Accelerating Virtual Validation for Automated Vehicles Using Data-Driven Optimization

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Main challenge of AV (Automated Vehicle) deployment

Safety assurance is the main challenge to AV deployment
  ◦ Correct system behaviour under “all” situations

Testing, verification & validation process is expensive
  ◦ >50% of engineering budget
  ◦ Extensive use of simulation
  ◦ Scenario based

Each base scenario can generate an enormous number of scenario variants
  ◦ Combinatorial explosion

How do you find out which of these combinations cause problems for your system?
One ‘base scenario’ can generate an enormous set of scenario variants

- Road geometry
- Traffic speed & density
- Weather
- Lighting
- Other driver behaviour
- Unpredictably moving objects

Example: 12 values for 6 variations $\rightarrow 12^6 = 3$ million combinations
Finding software defects in an enormous set of scenarios
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Driving scenario for the case study

Base driving scenario
- ACC (Adaptive Cruise Control)
- Cut out scenario
- Based on EuroNCAP 2018 Automated Driving Tests

CarMaker’s ACC control software is our device-under-test
Case study – Scenario variation parameters and KPIs

Scenario variation parameters
- Behaviour of ego vehicle
- Behaviour of other vehicles
- ACC control parameters

7 types of scenario variations
- 7 dimensional problem space

KPIs (Key Performance Indicators)
- Safety-related KPIs
- Could also include other types of objective or subjective KPIs
  - Effect on other vehicles or on traffic flow
  - Passenger comfort
Example results – Active search for a condition

Active search results
- Search condition is present in 0.06% of our 7 dimensional test space
- This represents our ‘needle in the haystack’

After 20 iterations, increase detection by 1000x from 0.06% to ~70%
- Now have found a large number of tests that meet the condition
Example results – Clustering test points

Newly found test points appear in clusters
- Used machine learning algorithms to
  - Convert 7D test point data to 2D
  - To aid in visualisation
  - Identify the clusters (shown as different colours)

Each cluster represents one issue
- Many test points are due to a common root cause
Example results – Clustering test points

Clear and simple reporting of issues to the AV development engineer
- 350+ test points → 7 clusters
- 50x reduction in reported issues

Easier to
- understand the issue
- resolve it
- eventually test that it has been resolved
Example results – Cluster characteristics

Visualise the cluster’s characteristics: size, shape, etc.
° Each cluster of test points will be caused by only a few scenario variations
° Focus on the 3 most important scenario variations / dimensions for that cluster
° The choice of 3 dimensions will probably be different for each cluster
Conclusions

Startup developing software tools to reduce the costs of AV development
  ◦ Currently developing Proof of Concept

Promising initial results
  ◦ 1000x increase in faults found
    ◦ Optimisation algorithms
    ◦ KPIs
  ◦ 50x reduction in reported issues
    ◦ Dimensionality reduction
    ◦ Clustering
Next step

Next step
- Pilot project with customer
  - Different driving scenarios
  - Different and more complex AV software

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