Ranking the City:

The Role of Location-Based Social Networks in Collective Human Mobility Prediction

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Outline

- Introduction
  - Problem Definition
  - Problem Significance
  - Research Objectives
- Data and Methodology
- Results and Discussion
- Conclusion and Future Works

Introduction

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Mobility Prediction - Applications

- Urban planning
- Transportation planning
- Infectious disease epidemiology
- Emergency management
- Location-based services
- … (much more)

Human Mobility - Models

- Gravity Model
- Intervening Opportunities Model (IO) (Stouffer 1940)
- Population Weighted Opportunities Models (PWO) (Yan et al. 2014)
- Radiation Model (Simini et al. 2012)
- Rank-Based Model (Noulas et al. 2012)

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Rank-Based Model - Theory

$$T\downarrow ij = T\downarrow i \, R\downarrow i(j)\uparrow -\gamma \,/ \sum k\neq i\uparrow N \blacksquare R\downarrow i(j)\uparrow -\gamma$$

- $T\downarrow i$: Total trips departing from region i;
- $R\downarrow i(j)$: Number of rank of region j w.r.t. region i;
- γ: An adjustable parameter (to fit the predicted pattern to real conditions)
- N: Total number of regions in the city

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Rank-Based Model - Theory

$$T_{ij} = T_i \, R_i(j)^{-\gamma} / \sum_{k \neq i}^{N} R_i(j)^{-\gamma}$$

- The adjustable parameter γ should be determined using ground truth data.
- Hyman proposes a standard method for calibration of spatial interaction models:

$$E(\gamma) = \left| \sum_i \sum_j T_{ij}(\gamma) r_{ij} \Big/ \sum_i \sum_j T_{ij} \right. \\ \left. (\gamma) - \sum_i \sum_j T_{ij} r_{ij} \Big/ \sum_i \sum_j T_{ij} \right| \\ \rightarrow min$$

Rank-Based Model - Theory

$$T_{ij} = T_i \, R_i(j)^{-\gamma} / \sum_{k \neq i}^{N} R_i(j)^{-\gamma}$$

- The above equation does not guarantee the equality of real and predicted number of trips arriving at destinations (singly-constrained model).
- Furness method is a balancing procedure to overcome this.

Methodology and Datasets

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Rank – The Problem Is!

$$T_{ij} = T_i \, R_i(j)^{-\gamma} / \sum_{k \neq i}^{N} R_i(j)^{-\gamma}$$

- Rank is often considered as rank-distance.
- But with such an assumption, the dynamic characteristics of human mobility will be neglected.
- Moreover, where is the role of humans in the above model?

Rank – Our Point of View

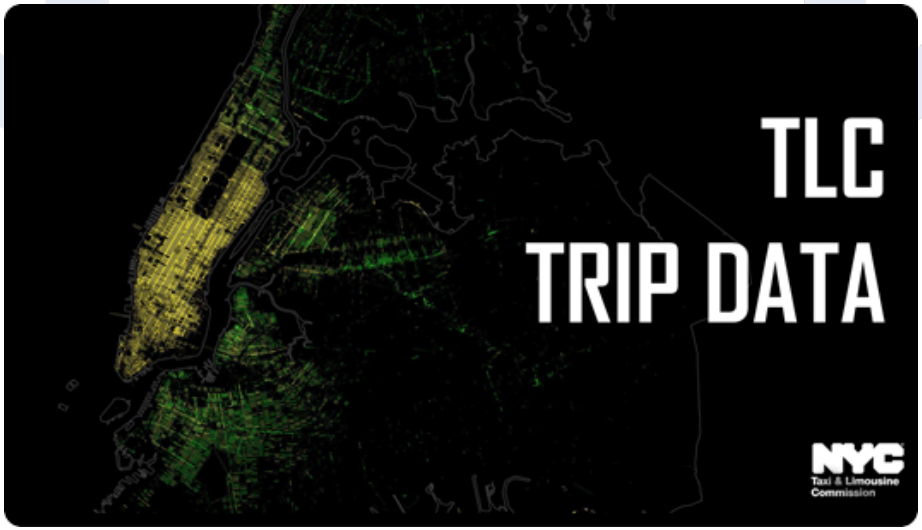
Three concepts for computing the rank were proposed:

1. Rank-distance (common approach);
2. Number of venues located in a circle centered at destination with a radius of r_{ij};
3. Using a check-in weighted rank concept;

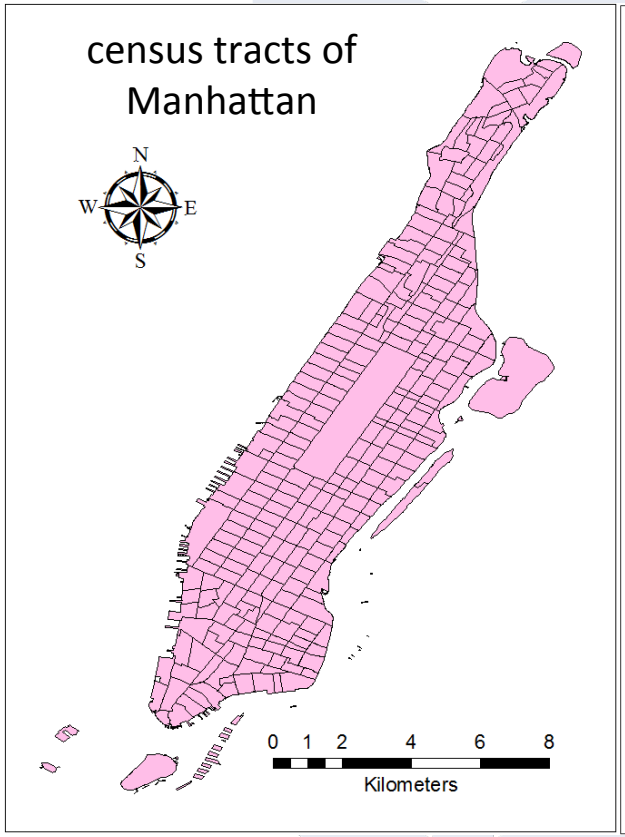
Datasets

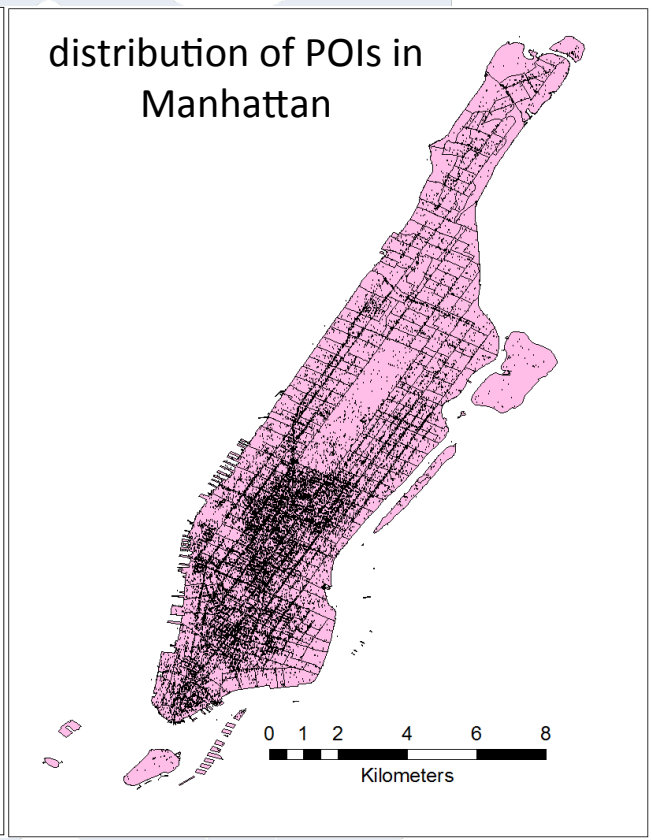
- Foursquare check-in data collected for about 18 months (from the work conducted by Yang et al. (2015))

- Taxi trips data (from NYC Taxi and Limousine Commission)



Study Area – Manhattan, NYC





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Results and Discussion

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Evaluation and Results

$$Sorensen\ Similarity\ Index = 1/N \uparrow 2 \sum i \uparrow N \sum j \uparrow N \frac{2\min(T\downarrow ij\uparrow\prime , T\downarrow ij)}{T\downarrow ij\uparrow\prime + T\downarrow ij}$$

- $T\downarrow ij\uparrow\prime$: number of travels from *i* to *j* predicted by model
- $T\downarrow ij$: observed number of travels
- N: total number of regions in the study area

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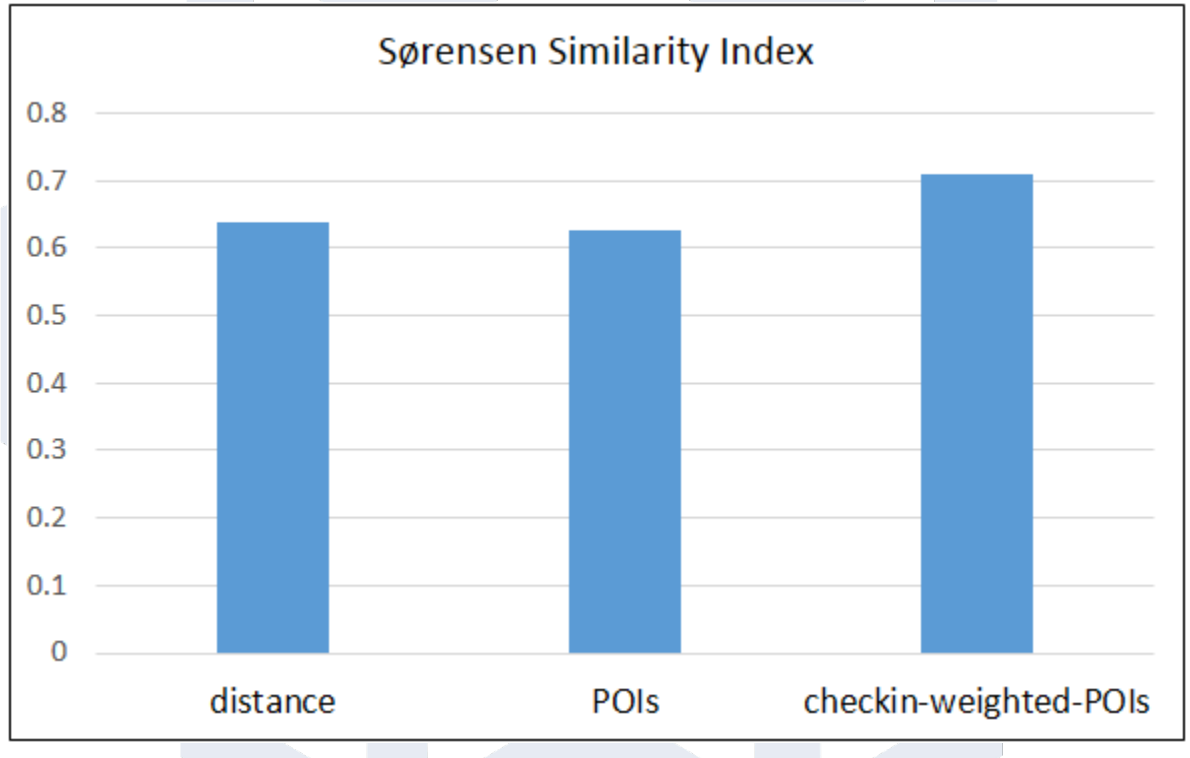
Evaluation and Results



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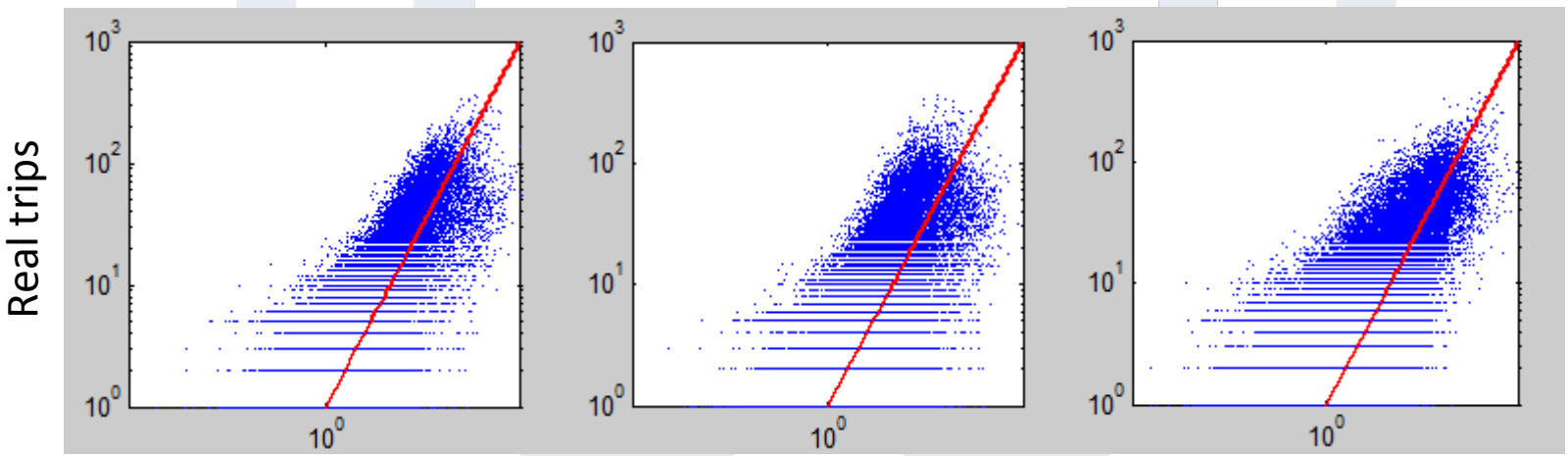
Evaluation and Results

- Identity line indicates the ideal case: if predicted and real number of trips are the same, the point will be located on the identity line.
- The more points that are concentrated about the identity line, the higher the accuracy of predictions has been achieved.

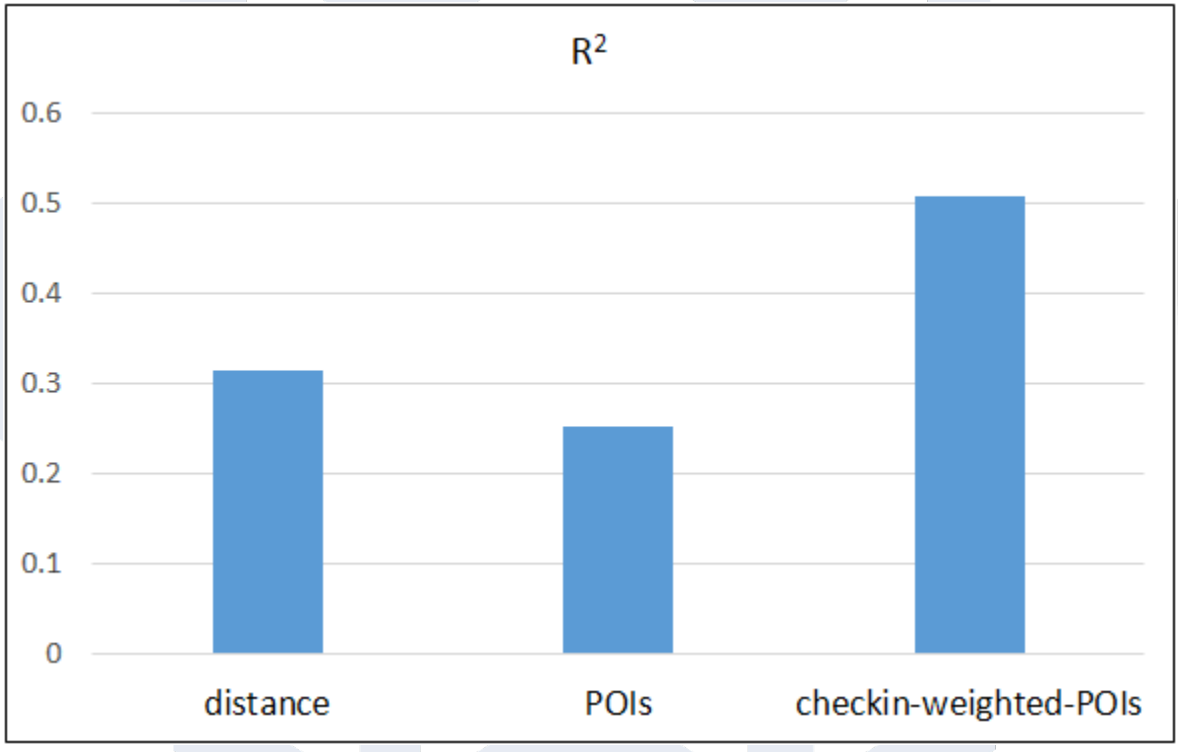


predictions using rank-distance concept

predictions using number of POIs

predictions using check-in weighted POIs

Evaluation and Results



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Conclusions and Future Works

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Conclusions

- Using a rank-distance (more similar to the Gravity model) leads to a slightly more accurate results rather than using just POIs (more similar to the Intervening Opportunities model).
- But, using check-in weighted POIs:
  - ✓ more accurate predictions can be achieved.
  - ✓ results are much more dynamic.
  - ✓ Relative importance of POIs will be preserved.

Limitations and Suggestions

- ✓In the current scenario, ranks are always incremented by 1. That is, the magnitude of differences between regions are not taken into account. Developing a mechanism to consider this issue seems to be advantageous.

- ✓The goal of trips could be extracted from LBSN data (land-use of POIs). The relationships between land-use, mobility, and the goal of trip can be investigated.

Thank you!

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