Network-Scale Ubiquitous Volume Estimation Using Tree-Based Ensemble Learning Methods

A PIONEERING PROJECT

The University of Maryland and NREL recognize that the success of this project is critical to broader national initiatives that require quality data to operate and model the transportation system with the goal of optimizing it for safety, mobility, and energy efficiency.

GOAL

Ubiquitous network observability

Best alternative

WHY DO WE NEED UBIQUEOUS VOLUME?

Utilize and fuse existing "sparse" data to predict traffic volumes on each and every link of the road network.

PROPOSED SOLUTIONS

DATA

- Data sources
  - Colorado Department of Transportation
  - TomTom
  - Federal Highway Administration’s Travel Monitoring Analysis System
  - Weather Underground
- February 1, 2017 – April 30, 2017
- A total of 14 automated traffic controller locations with 52,092 data points

MODEL EVALUATION CRITERIA

- Mean Absolute Percentage Error: \( MAPE = \frac{1}{N} \sum_{i=1}^{N} \left| \frac{V_i - \hat{V}_i}{V_i} \right| \)
- Error to Theoretical Capacity Ratio: \( ETCR = \frac{1}{N} \sum_{i=1}^{N} \frac{|V_i - \hat{V}_i|}{C_i} \)
- Coefficient of Determination: \( R^2 = 1 - \frac{|V_i - \hat{V}_i|^2}{|V_i - \bar{V}_i|^2} \)

MODEL RESULTS

<table>
<thead>
<tr>
<th>Model</th>
<th>Overall MAPE</th>
<th>Overall ETCR</th>
<th>Median R²</th>
<th>Training Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF</td>
<td>11.1%</td>
<td>0.2%</td>
<td>0.82</td>
<td>71s</td>
</tr>
<tr>
<td>GBM</td>
<td>16.3%</td>
<td>4.8%</td>
<td>0.83</td>
<td>126s</td>
</tr>
<tr>
<td>XGBoost</td>
<td>11.7%</td>
<td>0.3%</td>
<td>0.91</td>
<td>15s</td>
</tr>
</tbody>
</table>

MODEL COMPARISON

- \( MAPE \leq 10\% \) reduction
- \( ETCR \leq 30\% \) reduction
- \( R^2 \geq 0.9 \) increase

PROJECT VALUE

- Comprehensive special event management with the ability to monitor real-time traffic
- Improve traffic signal system timing management, enabling more cost-effective, timely, and accurate updates to signal timing plans
- More complete after-action reviews
- Better problem identification, root cause analysis, and project development
- More accurate system performance evaluation
- Enhance project/multiyear performance
- Improve traveler demand modeling accuracy
- Better address air quality and emissions requirements, enabling more accurate transportation energy analysis

CONTRIBUTION OF PROBE DATA

<table>
<thead>
<tr>
<th></th>
<th>Overall MAPE</th>
<th>Overall ETCR</th>
<th>Median R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Probe Data</td>
<td>20.1%</td>
<td>5.3%</td>
<td>0.89</td>
</tr>
<tr>
<td>With Probe Data</td>
<td>13.5%</td>
<td>0.3%</td>
<td>0.81</td>
</tr>
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Acknowledgements

This work was funded by the I-95 Corridor Coalition.