OPTIMIZING ISOLATED TRAFFIC SIGNAL TIMING CONSIDERING ENERGY AND ENVIRONMENTAL IMPACTS

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Background and Introduction

• Traffic signal timings are usually optimized to minimize vehicle delay and stops.
• However, environmental effects should be considered because signalized intersections are locations of excessive fuel consumptions and tailpipe emissions.
• OBJECTIVE: Develop an analytical formulation to approximate an optimum cycle length that minimizes delay, fuel consumption, and tailpipe emissions.

Signal Timing Optimization - Methodology

• INTEGRATION – delay, fuel consumption, and tailpipe emissions estimates by traffic simulations over different range of scenarios
• Assumptions and Scenarios:
  o Straight movements only
  o Approach speeds of 56 km/h or 35 mph
  o Base saturation flow rate of 1800 veh/h/ln
  o Jam density for all approaches of 167 veh/km/ln
  o Lengths of links = 1000 meters
  o Cycle Lengths – 30 to 180 seconds at 10 second increments.
  o Lost time varied by yellow and all-red times (3 to 7 seconds at 0.5 second increments).
  o Traffic demand generated to be totally random
  o Speed variability coefficient of 10 percent

Results and Conclusions

• Webster calibration – model parameters, 0.33 and 8.56, are comparable with Webster formulation parameters (1.50 and 5.00).
• Lower demand levels yielded similar optimum cycle length to Webster formulation.
• Cycle lengths for minimum fuel consumption and emissions are longer than the optimum cycle length to minimize delay.
• Webster formulation will overestimate the optimum cycle length to minimize delay.
• Future studies will consider four, eight, and multiphase simulations, along with different signal controls and vehicle demands, to determine if a more general formulation exists.

Table 1. Regression Results for Model

<table>
<thead>
<tr>
<th>MOE</th>
<th>R²</th>
<th>Estimated α</th>
<th>T-Value α</th>
<th>Estimated β</th>
<th>T-Value β</th>
<th>Estimated γ</th>
<th>T-Value γ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay</td>
<td>0.95</td>
<td>0.25</td>
<td>4.35 (0.05)</td>
<td>8.56</td>
<td>10.38 (0.05)</td>
<td>3.8</td>
<td>2.76 (0.05)</td>
</tr>
<tr>
<td>Fuel</td>
<td>0.24</td>
<td>0.02</td>
<td>3.27 (0.03)</td>
<td>0.49</td>
<td>0.13 (0.83)</td>
<td>40</td>
<td>8.83 (0.03)</td>
</tr>
<tr>
<td>CO₂</td>
<td>0.35</td>
<td>0.27</td>
<td>1.97 (0.05)</td>
<td>3.41</td>
<td>5.65 (0.05)</td>
<td>24</td>
<td>9.66 (0.03)</td>
</tr>
</tbody>
</table>

Acknowledgements

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