Intelligent Test-Case Generation and Automation for Real-Time Test Systems

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TestWeaver - Motivation

- Size of control software doubles every few years
- Budget for testing does not increase

Idea
- Increase degree of automation
- Generate and evaluate useful test cases automatically
Idea

- Intelligent generation of ... 1000s of differing test scenarios
- Active attempt to:
  - maximize state coverage
  - drive the system in “difficult” situations

Benefit

- High coverage
- Low efforts for test specification
TestWeaver - Test Generation Strategy

- controllable input
- component fault
- inputs $u$
- state
- outputs $y$
- MiL/SiL/HiL simulation
- vehicle model
- ECU controller
- quality observers
- alarm

Reactive scenario generation: each scenario depends on the history of generated scenarios.

All cases can be reproduced.

Drive the system in states that were not covered before.

Change sub-optimal scenarios to generate worst-cases.
TestWeaver with MATLAB/Simulink
TestWeaver - Result Analysis

Overview report for all scenarios

Detailed reports for individual scenarios

Replay, plot, debug
Example - Integer Range Violations

Monitoring the ranges of 6538 signals after time 1s

14 out of range signals -- names not containing "_L2_":

<table>
<thead>
<tr>
<th>Name</th>
<th>A2L Min</th>
<th>A2L Max</th>
<th>Sim Min</th>
<th>Sim Max</th>
<th>Scen Min</th>
<th>Time Min</th>
<th>Scen Max</th>
<th>Time Max</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>accVehX_VSC</td>
<td>-10.24</td>
<td>10.16</td>
<td>-12</td>
<td>14</td>
<td>s538</td>
<td>27.515</td>
<td>s209</td>
<td>17.885</td>
<td>127.451</td>
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<tr>
<td>trqClPrev_CctcVSWA</td>
<td>-500</td>
<td>1000</td>
<td>-500</td>
<td>1145.44</td>
<td>s0</td>
<td>1.005</td>
<td>s1186</td>
<td>28.755</td>
<td>169.696</td>
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<td>EngRPM_Max_Rq_DCT_OcptVUW</td>
<td>0</td>
<td>8190</td>
<td>8192</td>
<td>8192</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>EngRPM_Max_Rq_DCTcp_OcptVUW</td>
<td>122880</td>
<td>131070</td>
<td>122878</td>
<td>122878</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>EngRPM_Rq_TCM_OcptVUW</td>
<td>0</td>
<td>8190</td>
<td>8192</td>
<td>8192</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>EngRPM_Rq_TCMcp_OcptVUW</td>
<td>122880</td>
<td>131070</td>
<td>122878</td>
<td>122878</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>intrvlnMd_TCM_OcptVUC</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>6.555</td>
<td>200</td>
</tr>
<tr>
<td>intrvlnMd_TCMcp_OcptVUC</td>
<td>254</td>
<td>255</td>
<td>252</td>
<td>254</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>200</td>
</tr>
<tr>
<td>TxNShiftMd_OcptVUC</td>
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<td>1</td>
<td>3</td>
<td>3</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>TxNShiftMdCp_OcptVUC</td>
<td>254</td>
<td>255</td>
<td>252</td>
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<td>s0</td>
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<td>s0</td>
<td>1.005</td>
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<tr>
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<td>s0</td>
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<td>s0</td>
<td>3.305</td>
<td>s0</td>
<td>1.005</td>
<td>481.49</td>
</tr>
</tbody>
</table>

3 out of range signals -- names containing "_L2_":

<table>
<thead>
<tr>
<th>Name</th>
<th>A2L Min</th>
<th>A2L Max</th>
<th>Sim Min</th>
<th>Sim Max</th>
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<th>Time Min</th>
<th>Scen Max</th>
<th>Time Max</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>intrvlnMd_TCM_L2siVUC</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>6.555</td>
<td>200</td>
</tr>
<tr>
<td>TxNShiftMd_L2siVUC</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>s0</td>
<td>1.005</td>
<td>s0</td>
<td>1.005</td>
<td>0</td>
</tr>
<tr>
<td>TxShlRcmd-DispRqTCMcp_L2siVUC</td>
<td>0</td>
<td>252</td>
<td>254</td>
<td>255</td>
<td>s0</td>
<td>6.875</td>
<td>s0</td>
<td>1.005</td>
<td>0.396825</td>
</tr>
</tbody>
</table>

Example - Problem Found and Corrected

Oscillation of target gear
- found by TestWeaver
- replay in Silver

Improved control software
- run regression test
- problem solved

TestWeaver for HiL

- generate test cases run in real-time
- accurate timing on a milli sec scale

host PC

Python test

generate test
run each test
and record result

TestWeaver for HiL

- recorded test results

Experiment Specification

Test Report

r/w fault codes
r/w EEPROM (adapt. data)

measure calibrate

CAN, XCP, UDS

CANape
- measure during replay

Intelligenr Test-Case Generation for Real-Time Test Systems - ASAM Open Technology Forum USA 2011
DCT Speedshift for AMG SLS

- Control software tested with Silver and TestWeaver
- Every software release: 24h test run in parallel on several PCs
- Thousands of gearshifts generated and analyzed

Details in:
**Mercedes Crosswind Stabilisation Function**

**Crosswind Stabilisation**
- Function exported from Simulink
- Co-simulated with Mercedes in-house vehicle model, wind and road model using Silver
- Test of the stabilisation function with TestWeaver
- Generated and analysed 100,000 different driving scenarios, each 45 sec. within 3 weeks

Details in:
IFAC Symposium Advances in Automotive Control 2010, 12-14 July 2010, Munich, Germany
Systematic Test and Validation

- Intelligent generation of thousands of test scenarios
- High coverage of system states
- Reactive test execution using SiL, MiL or HiL
- Tests: requirements, safety, robustness, regression

Benefit

- Find more problems earlier

Cost and time savings

- $ millions