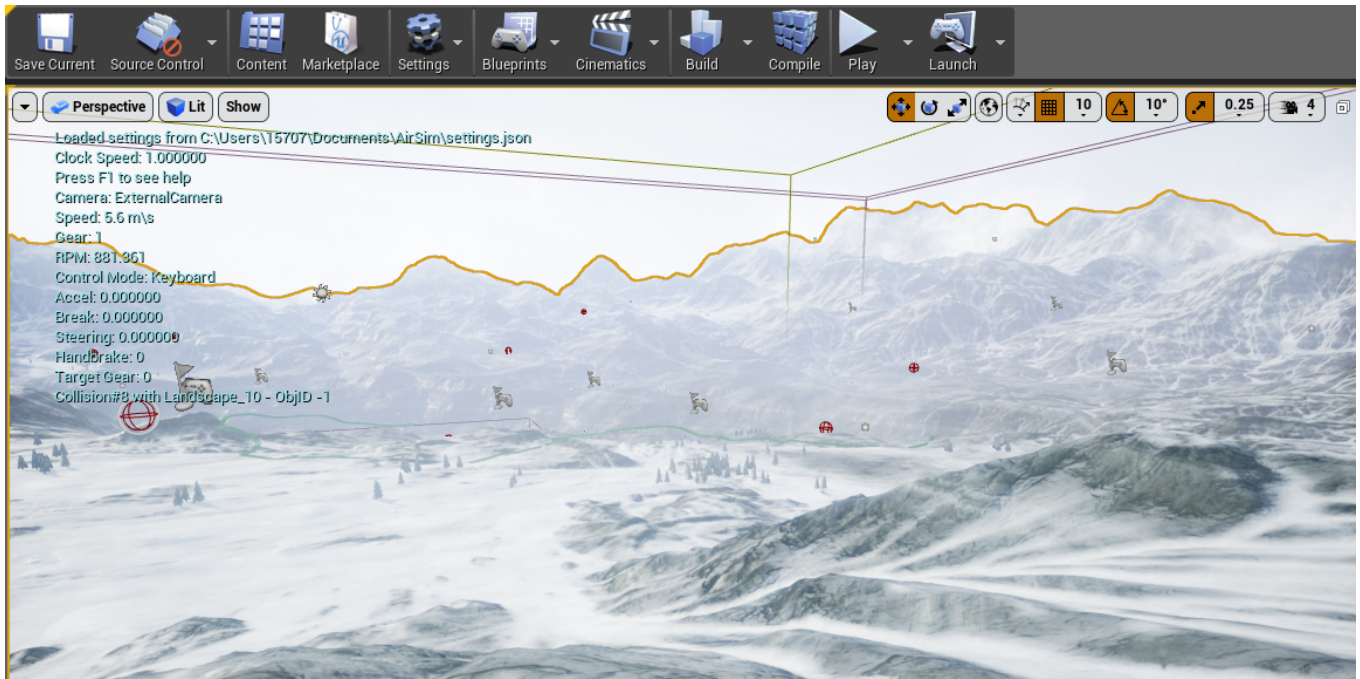


Key Thought

Use Unreal Engine to build the environment(for example, landscape mountain).

Then, AirSim will create a car or drone to this scene. Devices are driven by hardware(such as W/S/A/D) or script(via API).

There are a lot of free environment can be downloaded from Unreal Engine Store.



Screenshot– car controlled by keyboard

Next Step

- Find more papers about how to test Auto-car software efficiently and effectively;
- Try to learn AirSim (FSR 17'), find ways to control ego-cars and gather data;
- Follow the work of University of Passau.

Thanks!