Performance Evaluation of Choice Set Generation Algorithms for Modeling Truck Route Choice: Insights from Large Streams of GPS Data

Divyakant Tahlyan[a] and Abdul R. Pinjari[b]

[a]University of South Florida [b]Indian Institute of Science

Motivation

- Route choice set generation is an essential precursor to route choice modeling within the discrete choice modeling framework.
- Availability of large streams of GPS data provides a opportunity to evaluate the performance of route choice set generation algorithms in a better way.
- With ability to observe multiple trips between same OD pair, researchers can now essentially observe the travelers' consideration set, provided a sufficiently large number of trips are observed.
- With the help of observed consideration set, it is possible to compare the routes generated by a choice set generation algorithm with the observed routes to evaluate the performance of a choice set generation algorithms.

Objectives

- Evaluate the performance of breadth-first-search link elimination (BFS-LE) route choice set generation algorithm using large streams of truck GPS data.
- Derive guidance on using BFS-LE approach to maximize generation of relevant routes for modeling freight truck route choice.

Data

Truck GPS data by ATRI; 96 million records; 110,000 trucks spanning over 60 days temporally and 6 counties of Florida spatially.

↓

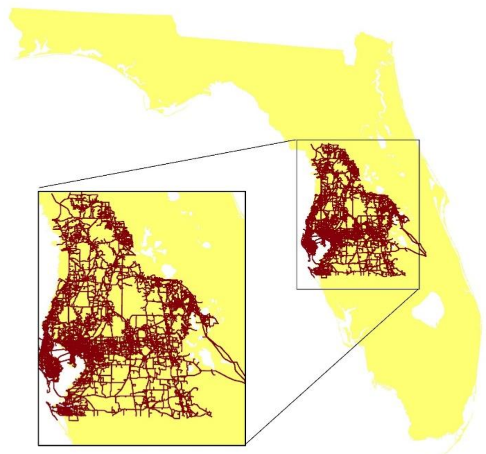
Raw GPS data processed to detect stops made by trucks to derive trips ends.

↓

Derived trips map-matched to road network to derive 228,000 travelled routes.

↓

Random sample of trips manually validated to check the quality of derived routes.



A snap-shot of the routes derived from truck-GPS data

Evaluation Design

Route Choice Set Generation

- BFS-LE approach used to generate choice set and for evaluation purpose.
- In BFS-LE, repeated least cost (free-flow travel time in this study) path search is done after removal of links from current shortest path, one by one.
- Search is stopped after either all routes are found, or a pre-defined time threshold is reached or a pre-defined number of routes are found.
- As travelers might not consider extremely similar routes as distinct, only routes that were at least 5 % dissimilar to each other were considered to be a part of the choice set for an OD pair.

Spatial aggregation and minimum number of trips to be observed

- Four types of spatial aggregation levels used to define OD pairs.
  - **Link Level:** ODs were defined based upon first and last link of the routes. Routes with same first link were assumed to have same origin and routes with same destination were assumed to have same destination.
  - **XY-Level:** ODs were defined by rounding off the XY coordinates of the trip ends of the routes to two decimal places. This roughly corresponds to spatial units of 1 km^2.
  - **TAZ Level:** ODs were defined using traffic analysis zones of the Florida statewide model (FLSWM). To account for the spurious diversity caused by extremely large TAZs, aggregation was done for TAZs with area 2, 5 and 10 km^2.
  - **Spatial Cluster Level:** To account for spurious diversity caused by large TAZs, TAZs were aggregated using leader clustering technique while preserving the TAZs boundaries.
- As it is important to observe sufficiently large number of trips in an OD pair for uncensored view of the choice set, only OD pairs with 20, 30, 50, 100 observed trips were selected.

Determination of unique routes at each spatial aggregation

- Evaluation was done at a unique route level instead of route level.
- The observed and generated routes at each spatial aggregation level were converted into unique routes using the commonality factor $C_{ij} = l_{ij}/\sqrt{L_i L_j}$, where l_{ij} is the length of shared portion between two routes and L_i and L_j are the lengths of the routes i and j, respectively.

Evaluation Metrics

- **False negative error (ε_n^-):** Proportion of observed unique routes not generated by the choice set generation algorithm.
- **Weighted false negative error (ε_{wn}^-):** Proportion of observed trips (not unique routes) whose observed unique routes are not generated by the choice set generation algorithm.
- **False positive error (ε_n^+):** Proportion of generated unique routes that are not present in the observed unique route set.

Performance Evaluation

- Comparison of error metrics across different combination of spatial aggregation and minimum number of trips.
- Determination of appropriate combination of spatial aggregation and minimum number of trips for unbiased evaluation.
- With data from OD pairs with determined level of spatial aggregation and minimum number of trips, compute error metrics at 0.95, 0.90, 0.85, 0.8 commonality factors to assess how different are the observed unique routes that are not captured at 0.95 commonality factor.
- Comparison of error metrics between determined level of spatial aggregation and link level aggregation, with 5, 10, 15, 20 and no limit on the maximum number of unique routes to be generated at link level aggregation. This is done to determine which is the better approach – generation of large choice set at disaggregate OD pair level or aggregation of small choice sets generated at disaggregated level and then spatially aggregated.
- Estimation of route choice models and application on validation to confirm the above hypothesis.
- Comparison of route attributes of the observed and generated routes to determine systematic differences in relevant and irrelevant routes.

Findings

- Based upon the observed unique routes, only OD pairs with minimum of 50 observed trips were appropriate to have a uncensored view of the consideration set.
- TAZ level aggregation (max. area = 2 km^2) gave the least false negative and weighted false negative error.
- The error metrics decreased significantly as the threshold to compare the observed and generated choice sets was decreased from 0.95 to 0.90 and further to 0.85, and 0.80. This suggested that BFS-LE algorithm is overall performing well to generate relevant routes.
- Comparison of errors for TAZ level aggregation (max. area = 2 km^2) and link level aggregation for different limits on maximum number of routes to generate suggested that TAZ level aggregation with 5 unique routes at link level performs equally as link level aggregation with maximum 15 unique routes.
- This finding was also supported by the estimated route choice models and validation.
- Comparison of observed and generated routes suggested that irrelevant routes are generally longer, have more number of ramps, turns, intersections and involve detours.

Future Work

- Post-processing of choice sets at larger aggregation levels to address irrelevant routes. The process could be simple deterministic removal of irrelevant routes or important probabilistic sampling, which is guided by information from large streams of GPS data.
- Use of observed travel time information on same route on different trips to impute travel time reliability measure and including it in the route choice model.

References

- Rieser-Schüssler N, Balmer M, Axhausen KW. Route choice sets for very high-resolution data. Transportmetrica A: Transport Science. 2013 Oct 1;9(9):825-45.
- Prato, Carlo Giacomo. "Route choice modeling: past, present and future research directions." Journal of choice modelling 2.1 (2009): 65-100.

Acknowledgement

This study was funded by the Florida Department of Transportation (FDOT) District 7 office and the US DOT through the University Transportation Center (UTC) called Center for Advanced Infrastructure and Transportation (CAIT).