Accelerating Virtual Validation for Automated Vehicles Using Data-Driven Optimization

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CAVpoint

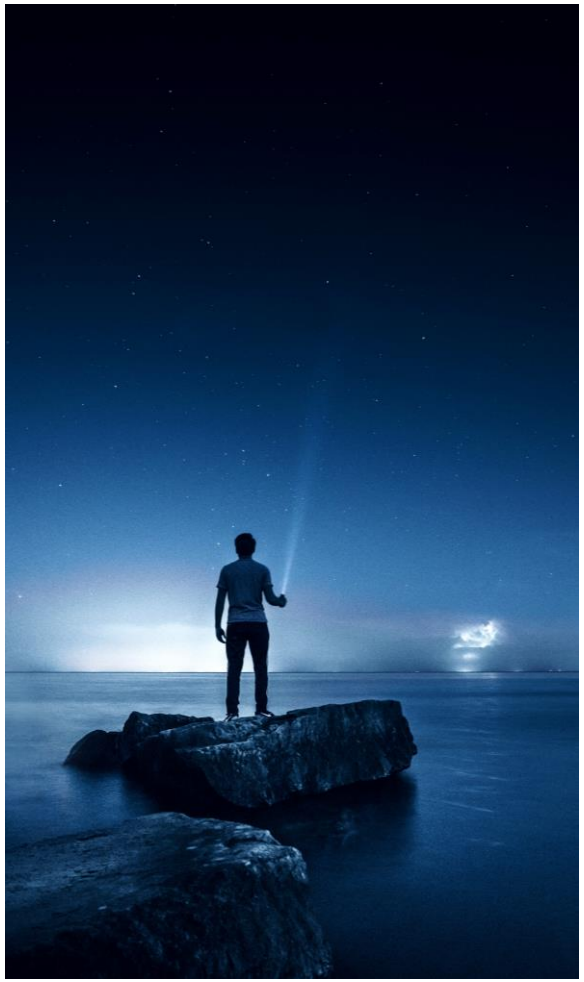
Main challenge of AV (Automated Vehicle) deployment

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

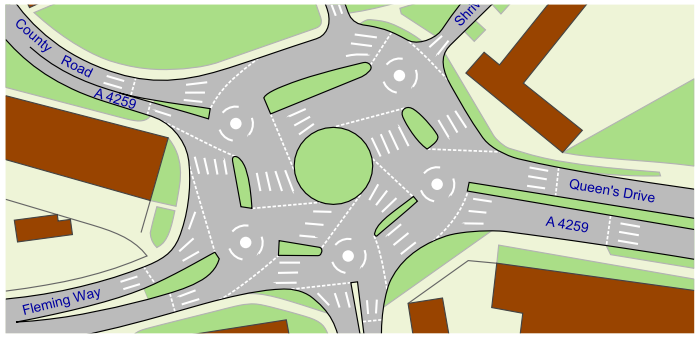
Testing, verification & validation process is expensive
- >50% of engineering budget
- Extensive use of simulation
- Scenario based

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

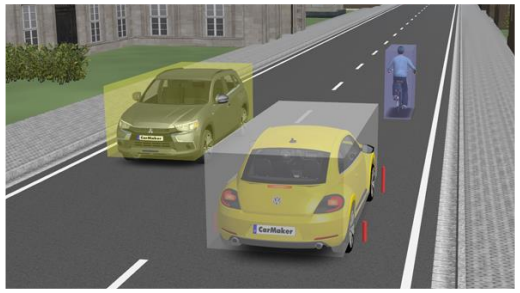
Lighting

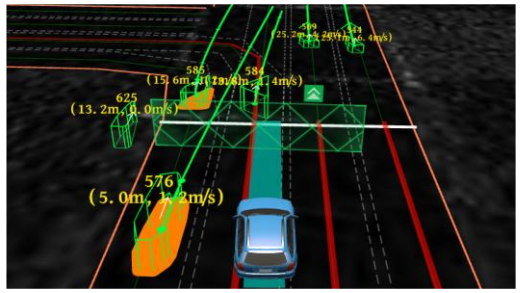
Other driver behaviour

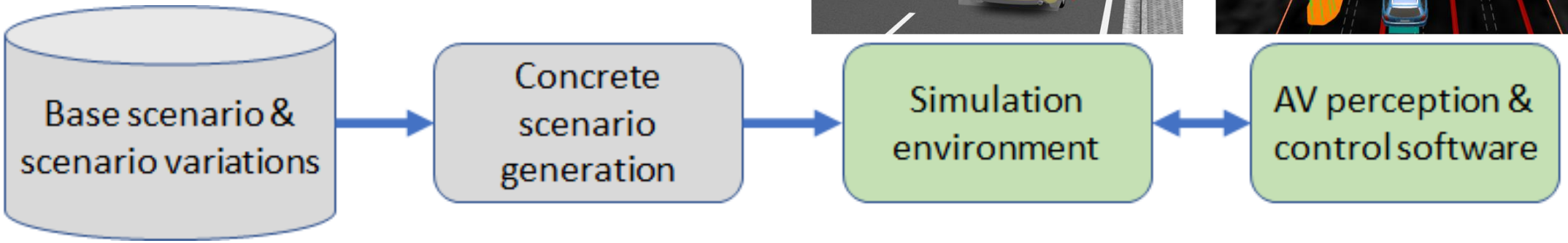
Unpredictably moving objects

Example: 12 values for 6 variations → 12^6 = 3 million combinations

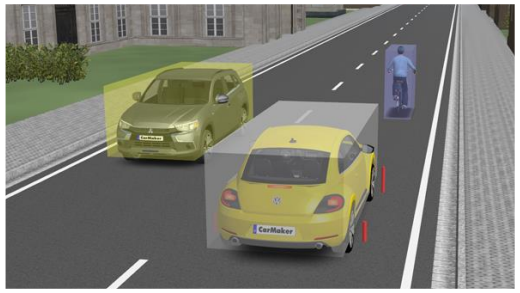
Finding software defects in an enormous set of scenarios

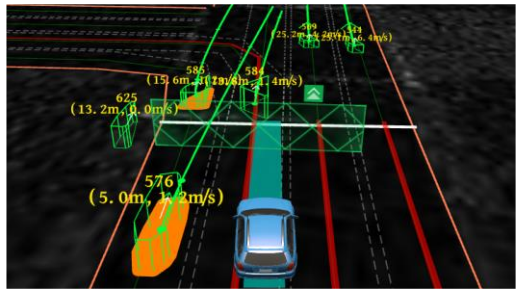


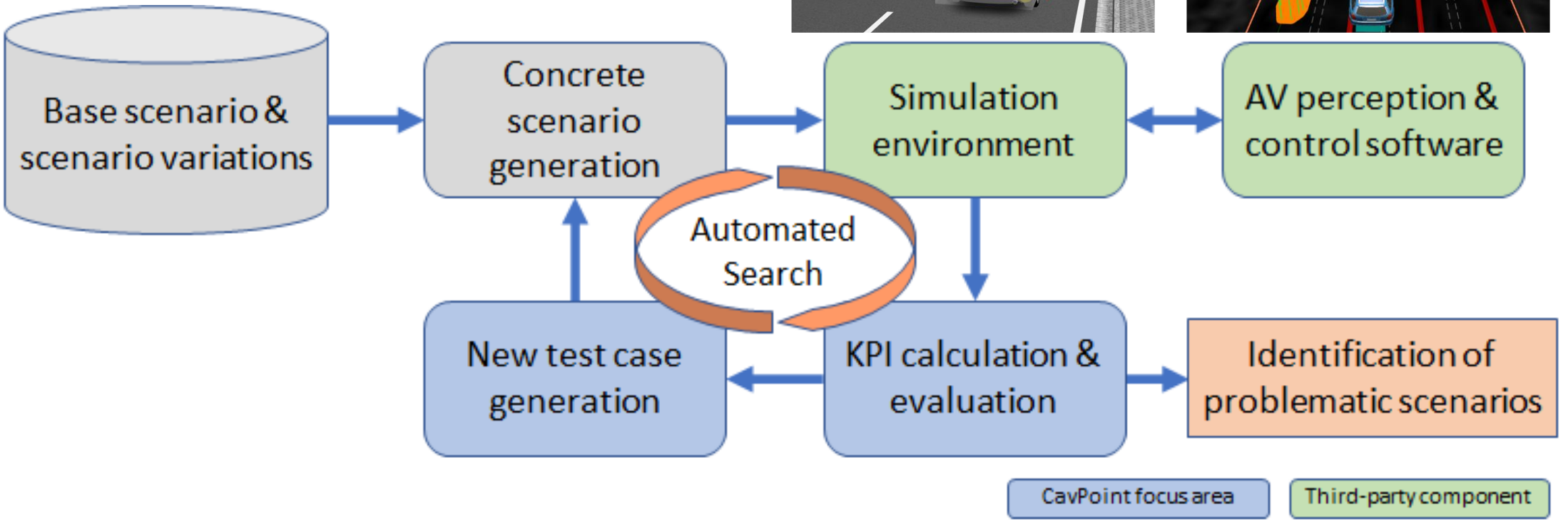




Finding software defects in an enormous set of scenarios





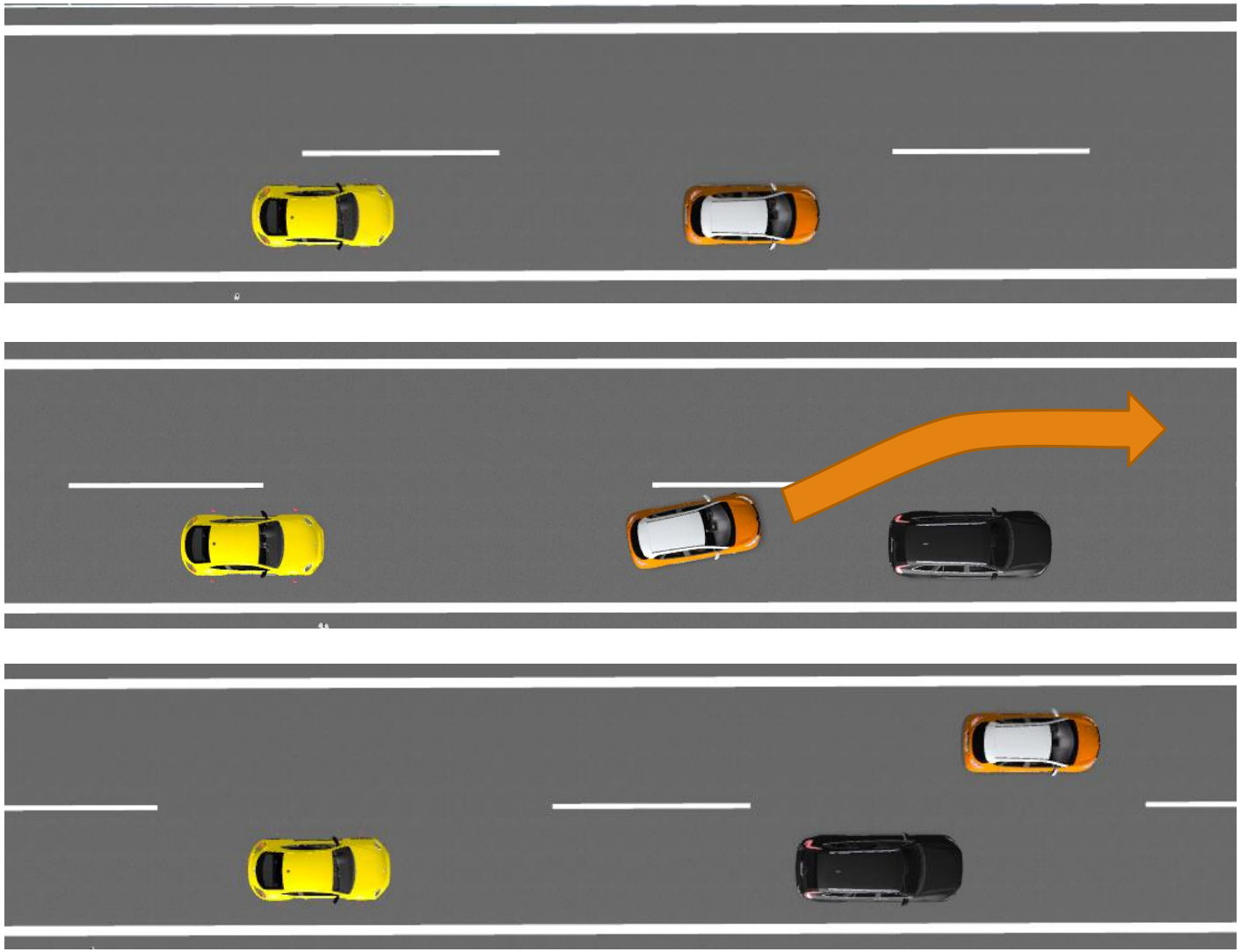


Driving scenario for the case study

Base driving scenario

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

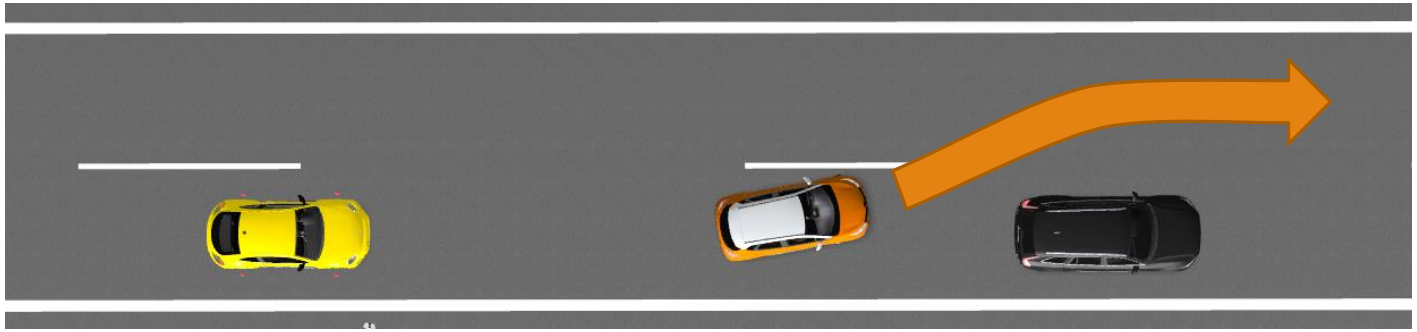
CarMaker's ACC control software is our device-under-test



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

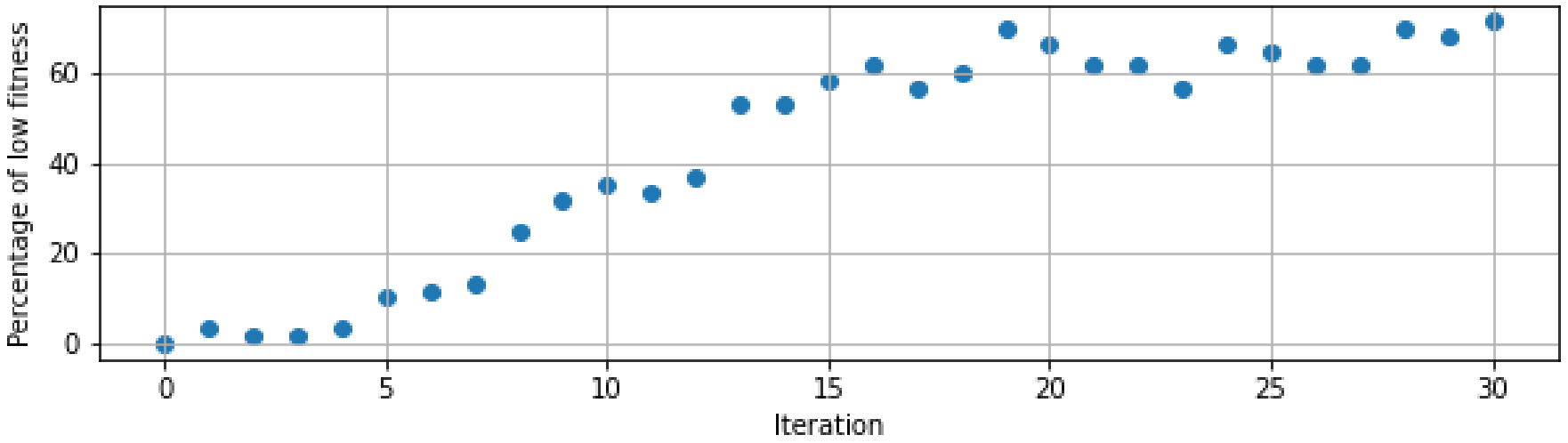
KPIs (Key Performance Indicators)

- 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

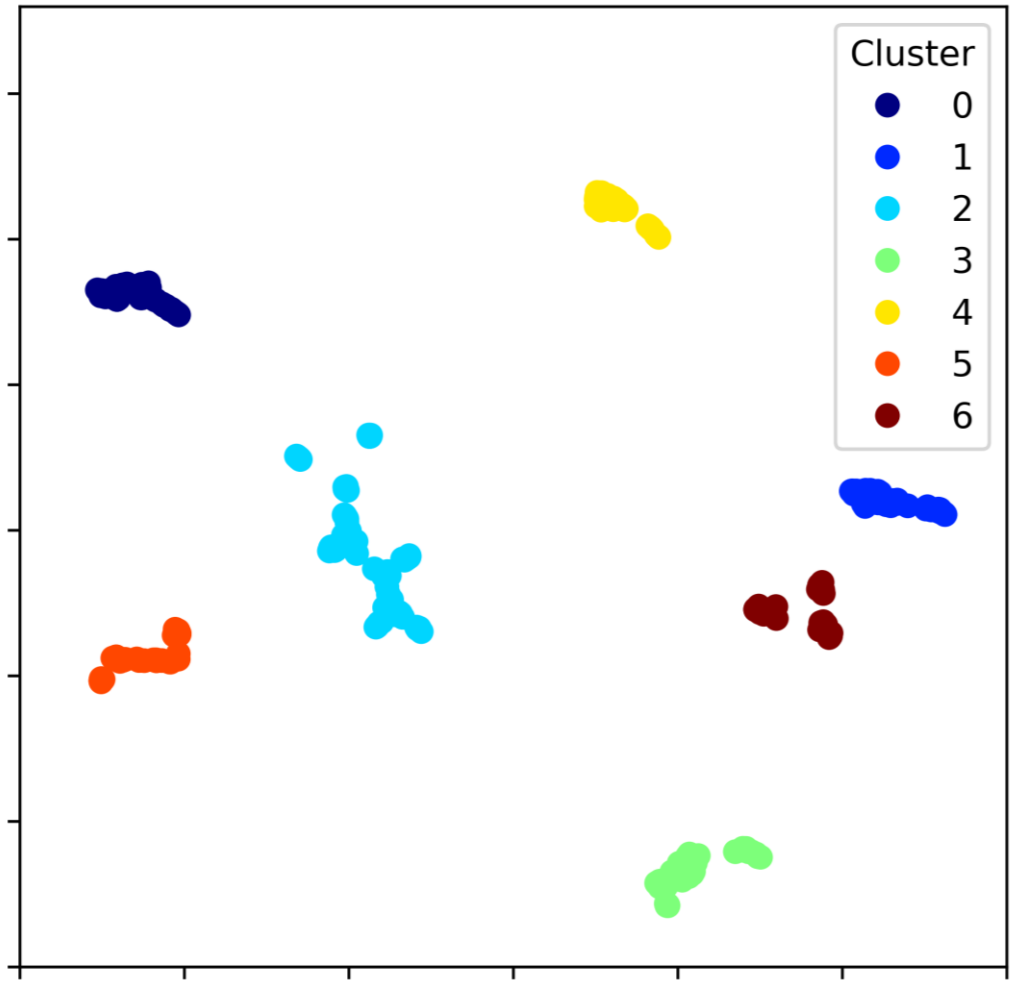
Example results – Clustering test points

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



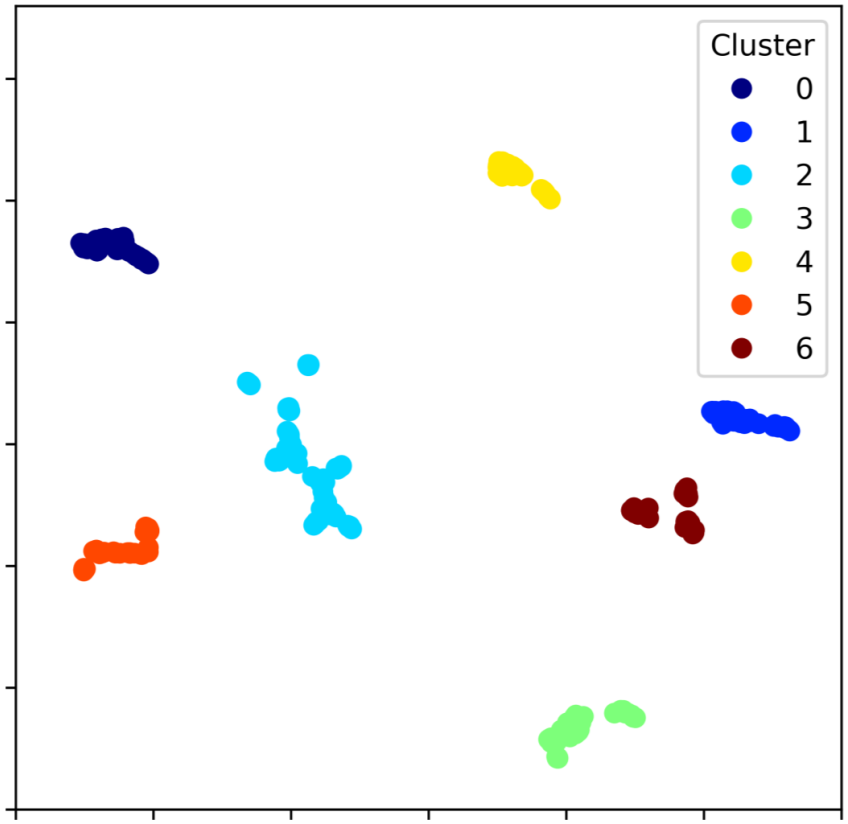
Example results – Clustering test points

Clear and simple reporting of issues to the AV development engineer

- 350+ test points → 7 clusters
- 50x reduction in reported issues

Easier to

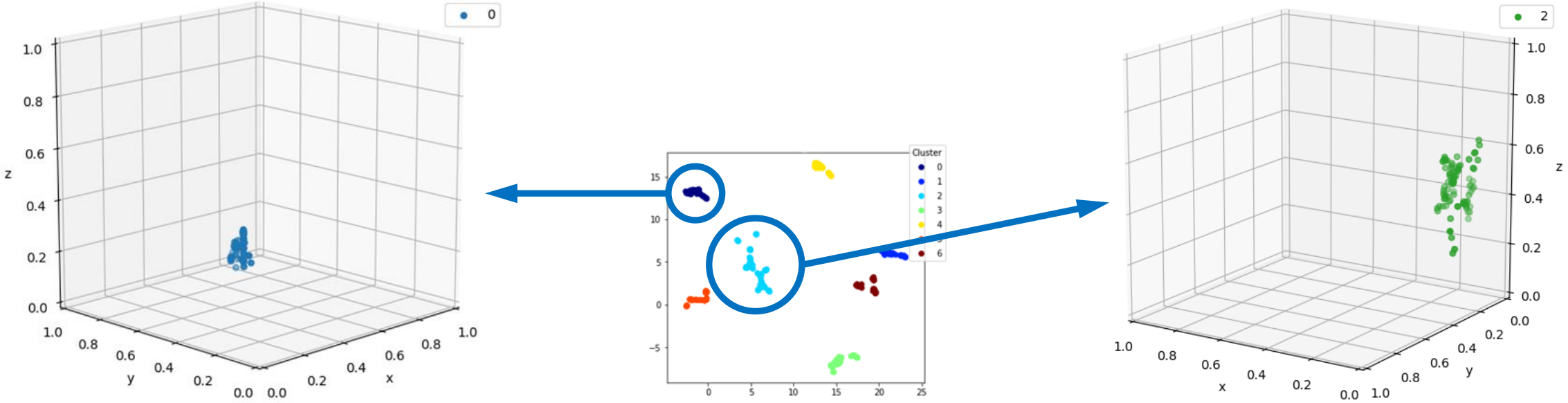
- understand the issue
- resolve it
- eventually test that it has been resolved



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

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

Acknowledgements

- IPG Automotive – CarMaker simulation software
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