Abstract: The Location-Based Social Networking (LBSN) is a location-sensitive service interactively carried out by users with mobile devices to “check-in” with the “venues” reflecting their daily activities. With its increasing popularity and sophistication, the LBSN data have emerged as a new data source for studying urban travel demand. Comparing with traditional Origin-Destination (OD) estimation method such as survey based or traffic count based methods, LBSN data has the potential to provide OD estimates with much higher temporal resolution and much lower cost. In this paper, the Foursquare LBSN data was used to analyze the OD matrix for the urban area near Austin, Texas, USA.

Methodology

Trip Distribution Model

Production: \( P_i = \sum_{j=1}^{77} a_{ij} x_i, \quad i = 1, 2, \ldots, 77 \)

Attraction: \( D_j = \sum_{i=1}^{77} a_{ij} x_j, \quad j = 1, 2, \ldots, 77 \)

Where \( a_{ij} \): Check-ins for venue type \( i \) in origin zone \( j \);
\( x_i \): Check-ins for venue type \( i \) in destination zone \( j \);
\( a_{ij} \): The ratio of trip production to Foursquare check-ins.
\( x_i \): The ratio of trip attraction to Foursquare check-ins.
\( T_{ij} \): Trips made between origin zone \( i \) and destination zone \( j \).

Friction Factor (\( F_{ij} \)) Models

Linear:
\[ F_{ij} = a + b d_{ij} \]  
(2)

Negative exponential:
\[ F_{ij} = e^{-\alpha d_{ij}} \]  
(3)

Gamma:
\[ F_{ij} = a d_{ij}^{-\gamma} \]  
(4)

Where \( \alpha \): A positive scaling factors
\( \gamma \): A parameter of transport friction related to the efficiency of the transport system between two locations, \( \gamma \) is always negative and can affect the distribution of longer trips.
\( d_{ij} \): The Manhattan distance between centroids of TAZ \( i \) and \( j \).

Two-Regime Friction Factor Models for short and long-distance trips.
\[ F_{ij} = \alpha_i I_{ij} + \beta_i d_{ij} \]  
(5)

Where \( I_{ij} \) is an indicator function for a logic clause (\( I_{ij} = 1 \) if the clause is true; otherwise, \( I_{ij} = 0 \)), the superscript \( i \) indicates short-distance route regime and the long-distance route regime.

Data Source and Evaluation Indexes

Foursquare Data: Hourly Checkins updating through Foursquare API

Ground Truth Data: 2010 CAMPO (Capital Area Metropolitan Planning Organization) OD Matrix

Scope and Duration: City of Austin, three weeks (June 11th to July 2nd, 2012)

Trip Purpose: Total Trips, Home-Based Work, Home-based Retail

Numeric Evaluation Index: \( P^s_i \): LBSN predicted trip percentage for trip length category \( i \)

Coincidence Ratio: \( CR_{ij} = \frac{\min(p_{ij}^s, p_{ij}^t)}{\max(p_{ij}^s, p_{ij}^t)} \)


Conclusion

This paper investigates the feasibility of using the Location-Based Social Networking (LBSN) data to analyze the urban travel demand pattern in Austin, TX. The study uses the check-in data from the leading LBSN provider, Foursquare, and the ground truth OD data from CAMPO. Compared with the traditional OD estimation methods, LBSN data have the following benefits: 1) better spatial and temporal coverage, 2) built-in user verification, 3) real-time updating capability, and 4) much lower data collection cost.

A gravity model based method is proposed to estimate the OD matrix based on the Foursquare “check-in” data. To fit the Foursquare data and the travel demand characteristics of the Austin area, a two-regime friction factor model is proposed. The model with the linear friction function for short-distance trips and negative exponential friction function for long-distance trips achieves the best results.

Using the calibrated model, we further investigate the static and dynamic travel demand patterns in Austin. Patterns that can be studied include geographical zonal production and attraction pattern, OD matrix, and bi-hourly patterns. The results are found to be consistent with the travel and activity routines in the Austin area.

Acknowledgement

The authors would like to thank Foursquare® for allowing the research team to obtain data through their developer API and Mr. Kevin Lancaster from Capital Area Metropolitan Planning Organization (CAMPO) for providing the 2010 OD data for this study.