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SHORT-TERM TRUCK TRAVEL TIME ESTIMATION USING A ROBUST HYBRID MODEL

1. Motivation

- Travel time is the key factor for many traffic management and intelligent transportation systems, as well as being the key to understanding the mobility performance measures.
- Travel time is the best indicator of the road transportation system condition.
- Efficient and reliable freight movement is a critical aspect to US economy.
- Accurate travel time estimation for commercial trucks is important for freight scheduling and operations.
- Accurate truck travel time can bring supportive information for both private and public agencies.
- Freight travel time is becoming increasingly important for state’s Department of Transportation (DOT). DOTs can use freight travel time to estimate truck mobility performance measures such as truck travel time index, delay, and buffer time.

2. Objectives

- Developing a new hybrid model to estimate truck travel time for regions where truck data is limited or is not available.
- Estimating truck travel time based on indirect travel time from loop detectors and historical truck travel time.
- The structure of the hybrid model will allow us to incorporate other data sources than loop detectors, which makes the model transferable to other application.
- Increasing the robustness of the estimation by incorporating prior knowledge.

3. Backgrounds

- Recent emerging technologies, such as mobile phones and vehicles with Global Positioning Systems (GPS), offer encouraging enhancement in providing traffic travel time information. The data collected from these new technologies are commonly known as the probe vehicle data.
- Many truck companies have their own GPS-based travel time data to track their commercial vehicles. The truck companies are less willing to share their information due to privacy issues.
- Fused data have lots of advantages compared to data from only one source. Using fused data will increase the estimation robustness. Also, the spatial coverage of data from multiple sources is more than using single data sources.

4. Methodology

To verify the effectiveness of the proposed hybrid model, the traffic data collected on Interstate 10 (I-10), Arizona was used in this study. The Eastbound direction on the corridor was selected for three reasons:
- It has recurring congestion during morning and afternoon peak hours.
- Non-recurring congestion happens frequently due to high volume traffic leaving the Phoenix central business district (CBD).
- Two types of data, the loop detector data and probe vehicle data, can be collected concurrently.

Two types of data are used in the proposed hybrid model:

- Probe-Vehicle-Based Travel Time: The National Performance Management Research Dataset (NPMRDS) is provided by FHWA. This dataset provides vehicle probe-based travel time data for vehicles and trucks separately. The travel time information is broadcast by Traffic Message channels (TMCs). The TMCs are located approximately on average one TMC per mile in urban areas.

The proposed hybrid model consists of two different modules. The first module is the estimation module, and the second is the prior knowledge module. The estimation task is handled in the first module with the help of recursive least square (RLS) filter. The prior knowledge module is incorporated to increase the estimation accuracy while facing anomalies in the data. Maximum a posterior estimator is used in the second module.

5. Study Site and Data

The proposed hybrid model was tested and validated on Interstate 10, MP 150 to MP 155. The study site was selected due to the high latitude (urban areas) and the presence of TMCs.

The proposed hybrid model was validated on 20 days during April 11-20, 2014. A total of 102 traffic records from the NPMRDS were used to validate the model. The data were collected from Loop Detectors located on Interstate 10.

6. Experimental Results

Calibrating Initial Model Coefficients

The performance of the RLS algorithm is closely associated with the initial values chosen for the model. To illustrate the importance of initial values, the model is run for 100 times to obtain the estimation error.

Model Performance

The trained and validated hybrid model was used to estimate average peak hour truck travel time for April 11-20, 2014. The model was tested using traffic data from Loop Detectors located on Interstate 10. The results showed that the proposed hybrid model was able to estimate the average peak hour truck travel time with high accuracy.

Model Robustness

To show the effectiveness of the proposed hybrid model, the truck travel time was compared to the real truck travel time calculated from probe-vehicle data. The proposed hybrid model was able to estimate the average peak hour truck travel time with high accuracy.

7. Conclusion

- The truck travel time is estimated by fusing indirect travel time from loop detectors and historical truck travel time from NPMRDS.
- The proposed method can be beneficial in cases when truck data is limited or unavailable. Also, since prior knowledge is incorporated to the hybrid model, the model robustness and reliability is improved compared to other estimator filters.
- The model shows approximately 8.7 percent error while estimating truck travel time.
- The robustness of the proposed model is compared with a simple estimation filter. The proposed model showed 3% more accuracy while estimating truck travel time in case there exist anomalies in the database.