Application I:

Highways and Cooperative Adaptive Cruise Control
Mobility Assessment

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Agenda

- Introductions
- Objective
- Methodology
- Modeling Paradigm
- Simulation Environment
- Simulation Process
- Travel Trajectory
- Results
- Conclusion
Challenge

http://thehill.com/policy/transportation/248060-house-approves-8-billion-highway-patch


Initiative

Wyoming I-80 Corridor - Connected Vehicle Map

Source: Wyoming CV Pilot Deployment Team

http://www.its.dot.gov/pilots/wave1.htm
Cooperative Adaptive Cruise Control

[Diagram showing the interaction between a driver, Vehicle OBE, and remote vehicle OBEs, with wireless communication between vehicles]

Questions

• What are the impacts of Cooperative Adaptive Cruise Control have on traffic operations?

• What is the importance of the adoption rate?

Objectives

• Observe an effect of CACC over the base scenario for different market penetration rates.

• Discover estimates for critical adoption rates
Methodology

- One lane on a 3.5-mile stretch of straight continuous highway
- No on- or off-ramps
- Normal weather condition
- A 1-mile section of reduced speed (bottleneck) in the middle
- Speed limit set at 70 mph
- Bottleneck speed limit set at 10 mph
Modeling Paradigm

http://www.anylogic.com/learn-simulation
Simulation Environment: Parameters

Poisson Vehicle Arrivals
Mean inter-arrival time is 4 sec

Negative Exponential Inter-arrival
\[ f(x, \lambda) = \begin{cases} \lambda e^{-\lambda x} & x \geq 0 \\ 0 & x < 0 \end{cases} \]

Initial Arrival Speed
between 60 to 40 mph

Uniform Initial Speeds
\[ f(x) = \begin{cases} \frac{1}{b - a} & a \leq x \leq b \\ 0 & x < a \text{ or } x > b \end{cases} \]

Market Penetration of CVs

Bernoulli Vehicle Type Selection
\[ f(x, p) = \begin{cases} p & x = 1 \\ 1 - p & x = 0 \end{cases} \]
Simulation Environment: Car-following (Non-CV)

Leading Car Behavior

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration</td>
<td>$3.3 \text{ ft/s}^2$</td>
</tr>
<tr>
<td>Deceleration</td>
<td>$7.9 \text{ ft/s}^2$</td>
</tr>
</tbody>
</table>

Car-Following Behavior

$$a_{n+1} = \alpha \frac{V_{n+1}^m}{[X_n^t - X_{n+1}^t]^l} [V_n^t - V_{n+1}^t]$$

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Notation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance headway exponent</td>
<td>$l$</td>
<td>2</td>
</tr>
<tr>
<td>Speed exponent</td>
<td>$m$</td>
<td>0</td>
</tr>
<tr>
<td>Jam density</td>
<td>$K_j$</td>
<td>200 vpm</td>
</tr>
<tr>
<td>Free Flow Speed</td>
<td>$V_f$</td>
<td>70 mph</td>
</tr>
<tr>
<td>Sensitivity Coefficient</td>
<td>$\alpha$</td>
<td>0.35 mi$^2$/hr</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>$\Delta t$</td>
<td>0</td>
</tr>
</tbody>
</table>
Simulation Environment: Car-following (CV)

\[
\text{Desired Speed} = \frac{\text{Space Headway}}{\text{Desired Time Headway}}
\]
Summation Process

0% Connected Vehicle – 100% Ordinary Vehicle
Summation Process

50% Connected Vehicle – 50% Ordinary Vehicle
Summation Process

0% Connected Vehicle – 100% Ordinary Vehicle
Trajectory – Shock Wave
Trajectory - Platooning
Results – Backpropagation Time vs. Market Penetration
Results – Mean Travel Time vs. Market Penetration
Results – Throughput vs. Market Penetration

![Graph showing Throughput vs. Market Penetration](image-url)
Conclusions