Micro-Simulation Based Framework for Freeway Travel-Time Forecasting

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Overview
This project presents a micro-simulation based framework to generate short-term travel-time forecasts on freeway corridors. A micro-simulation model was developed that replicated freeway capacity drop and relaxation phenomena critical for modeling non-steady state conditions. An origin destination flow estimation algorithm was also developed that was utilized to generate input for the micro-simulation model. This framework was evaluated offline on a real-world freeway corridor using Georgia DOT’s video detection system data and manual counts. The travel-time forecasts were compared with the ground truth travel-time data which demonstrated the efficacy of this framework to produce realistic forecasts.

Methodology

![ALGORITHM]

ALGORITHM
1. Let a new simulation be initiated (with new OD) at time $t = h, 2h, 3h, ... nh$ with prediction horizons $r, 2r, 3r, ... mr$ where $n, h, m, r$ and $p$ are integers.
2. Therefore, at any time $t = ph$, travel-time predictions are made for $t = ph + r, ph + 2r, ph + 3r, ... ph + mr$
3. For each simulation run perform the following steps:
   • Calculate initial queue at the beginning of the simulation using the traffic sensor speed and flow data.
   • Calculate OD matrix using the travel-time predictions for each origin - destination pair in the previous simulation run.
4. Run the simulation for sufficient duration to obtain vehicle trajectories. Process vehicle trajectories to make travel-time predictions for different prediction horizons
5. Repeat step 3 for each simulation run

Data Collection

- 6.5 miles long
- 5 origins and 8 destinations
- 13 PTZ cameras recorded the boundaries
- Traffic volumes manually extracted
- Bluetooth timestamps collected from overpasses

Results

- Instantaneous Travel Time (ITT) and Reactive Travel Time (RTT) estimates follow the same pattern as Actual Travel Time (ATT)
- Difference between ATT and ITT is around 3 minutes
- Percent change as much as 45%

<table>
<thead>
<tr>
<th>Travel Time Data Source</th>
<th>RMSE (mins)</th>
<th>MAPE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st prediction</td>
<td>1.04</td>
<td>6.79%</td>
</tr>
<tr>
<td>2nd prediction</td>
<td>1.28</td>
<td>7.37%</td>
</tr>
<tr>
<td>3rd prediction</td>
<td>1.58</td>
<td>8.35%</td>
</tr>
<tr>
<td>ITT</td>
<td>1.56</td>
<td>10.64%</td>
</tr>
</tbody>
</table>

- RMSE and MAPE values for 5-min and 10-min predictions are better than ITT estimates

Summary

- Proof of concept successful
- Required accurate counts (manual)
- Short-term travel-time predictions better
- Current framework not fully exploited yet
- Strength of predictive framework highlighted under:
  • Long corridors
  • Incidents
  • Onset and dissipation of Congestion

This research was sponsored by the Georgia Department of Transportation under contracts 10-03. Opinions expressed here are those of the authors and not necessarily those of the Georgia Department of Transportation.