Micro-Simulation Based Framework for Freeway Travel-Time Forecasting

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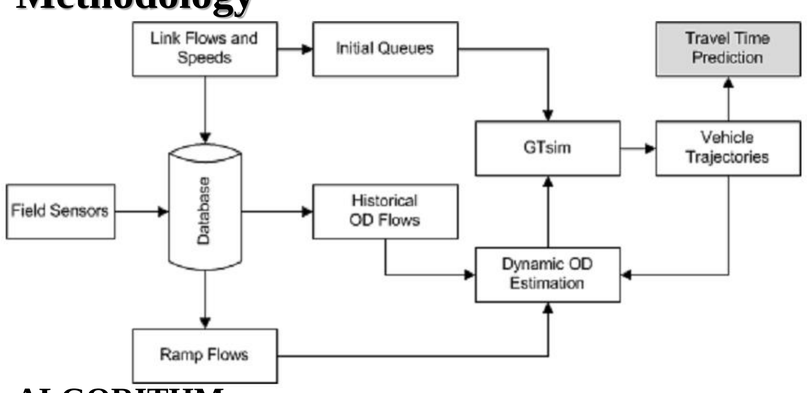
Overview

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.

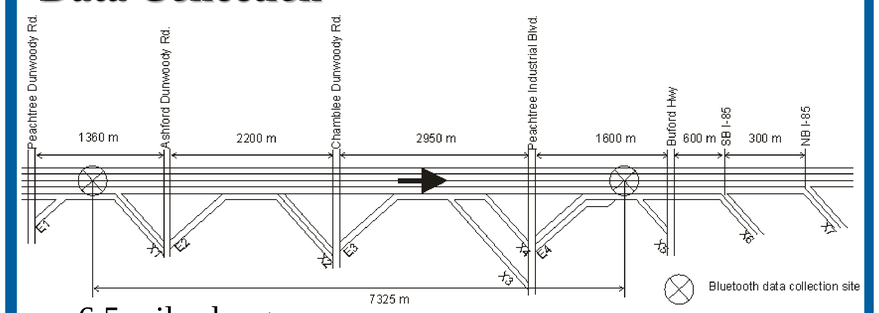
Methodology



ALGORITHM

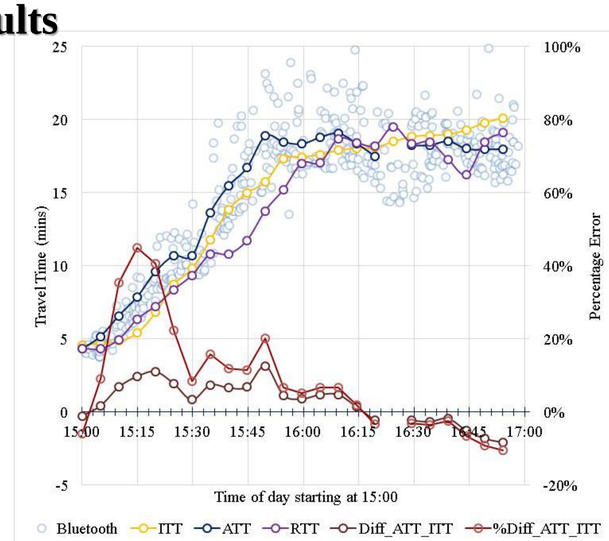
1. Let a new simulation be initiated (with new OD) at time t = h, 2h, 3h,..ph…nh with prediction horizons r, 2r, 3r,…mr where n, h, m, r and p are integers.
2. Therefore, at any time t = ph, travel-time predictions are made for t = ph+r, ph+2r, ph+3r,….ph+mr
3. For each simulation run perform the following 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

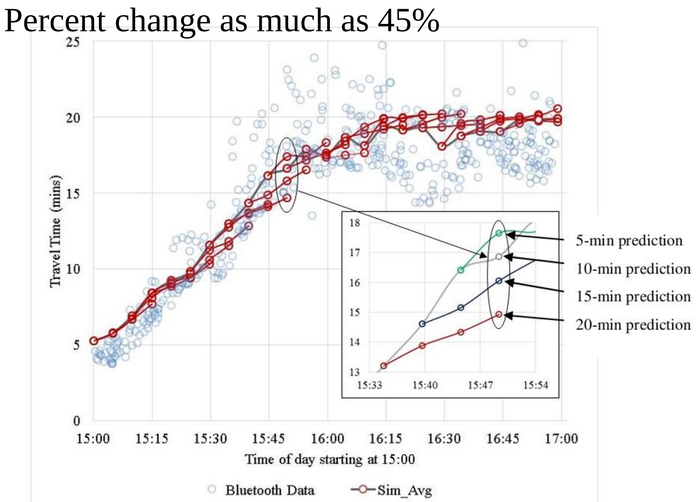


- 6.5 miles long
- 5 origins and 8 destinations
- 13 PTZ cameras recorded the boundaries
- Traffic volumes manually extracted
- Bluetooth timestamps collected from overpasses

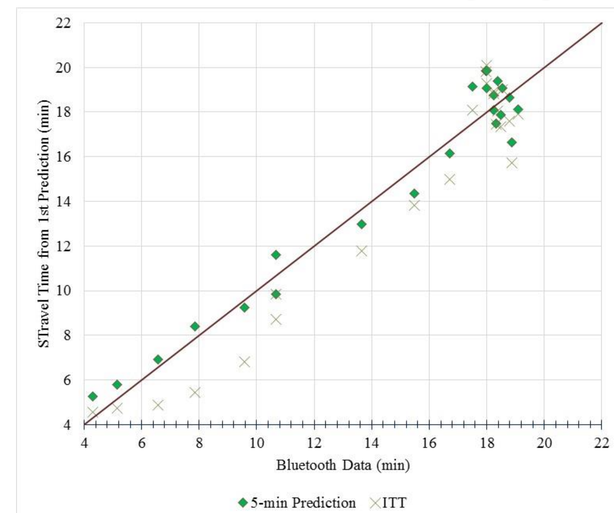
Results



- 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%



- For robustness of prediction use of at least 100 vehicles for obtaining average travel time
- Forecasts estimate longer travel-times during onset of congestion
- Forecasts estimates flatten out during congestion



- ITT and RTT estimates follow the same pattern as ATT
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Travel time data source	RMSE (mins)	MAPE (%)
1st prediction	1.04	6.79%
2nd prediction	1.28	7.37%
3rd prediction	1.58	8.35%
ITT	1.56	10.64%

- 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

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