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Simulation of the Impact of the Autonomous and Connected Vehicles at a signalized Intersection

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Research Objective
The primary focus of this research is to evaluate if autonomous vehicles (AVs) can decrease the traffic congestion on roads and especially at an urban signalized intersection.

Introduction
- The Governors Highway Safety Association GHSA (2018) reported that more than 90% of automobile crashes are caused by human errors.
- An IIHS (2010) report points out that the high-end crash avoidance features in the AVs can prevent one of every three fatalities and prevent one of five fatal injuries caused by passenger vehicles.
- AVs could reduce the road fatalities by 30,000 each year in the US alone (KPMG 2017).
- AVs use smaller headway (gaps) between other vehicles and constant speeds in traffic stream which can reduce traffic congestion on roadways.
- In addition, an AV has less reaction time which can also reduce delays at the signalized intersections.

Methodology
- Using a real existing traffic count for the morning peak hour at a signalized intersection in Dayton, Ohio.
- Optimizing the intersection signal timing by using Synchro software.
- Using the PTV Vissim microscopic simulation to evaluate the efficiency of the signalized intersection in five different scenarios (Table 1).
- The parameters for the AV that have been used in the simulation are defined by CoEXist and are installed in PTV Vissim software (Table 2).

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Results
- AVs use smaller headway (gaps) between other vehicles and constant speeds in traffic stream which can reduce traffic congestion on roadways.
- In addition, an AV has less reaction time which can also reduce delays at the signalized intersections.

Table 2 AV (CoEXist) Definitions

<table>
<thead>
<tr>
<th>Definition under CoEXist project</th>
<th>AV Cautious:</th>
<th>AV Normal:</th>
<th>AV All-knowing:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✚ Big gaps ✚ Cautious behavior</td>
<td>✚ Gaps similar to human drivers but with higher safety</td>
<td>✚ Smaller gaps but still safe</td>
<td>✚ Cooperative behavior</td>
</tr>
</tbody>
</table>

Fig.3 Simulation network model in Vissim
Fig.4 Simulation for scenario 1 in Vissim

Table 3 Results Summary

<table>
<thead>
<tr>
<th>Network performance measures of effectiveness (MOEs)</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4</th>
<th>Scenario 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Queue Delay (sec) [%]</td>
<td>0%</td>
<td>-4%</td>
<td>10%</td>
<td>-7%</td>
<td>-12%</td>
</tr>
<tr>
<td>Average Stopped Delay (sec) [%]</td>
<td>0%</td>
<td>-8%</td>
<td>14%</td>
<td>-13%</td>
<td>-17%</td>
</tr>
<tr>
<td>Average Vehicle Travel Time (sec) [%]</td>
<td>0%</td>
<td>-4%</td>
<td>-1%</td>
<td>-9%</td>
<td>-17%</td>
</tr>
<tr>
<td>Average Queue Length (ft) [%]</td>
<td>0%</td>
<td>-11%</td>
<td>17%</td>
<td>-15%</td>
<td>-22%</td>
</tr>
</tbody>
</table>

Fig.5 Average Queue Delay at the Intersection
Fig.6 Average Stopped Delay at the Intersection
Fig.7 Average Vehicle Travel Time at the Intersection
Fig.8 Average Queue Length at the Intersection

Conclusion
- AVs can decrease the queue delay (7% - 12%), the stopped delay (13% - 17%), the vehicle travel time (9% - 17%), also the queue length will dropped by (15% - 22%).
- Therefore, traffic congestion at the signalized intersection will be decreasing as well.