Bug localization for autonomous driving systems

Localising System Parameters Leading to Autonomous Driving Collisions

Xiao-Yi Zhang, Paolo Arcaini, Fuyuki Ishikawa

**Problem**

- Several benefits from Autonomous Driving (AD)
- However, collisions during AD can lead to disruptive damages
- Important to explore why these collisions can occur and how to solve them
- Autonomous Driving Systems (ADS) contain various components with various parameters
- Difficult to localise the *suspicious* parameters

**Our study**

- We propose an approach to assess ADS collisions
- We apply spectrum-based techniques (borrowed from software debugging) to analyse the relationship between the incorrect behaviours of ADS components and the parameters of these components
- Our approach shows which parameters can cause AD collisions

**Why can collisions occur?**

Sometimes, collisions are detected during testing!

Motion planner’s “fault”

Perception DNN’s “fault”

- Parameter 1
- Parameter 2
- Parameter 3 (error)

Incorrect behaviour!

Our study: finding the parameters that can cause the incorrect behaviours of ADS components

**Localising suspicious path planner parameters**

Benchmark: an industrial path planner (PP)

At runtime, automatically generate safe and efficient path for the ego car

**Localising suspicious neurons for DNNs**

Spectrum-based analysis for PP

Generate various test cases and scenarios

Generate various inputs images

Classification through DNN

Activated neurons

Outputs (correct or not)

Assessment

Neuron 1 is activated

Cat

Neuron 2 is activated

Cat

Neuron 3 is activated

Dog

Assign a score to each neuron through some metrics according to their activation

**Experiments**

Spectrum-based analysis for DNN models

- Dataset: MNIST, CIFAR10
- DNN – CNN with various structures

Intersection of the suspicious neurons among different misclassifications

Wrong labels

Correct labels

Wrong labels

Errors synthesised by activating the suspicious neurons

The intersection sizes are small → Different misclassifications are caused by different neurons

Synthesising inputs by triggering the suspicious neurons can indeed produce misclassifications (errors!)

Collisions occur or not

Run path planner

Collision

Test information

<table>
<thead>
<tr>
<th>Parameter 1</th>
<th>Parameter 2</th>
<th>Parameter 3</th>
<th>Collision?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>Large</td>
<td>Large</td>
<td>Yes</td>
</tr>
<tr>
<td>Median</td>
<td>Median</td>
<td>Median</td>
<td>No</td>
</tr>
<tr>
<td>Small</td>
<td>Small</td>
<td>Small</td>
<td>No</td>
</tr>
</tbody>
</table>
