Spatio-temporal Trajectory-based Estimation of Automobile CO_2 Emissions Using Mobile Phone Positioning Data

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Background

- Seasonal variations of travel behavior and automobile emissions are unclear, as Japan's Road Traffic Census covers only specific days.
- It is difficult for Japanese local governments to validate the immediate efficacy of regional policies as to transportation and land use, since the Census is conducted only every five years.

- It is desirable to develop a new framework to analyze travel behavior and to monitor emissions by using mobile phone positioning data, which have widely become available in recent years.

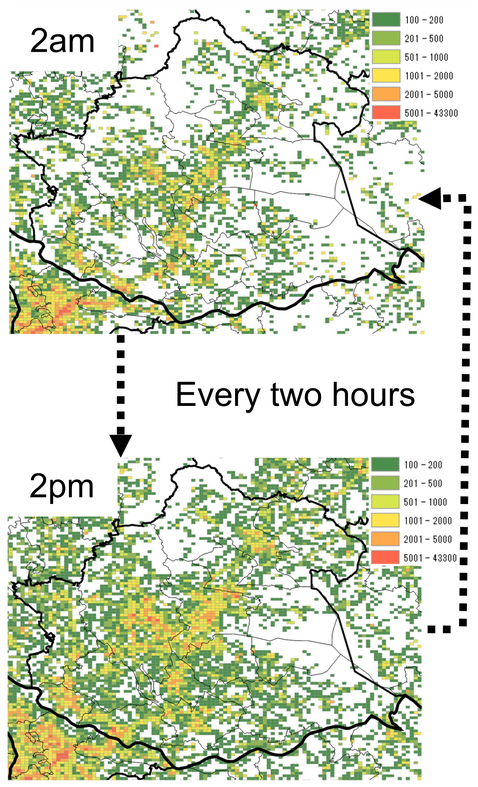
Objective

- To explore a new framework to calculate inner-city automobile emissions by using hourly gridded population data estimated from mobile phone positioning data.

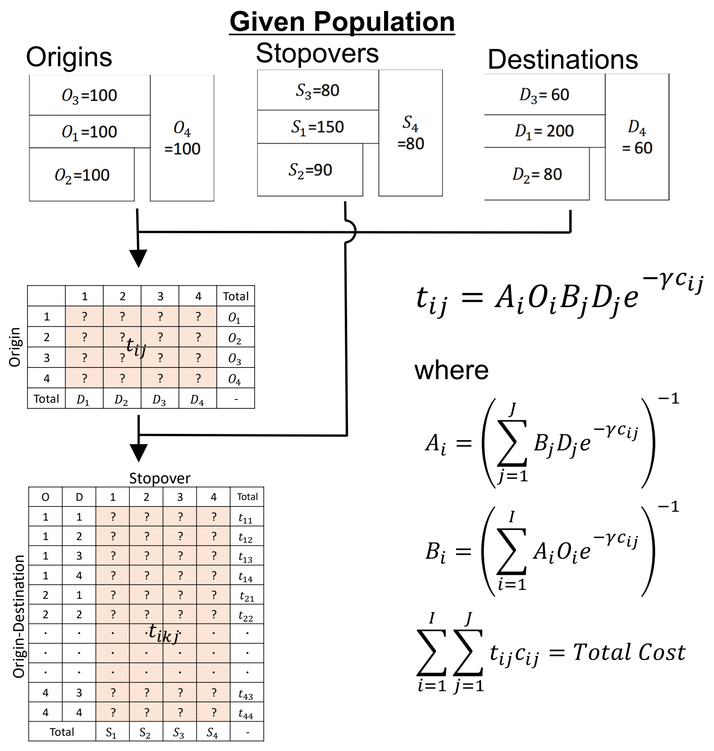
Methodology

- The framework was developed under the assumptions that…
  1. The target region named Tsuchiura is closed off from other regions.
  2. People's trajectories start at their home cell at 2am and end at the same cell 24 hours later.

Floating Population Data
By Agoop Corp. (Softbank)
Tsuchiura Region, 500m x500m cells
Weekdays as of October 2015



Extended Entropy Model



$$t_{ij} = A_i O_i B_j D_j e^{-\gamma c_{ij}}$$

where

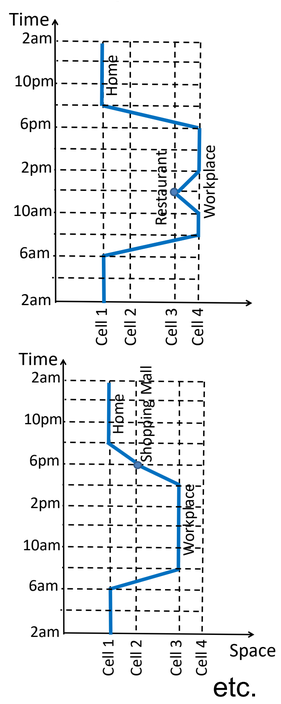
$$A_i = \left(\sum_{j=1}^{J} B_j D_j e^{-\gamma c_{ij}} \right)^{-1}$$

$$B_i = \left(\sum_{i=1}^{I} A_i O_i e^{-\gamma c_{ij}} \right)^{-1}$$

$$\sum_{i=1}^{I} \sum_{j=1}^{J} t_{ij} c_{ij} = Total\ Cost$$

Duplication of Spatio-temporal Trajectories

Duplication of individuals' space-time paths



etc.

Kilometers Traveled by Automobile

Automobile CO_2 Emission

Modal Splits Provided by Online Survey

Unit of Emission
188g-CO_2/(capita・km)

Online survey with Maps APIs

Correction of Positioning data of home and office

Questionnaire on travel behavior
- Transportation modes
- Travel times
- Car ownerships
- Driver License

etc.

Matrix for regions whose population is less than 500,000

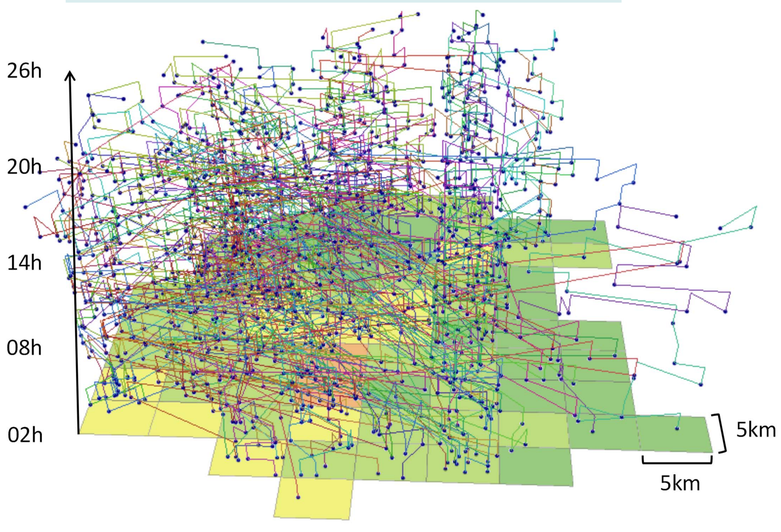
(N=1582)	Commuting Trips		Trips without Commuting
	Office in DID	Office out of DID	
Home in of DID	58.6%	58.3%	69.8%
Home out of DID	57.4%	64.7%	67.3%

Results & Discussion

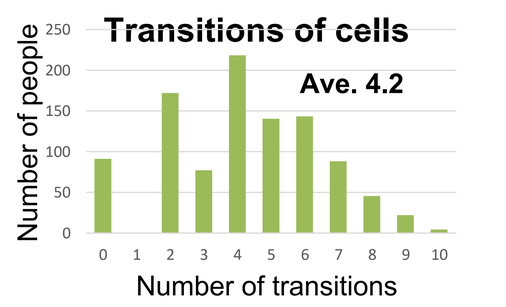
Duplication of Spatio-temporal Trajectories

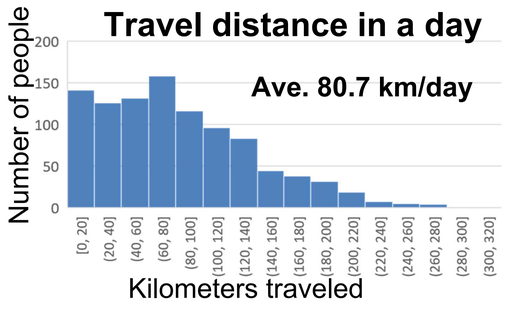
- The model successfully duplicated people's spatio-temporal trajectories, even though it seems that the indexes might be slightly overestimated.

1000 representatives' trajectories



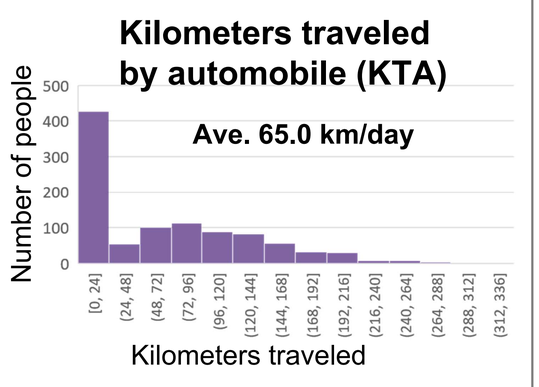
Indexes of the trajectories



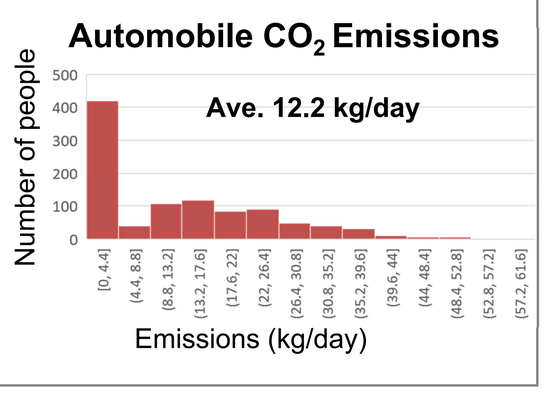


Trajectory-based Estimation of Emissions

- The results showed that a few people travel great distance by automobile (KTA) and emit plenty of CO_2, which rises the averages of KTA and CO_2 emissions.



- The trajectory-based estimation has visualized not only the averages but also the dispersion of KTA and CO_2 emissions.



Conclusion

- This study showed a new comprehensive framework for analysis of people's travel behavior and automobile CO_2 emissions by applying data set of Tsuchiura Region.
- The results revealed that a small number of people play an active role to rise the average of CO_2 emissions.