Traffic Simulation for Connected Automated Vehicles

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<table>
<thead>
<tr>
<th>Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsimulation Assumption for AV/CAVs</td>
</tr>
<tr>
<td>Case Studies:</td>
</tr>
<tr>
<td>1. Freeway Capacity per AV Fleet Penetration</td>
</tr>
<tr>
<td>2. AVs on Arterial Streets</td>
</tr>
<tr>
<td>3. A Cooperative Controller Approach for CAVs</td>
</tr>
</tbody>
</table>
Connected & Autonomous Vehicles in Simulation

- **CAV Driving Assumptions**
  - Accelerate and decelerate uniformly
  - Deterministic estimation of distance and speed
  - V2V & V2I (number of interaction vehicles)

- **Wiedemann Car Following Model**
  - Smaller car-following parameters
  - Larger lookahead & look back distances
  - A larger number of observed vehicles
  - Lane change
    - Larger for “Conservative”
    - Default/smaller for “Optimal”
1 Freeway Capacity per AV Fleet Penetration
Assumptions

- AV Driving Characteristics
  - Optimal (All-knowing)
- Market Penetration Rates
  - 0%, 10%, 30%, 50%, 70%, 90%, 100%
- Setting
  - Roseville, CA: 21 freeway miles & 36 intersections
Freeway Capacity - AVs

Flow Comparison
- Capacity – 3,200 pcp/hpl
- 36% higher capacity

Speed Comparison
- Breakdown for 100% AVs
- 5-10 mph higher congested speed

100% AV
0% AV
Case Study

- I-80 and State Route 65 System Interchange, Roseville, CA

- Measures of Effectiveness and Findings
  - Bottleneck speed and throughput
  - Intersection delay
  - Overall delay change with AVs percentage
Network Performance

AV Percentage Effect on Total Network Delay

AV Percentage Effect on Network Average Speed

AM PEAK LEVEL OF SERVICE
2 Autonomous Vehicles on Arterial Streets
Assumptions

- **AV Driving Characteristics**
  - Conservative: large gaps & braking distances
  - Moderate: intermediate gaps & braking distances
  - Optimal: small gaps & braking distance

- **Market Penetration Rates**
  - 0%, 10%, 25%, 50%, 75%, 100%

- **Settings**
  - Heavy Congestion: SR-29 in American Canyon, CA (5 miles)
  - Moderate Congestion: El Camino Real in Palo Alto, CA (2 miles)
Measures of Effectiveness and Findings

Network Delay

Heavy Congestion

SR-29 (American Canyon)
Average Network Delays - PM Peak Hour

- AVs - Conservative
- AVs - Moderate
- AVs - Optimal
- Baseline

Moderate Congestion

El Camino Real (Palo Alto)
Average Network Delays - PM Peak Hour

- AVs - Conservative
- AVs - Moderate
- AVs - Optimal
- Baseline
Measures of Effectiveness and Findings
Travel Time

**Heavy Congestion**

SR-29 (American Canyon)
Peak Direction Travel Times - PM Peak Hour

<table>
<thead>
<tr>
<th>% AV Share</th>
<th>AVs - Conservative</th>
<th>AVs - Moderate</th>
<th>AVs - Optimal</th>
<th>Baseline</th>
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**Moderate Congestion**

El Camino Real (Palo Alto)
Peak Direction Travel Times - PM Peak Hour

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<tr>
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<th>AVs - Moderate</th>
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A Cooperative Controller Approach for CAVs
Assumptions

- **CAV Driving Characteristics**
  - CACC
  - V2V & V2I
  - Platooning

- **Market Penetration Rate** = 100%

- **Settings**
  - Without a merging controller
  - With a merging controller
    - Lane Change on the mainline
    - Slowdown on the on-ramp
    - Slowdown on the mainline
A Cooperative Controller Approach For CAVs

Current merging
- Perception and judgment
- Random gaps
- Challenging

Future merging
- V2I and V2V
- Uniform gaps
- Controller
Measures of Effectiveness and Findings

![Graph showing measures of effectiveness with various scenarios and their effects on speed and volume.]
Microsimulation is an effective tool to investigate CAVs’ traffic conditions

Most of AVs’ benefits can be obtained at 50% of AVs

Fully CAV traffic requires communication-based approaches