Refining Testable Cases and Scenarios for Evaluating Level 3 Through Level 5 Automated Driving System Concepts

Project Overview
Refining Testable Cases and Scenarios for Evaluating L3 - L5 ADS Concepts

**Purpose:**
Develop a method to guide the design and selection of cases to test the performance of an Automated Driving System (ADS) - using lane change scenario data for piloting purposes.

**Objectives:**
- Develop a model-based feature representation of multivariate driving scenario data to further define testable cases.
- Apply previous testable cases framework to identify ADS test cases and quantify the relationship and boundaries between test cases.
Refining Testable Cases and Scenarios for Evaluating L3 - L5 ADS Concepts

Project Motivation:

- Data Breadth
- Data Scale
- Data Science
**Project Overview**

**Surveying Scenario-based Activities & Selection**
- Survey Scenario Activities
- Review Parameterization Approaches
- Select Family of Scenarios to Exercise

**Data Input Preparation**
- Review available test & data venues
- Construct Input and Preparation Process
- Instantiate Accessible Data

**Statistical and Machine Learning Engineering and Modeling**
- Cleaning and Imputation Strategies
- Feature Engineering
- Data Representation [Deep Learning]
- Cluster Modeling
- Cluster Merging

**Approaches for Test Case Selection**
- Validation (e.g., unseen data)
- Extension
- Test Case Selection

**Test Case Authoring**
- Survey Common Authoring Approaches
- Construct Authoring Process
- Demonstrate Process

**Stakeholder and Advisory SMEs Feedback**
- Established Industry Stakeholder and SME Advisory Groups
- Intermediate Milestone Presentations
- Solicited and Incorporated Feedback
Scenario Sources for Statistical Models

<table>
<thead>
<tr>
<th>Venue</th>
<th>Approximate Count</th>
<th>Description</th>
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<tbody>
<tr>
<td>NDS</td>
<td>500,665</td>
<td>Routine lane changes greater than 31 mph</td>
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<tr>
<td>NDS</td>
<td>435</td>
<td>Routine lane changes, located in random samples</td>
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<tr>
<td>Public ADS</td>
<td>306</td>
<td>Lane changes in proximity of automated driving system</td>
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<tr>
<td>NDS</td>
<td>5003</td>
<td>Routine merges</td>
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<tr>
<td>Test Track</td>
<td>567</td>
<td>Routine lane changes</td>
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<td>Cut-ins</td>
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<td>3 core cases X 3600 simulated variations</td>
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<td>Near-crashes</td>
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<td>Event avoidance lane changes</td>
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<td>NDS</td>
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<td>Crashes</td>
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<td>CISS with EDR</td>
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<td>CISS EDR cases</td>
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<td></td>
<td>520,291</td>
<td>Total</td>
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Note: Tables were intentionally populated with more units than would be used (1) to learn more from the import and preparation task and (2) to provide more options for downstream processes.
Cluster Modeling Workflow

Models Considered

1. Variational Auto Encoder (VAE-NF)
2. Principal Component Analysis (PCA)
3. Fast Independent Component Analysis (Fast-ICA)
4. Kernel-PCA
5. t-distributed stochastic neighbor embedding (tSNE)
6. Truncated Singular Value Decomposition (TSVD)
7. Spectral Embedding (SE)

Clustering

Validation and Extension
Relating Latent Factors to Engineered Features

The database structure, data standardization functions, and analysis tool created by the team provide data traceability and human interpretability to the cluster modeling workflow.
Clustering to Test Cases

High Speed, Smooth (brown)

Moderate Speed, Jerky (red)
Clustering to Test Cases

Moderate speed, jerky

High density: More likely to happen
Low density: Less likely to happen

- safety-critical events

- Certain feature combinations occur more frequently than others
- Safety-critical events tend to occur on low-density regions
Test Case Authoring

The SUT is traveling straight on a multi-lane highway with V1 ahead in left adjacent lane. As V1 initiates lane change into SUT's path, SUT responds.
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Thank You!