Evaluating the impact of autonomous vehicles at a Stillwater intersection

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Introduction
- Car crashes: mainly caused by human error, >90% (Buck, Toscano & Tereskerz, 2021)
- Autonomous vehicles (AV) - crucial to future transportation systems
  - Institute of Electrical and Electronic Engineers (IEEE): predicting 75% AV by 2040
  - KPMG Study (2018): AVs will be a major commodity within the next 5 years (NAIC, 2020)
- Benefits of AVs
  - Reduce congestion: smaller headway, constant speed, less reaction time
  - Improved safety: prevent one of every three fatalities (30,000 annually in US) (IIHS 2010); reduce accidents by ~90% in 2050 (NAIC, 2020)
- Objectives
  - Collect field traffic data at a Stillwater intersection for PTV VISSIM simulation
  - Evaluate the impact of autonomous vehicles on traffic mobility in VISSIM

Data Collection
- Field traffic count: 15 minutes for each approach & movement
- Annual average daily traffic (AADT): ODOT AADT Map
- Peak hour volume: 30th highest hourly volume (K30)
- Intersection geometry: turning radius, length of left turn bay, # lanes and width
- Signal timing: red, yellow, green

VISSIM Simulation
- Simulation scenarios
  - Microscopic simulation in VISSIM
  - 7 scenarios: conventional vs. AVs at different penetration rates
  - AV definitions: CoExist project
- Simulation setting
  - Each scenario simulated with 5 runs
  - Each run: 4500 seconds
  - Result reporting: collected every 300 seconds

Table 2 Simulation scenarios

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>100% Conventional Vehicles</td>
</tr>
<tr>
<td>2</td>
<td>90% Conventional Vehicles and 10% Autonomous Vehicles (AV Normal CoExist)</td>
</tr>
<tr>
<td>3</td>
<td>75% Conventional Vehicles and 25% Autonomous Vehicles (AV Normal CoExist)</td>
</tr>
<tr>
<td>4</td>
<td>50% Conventional Vehicles and 50% Autonomous Vehicles (AV Normal CoExist)</td>
</tr>
<tr>
<td>5</td>
<td>100% Autonomous Vehicles (AV Normal CoExist)</td>
</tr>
<tr>
<td>6</td>
<td>100% Autonomous Vehicles (AV Cautious CoExist)</td>
</tr>
<tr>
<td>7</td>
<td>100% Autonomous Vehicles (AV Allknowing CoExist)</td>
</tr>
</tbody>
</table>

Table 3 CoExist terminology for different AVs

<table>
<thead>
<tr>
<th>Definition under CoExist project</th>
<th>AV Cautious</th>
<th>AV Normal</th>
<th>AV Allknowing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick wall stop distance</td>
<td>Gaps similar to human drivers but with higher safety</td>
<td></td>
<td></td>
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<tr>
<td>Big gaps</td>
<td>Small gaps but still safe</td>
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<td></td>
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<tr>
<td>Cauliflower behavior</td>
<td>Cooperative behavior</td>
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<td></td>
<td>Communication is a precondition</td>
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Performance Comparisons
- Queue Delay
- Stopped Delay
- Vehicle Travel Time
- Queue Length

Conclusions
- Overall AV’s can have a major impact by reducing the queue delay, stopped delay, and queue length
- AV techniques
  - Allknowing vehicles: the most significant decrease in all performance measures
  - Cautious vehicles: will lead to an increase in queue delay (5.17%), stopped delay (3.45%), and queue length (3.84%) due to larger gaps created between each vehicle
- Future work
  - Conduct sensitivity analysis of AV related features: more realistic scenarios
  - Integrate V2I and V2V communications
  - Evaluate emission, safety at both project and corridor level