Exploring and Modeling Truck Tours and Their Associated Stop Locations: Towards A Micro-Simulation Approach

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Introduction

The continuous growth in freight transportation activities in recent years has led to an increased interest in studying freight movement and predicting future freight demand. To date, the majority of freight demand models are either too aggregate in nature or still under developed to be included in advanced agent-based microsimulation transportation modeling systems (Mladenovic and Trifunovic 2014). This is a problem given the fact that freight activities represent a significant portion of the observed daily traffic on the transportation network. The lack of adequate data and the diversity of carries that interact in the shipping operations have curtailed the progress of developing advanced freight demand forecasting models. In general, freight travel activities are more complicated when compared to personal travel activities in both theoretical and simulation modeling analyses Jansuwan et al. (2017). Advanced freight demand modeling requires disaggregate data to understand on-ground activities and effectively predict future freight travel demand.

When dealing with truck movements at the micro-level, it is important to analyze tours as opposed to trips. Truck tours represent a chain of travel activities in which a truck starts from an establishment and then makes several stops—including stops to pick up/deliver goods, refuel, or rest—before returning back to the establishment. We contend that the analysis of truck tours within a microsimulation framework will provide a more realistic picture of the true process governing the movement of trucks. The objective of this paper is to develop truck stop destination models within a tour-based microsimulation framework. Truck tours for the month of March 2016 are derived from a large sample of GPS truck dataset. The paper will highlight the work conducted to process the tours in ArcGIS and to model the location of the stops associated with the derived tours.

Methodology

The devised truck tour-based microsimulation modeling framework is highlighted in Figure 1. The framework consists of the following three integrated Modules for generating full truck tours for individual establishments and associated trucks: (1) Tour Generation Module, (2) Tour Time Module, and (3) Tour Stop Module.

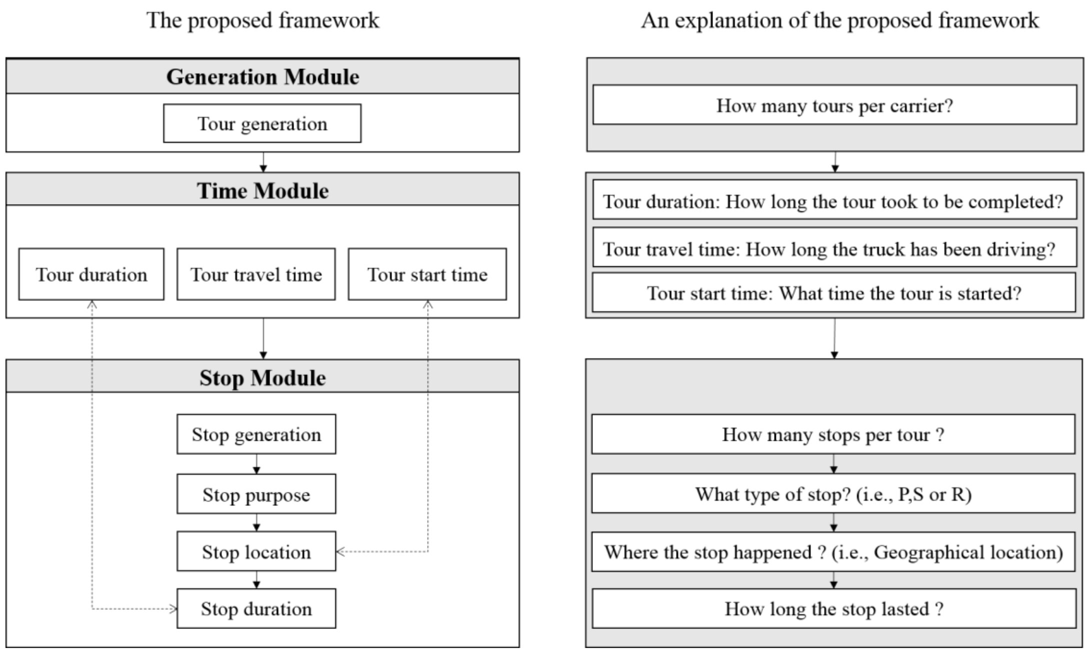

Figure 1: Modeling Framework of Proposed Tour-Based Microsimulation Model

The proposed framework starts by determining the number of tours per carrier or establishment. Once the number of tours has been determined for each establishment, the second module (i.e. time module) is engaged. Within this module a total of three models are proposed: a tour duration model, a tour travel time model and a tour start time model. The tour duration model will be used to determine the length of the tour from start to end in minutes. A tour travel time model will also be used to predict the total time spend for driving. This part represents the service area covered by the tour and will become instrumental in the tour stop location model. Finally, within the second module, a tour start time model will be used to predict the start time of the tour.

This could be done following a similar approach to the one used in Hunt and Stefan (2007). The third module of the framework is concerned with the stops comprising the tours. Within this module, the stop generation component can be modeled as in Gingerich et al. (2015). That is, an ordered logit model can be used to predict the number of stops per tour (i.e. 1-stop, 2-stops, 3-stops, etc.). Upon determining the number of stops per tour, the type of the generated stops can be predicted using a multinomial logit model. Such model, as shown by Gingerich et al. (2015), predicts the probability of the stop being a primary, secondary or return to establishment.

Next, a stop location model is proposed and will be developed as part of the research presented in this paper to predict the location of the stops associated with the generated tours. Given the predicted information from the previous two steps and the travel time associated with the truck making the tour from the second module, a list of potential stops from the universe of all stops of a particular type in the study area will be selected and used to form the choice set for possible destinations. Tours will be classified as 1-stop, 2-stop, 3-stop or 4 or more-stop tours.

Finally, the last component in the third module of the microsimulation framework is a stop duration model, which is used to predict the length of each stop made by the truck within the tour.

Results

Work is currently underway to develop a number of multinomial logit models for the different classes of tours. These models will be used to predict the destination location of truck stops. For instance, if a given tour is a 4-stop tour with the first two stops being primary, the third being secondary and the fourth being a return, the framework will engage a MNL model for primary stops (MNL-P) to determine the location of the first primary stops based on the formulated choice set. Next, another MNL-P will be engaged to determine the location of the second primary stop taking into consideration certain information about the first primary stop (e.g. location, stop duration, etc.). This is followed by engaging a third MNL for the secondary stop (MNL-S) to determine the location of the stop based on the list of potential secondary stops within the determined service area. The main findings from the modeling work are expected to allow us to unravel the significant factors that impact the location choice decision of heavy trucks on the road network system in Southern Ontario, Canada.

The work is based on truck tours that were derived from a large truck GPS dataset, which depicts the movement of Canadian trucks during the month of March 2016. The tours derived from the GPS records were further analyzed and the tours originating from the Peel region in Ontario were considered in the modeling exercise. The Peel region was chosen given it had the highest volume of generated tours across Ontario. Besides the statistical modeling results, the paper will also feature the geo-spatial characteristics of the tours dervived from the GPS dataset.

Conclusion

The obtained geospatial and statistical results from the conducted analysis in this paper will form the basis for developing a more comprehensive understanding of freight movement processes. The obtained models will be incorporated in the modeling framework highlighted above as they will be used to predict the destination of truck tour stops at the micro-level. The contribution of the work from this paper is twofold: (1) the geo-spatial characteristics of a large sample of truck tours from the Peel region will be highlighted for the first time, (2) the statistical analysis will form the basis for a novel truck tour microsimulation framework that is built with data derived from passive truck GPS data.

References

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