Connected and Autonomous Vehicles Simulation

Current Trends and New Challenges

Bay Area ITE / ITS CA Joint Transportation Workshop
April 27, 2017
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Stakeholders

- OEMs and other Technology Firms
- Simulation Software Developers
- Consultants and Engineering Firms
- Transportation Authorities

CAV
Microscopic traffic simulation

- Started in the 80s-90s – assessment of ITS applications
Architecture

“Universal” models

<table>
<thead>
<tr>
<th>Length</th>
<th>3.55173 meters</th>
</tr>
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<tbody>
<tr>
<td>Width</td>
<td>2 meters</td>
</tr>
<tr>
<td>Maximum Acceleration Desired</td>
<td>2.98245 m/s²</td>
</tr>
<tr>
<td>Deceleration Desired</td>
<td>-4.12196 m/s²</td>
</tr>
<tr>
<td>Maximum Deceleration Desired</td>
<td>-6.73498 m/s²</td>
</tr>
<tr>
<td>Mean Speed Desired</td>
<td>132.759 km/h</td>
</tr>
<tr>
<td>Speed Limit Acceptance</td>
<td>1.15769</td>
</tr>
</tbody>
</table>

Length  | 4.29007 meters |
Width   | 2 meters       |
Maximum Acceleration Desired | 3.00926 m/s² |
Deceleration Desired       | -3.95441 m/s² |
Maximum Deceleration Desired | -6.59264 m/s² |
Mean Speed Desired         | 90.3137 km/h  |
Speed Limit Acceptance     | 1.06603        |
Architecture

Vehicle Model

Infrastructure Model

Outputs

Get the state of the vehicles and of the infrastructure

Apply car-following

Solve lane-changing conflicts

Check lane-changing motivation and feasibility

Apply give-way and traffic light model
How CAVs are currently modeled

1. Behavioral parameters
2. Communication API that reads and sends information about the vehicles and the infrastructure (e.g. dynamic speed harmonization, intelligent traffic signals, dynamic routing, etc.)
How CAVs are currently modeled

1. Behavioral parameters
2. Communication API that reads and sends information about the vehicles and the infrastructure (e.g. dynamic speed harmonization, intelligent traffic signals, dynamic routing, etc.)
How CAVs are traditionally modeled

3. Replace the default car-following, lane-changing and/or gap-acceptance models with AV algorithms (e.g. adaptive cruise control, lane departure warning, automated parking, advanced intersection management, etc.)
DMA-ATDM AMS Testbed Project, funded by US DOT

- INFLO bundle of CACC, SPD-HARM and Q-WARN applications
FLOURISH
Limitations of the current approaches

1. Perfect perception of the state of the infrastructure and of the surrounding vehicles
2. No incidents, no mistakes – example: spontaneous capacity drop
3. Collective decisions with instantaneous and perfect communication
4. The simulation step constrains the refresh rate of different devices
5. No explicit physical constraints in vehicle dynamics
6. We need to improve the models for human drivers and non-connected vehicles!
New requirements
1.- Consider human (*not only*) factors
2.- Vehicle dynamics model
3.- Emulate wireless data transmission
4.- Emulate V2V and V2I communication
5.- Emulate AV behaviour

Simulator

AV

Perception

Execution

Planning
6.- Integrate all type of agents
A framework to model CAVs
Conclusions

• The current traffic simulation approach is suitable to assess the impact of CAVs at aggregated level
• A new traffic modeling framework based on perception, planning and execution with individual agents is needed for more detailed evaluations