机器学习时代下的城市交通行为分析

Tao Feng (冯　涛)

Professor, Advanced Science and Engineering, Hiroshima University, Japan

Department of the Built Environment, TU/e

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Tao Feng

Professor

Urban and Data Science

Graduate School of Advanced Science and Engineering

Hiroshima University

Japan

taofeng@hiroshima-u.ac.jp

Guest Professor

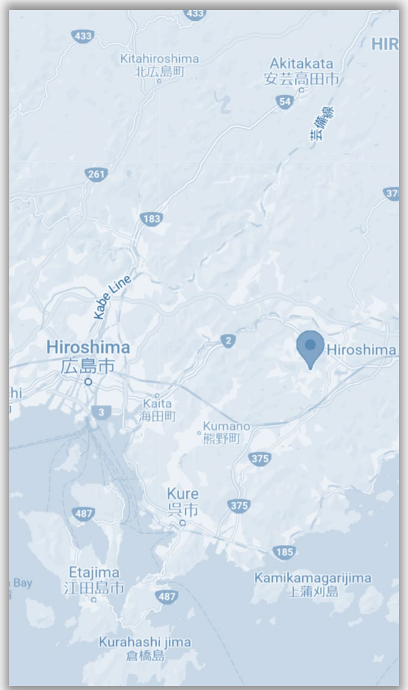
Urban Planning and Transportation

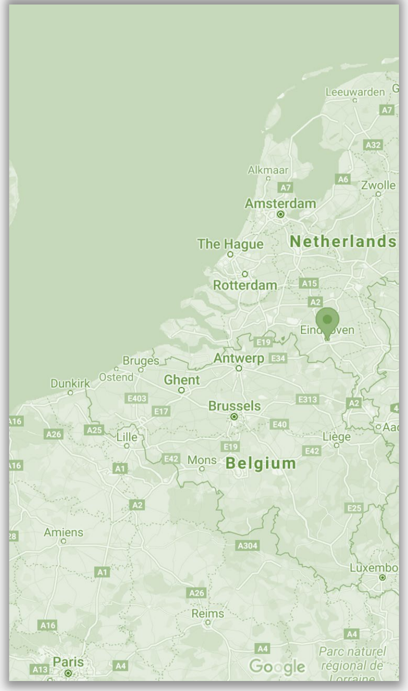
Department of the Built Environment

Eindhoven University of Technology

The Netherlands

t.feng@tue.nl





Research interests

- ✓ Urban planning
- ✓ Smart mobility
- ✓ Travel behaviour
- ✓ Transport network analysis
- ✓ Data driven technology
- ✓ Mobility in built environment
- ✓ Spatial planning
- ✓ Urban environment analysis
- ✓ Decision making in smart energy
- ✓ Big data & machine learning for urban research

https://research.tue.nl/en/persons/tao-feng

*Website of Hiroshima University is under construction.

Contents

Our research

+

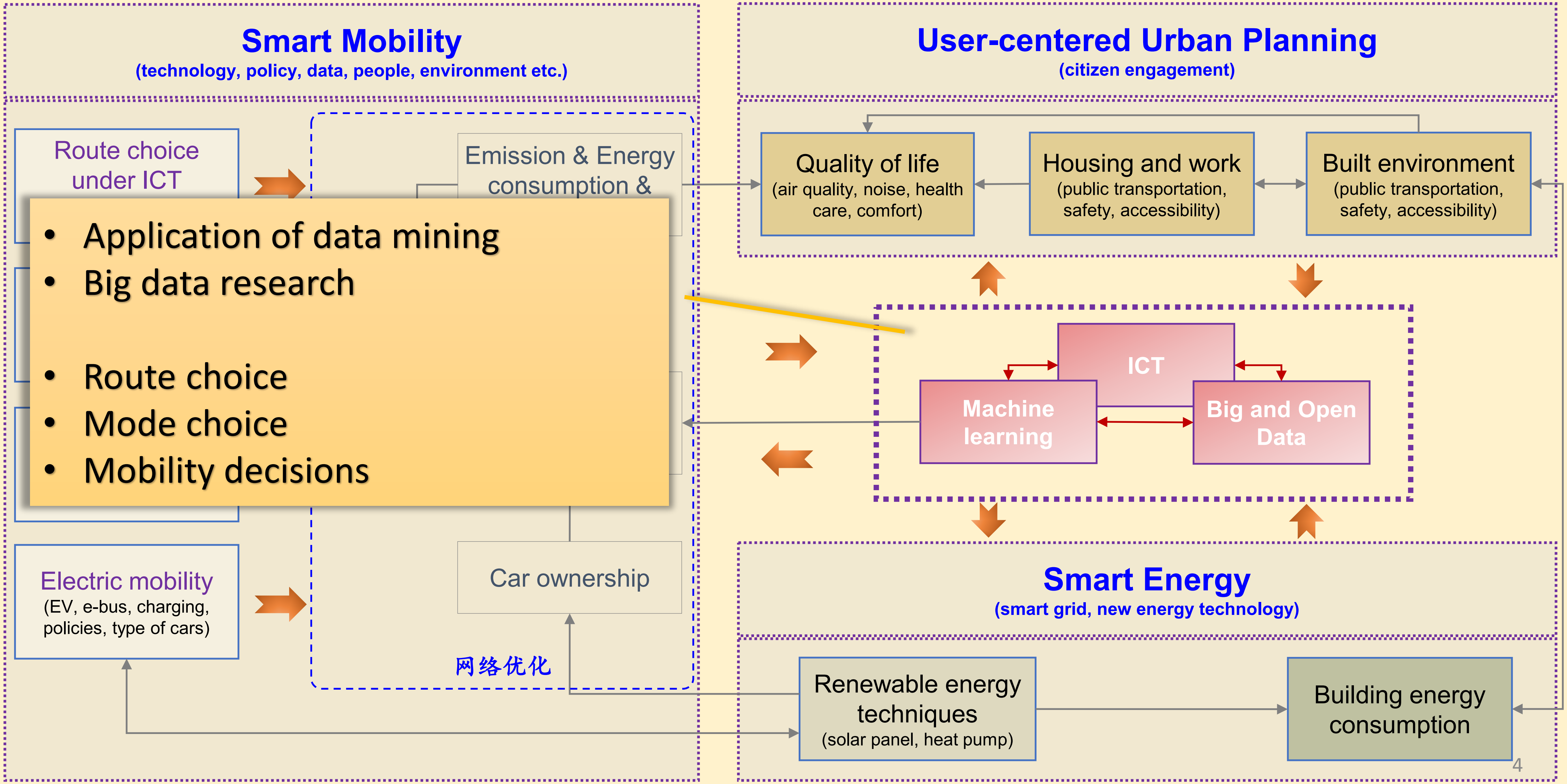
Travel behavior analysis

Mobility decision

+

Data mining & AI

Research topics



- Application of data mining
- Big data research

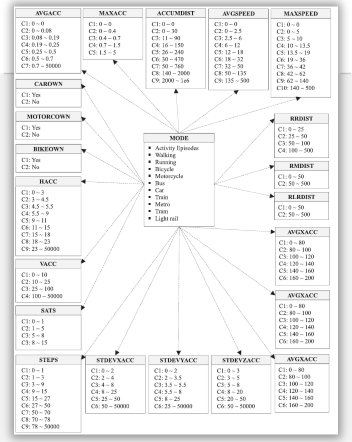
- Route choice
- Mode choice
- Mobility decisions

Data imputation & mining

GPS辅助居民出行调查

Trace Annotator

An integrated data imputation tool



Machine learning algorithms

(Bayesian belief network, support vector machine, decision table, logistic regression, neural networks)

New ICT technology
(loggers, smart phones)

GPS data

Location-based services

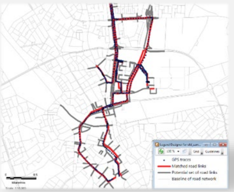
Improved survey methods

Transportation mode recognition

Location-based activity types

Map matching

Energy consumption, emission, distance



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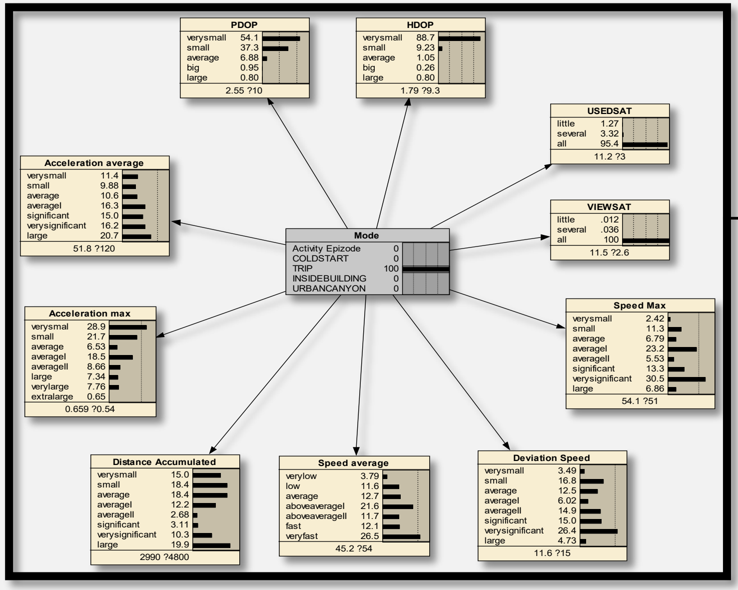
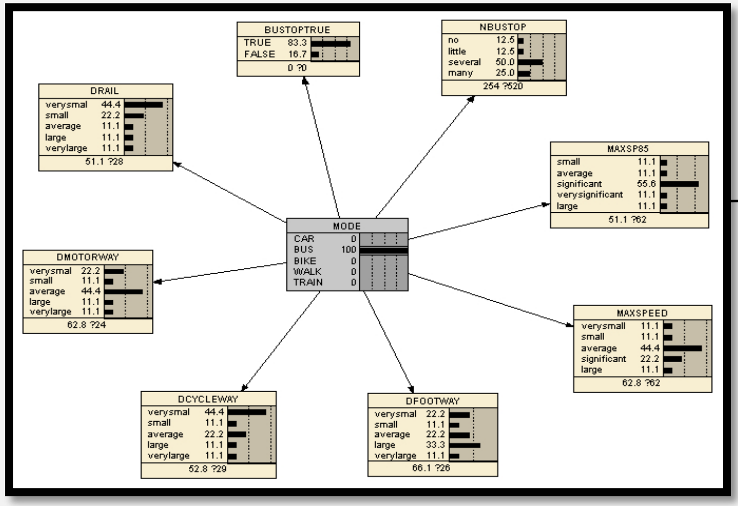
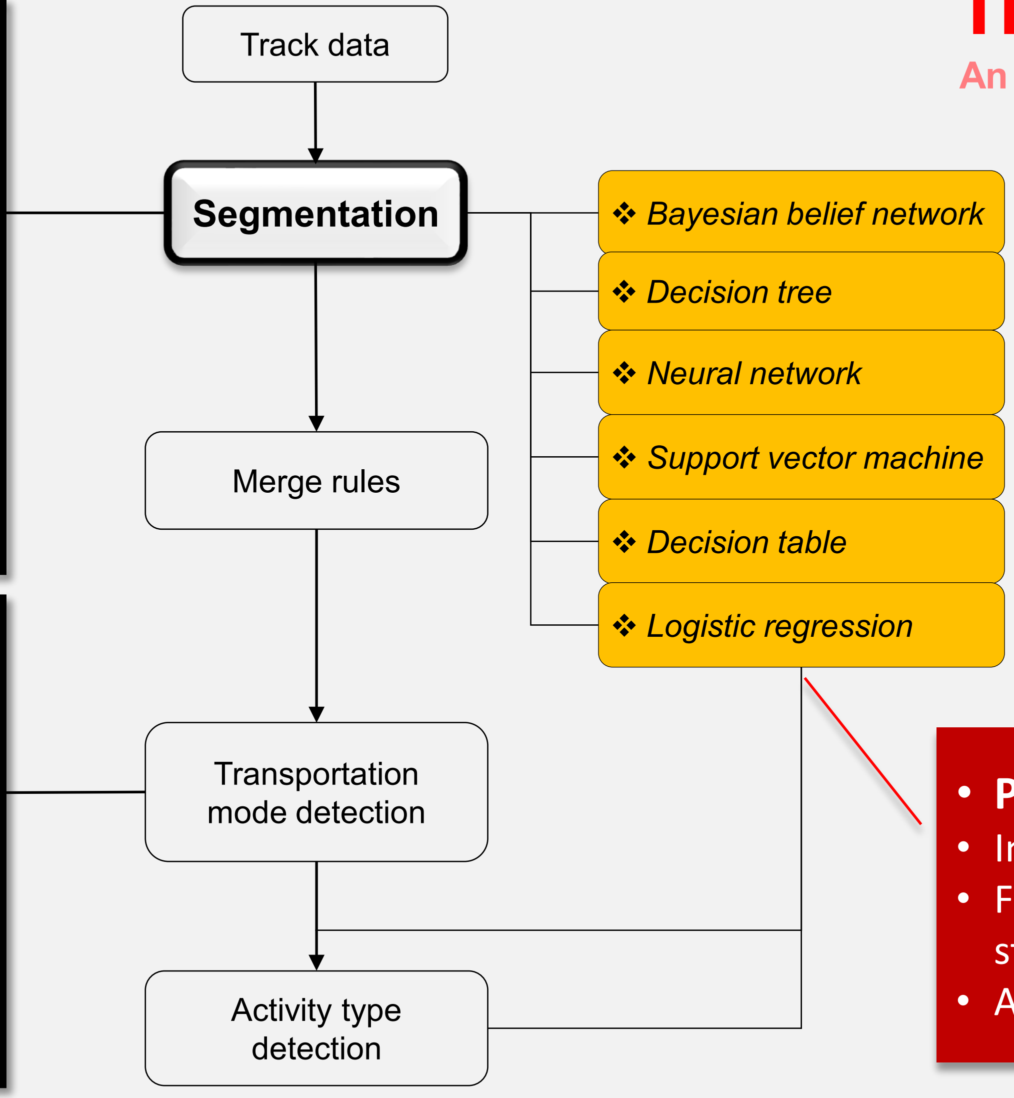
- Feng, T. & Timmermans, H.J.P. (2016) Comparison of advanced imputation algorithms for detection of transportation mode and activity episode using GPS data. *Transportation Planning and Technology*, 39, 2, 180-194.
- Feng, T. & Timmermans, H.J.P. (2015) Detecting activity type from GPS traces using spatial and temporal information. *European Journal of Transport and Infrastructure Research*, 15, 4, 662-674.
- Feng, T. & Timmermans, H.J.P. (2015) Enhanced imputation of GPS traces forcing full or partial consistency in activity-travel sequences: Comparison of algorithms. Transportation Research Record, 2430, 20-27.
- Feng, T. & Timmermans, H.J.P. (2013) Map matching of GPS data with Bayesian belief networks. *Journal of the Eastern Asia Society for Transportation Studies*, 10, 100-112.
- Yao, B. & Feng, T. (2018) Machine learning in automotive industry. *Advances in Mechanical Engineering*, 10, 10, 1-2.

Data imputation & mining

GPS辅助居民出行调查







Trace Annotator

An integrated data imputation tool

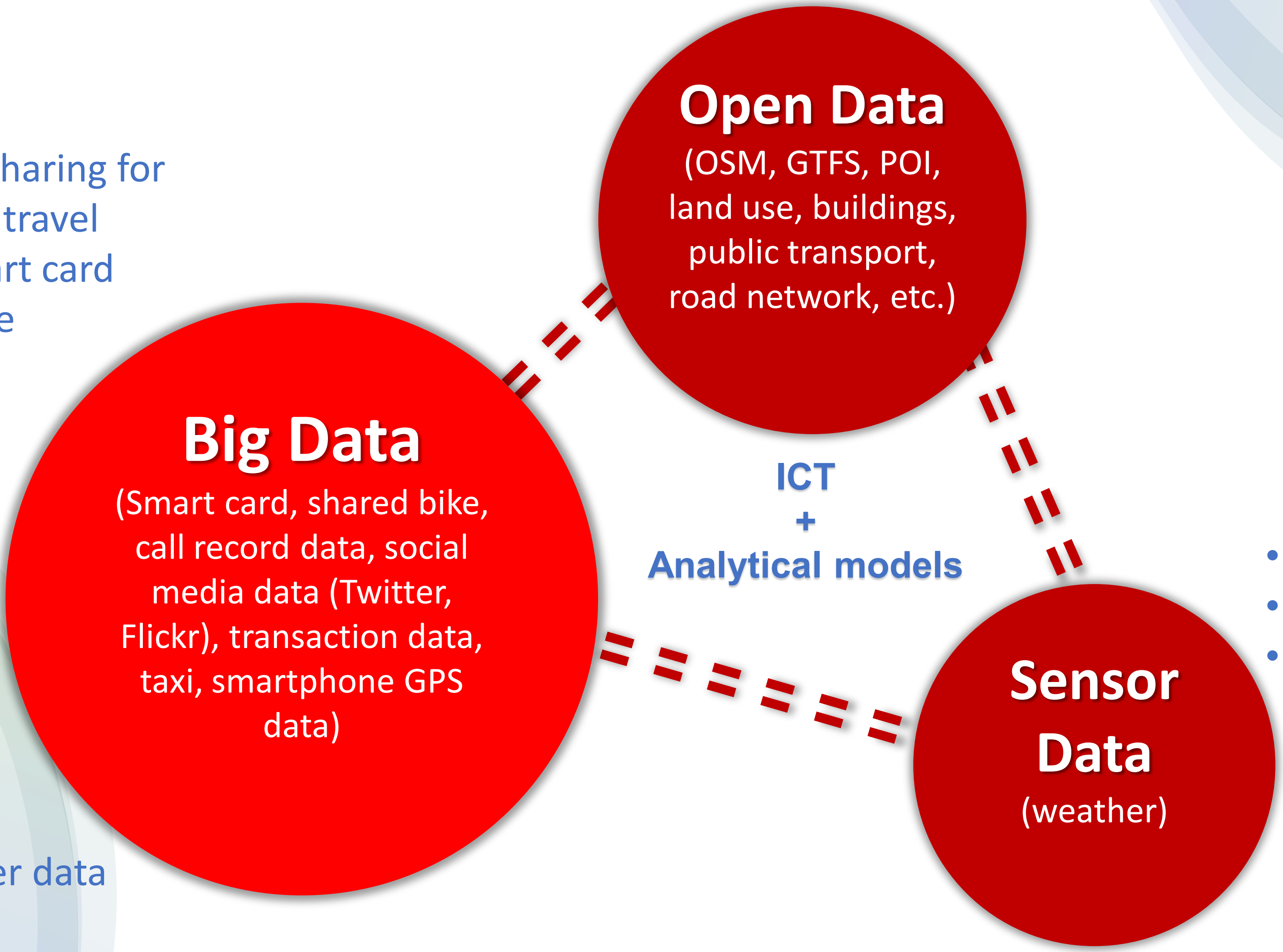
- **Programmed by Java**
- Incorporated AI algorithms
- Fast processing and flexible structure
- Applied for many applications

Big data research

Ridership and the built environment
(smart card data and land use data)

Metro-bike sharing for the last mile travel

- Metro smart card
- Shared bike
- Mobike



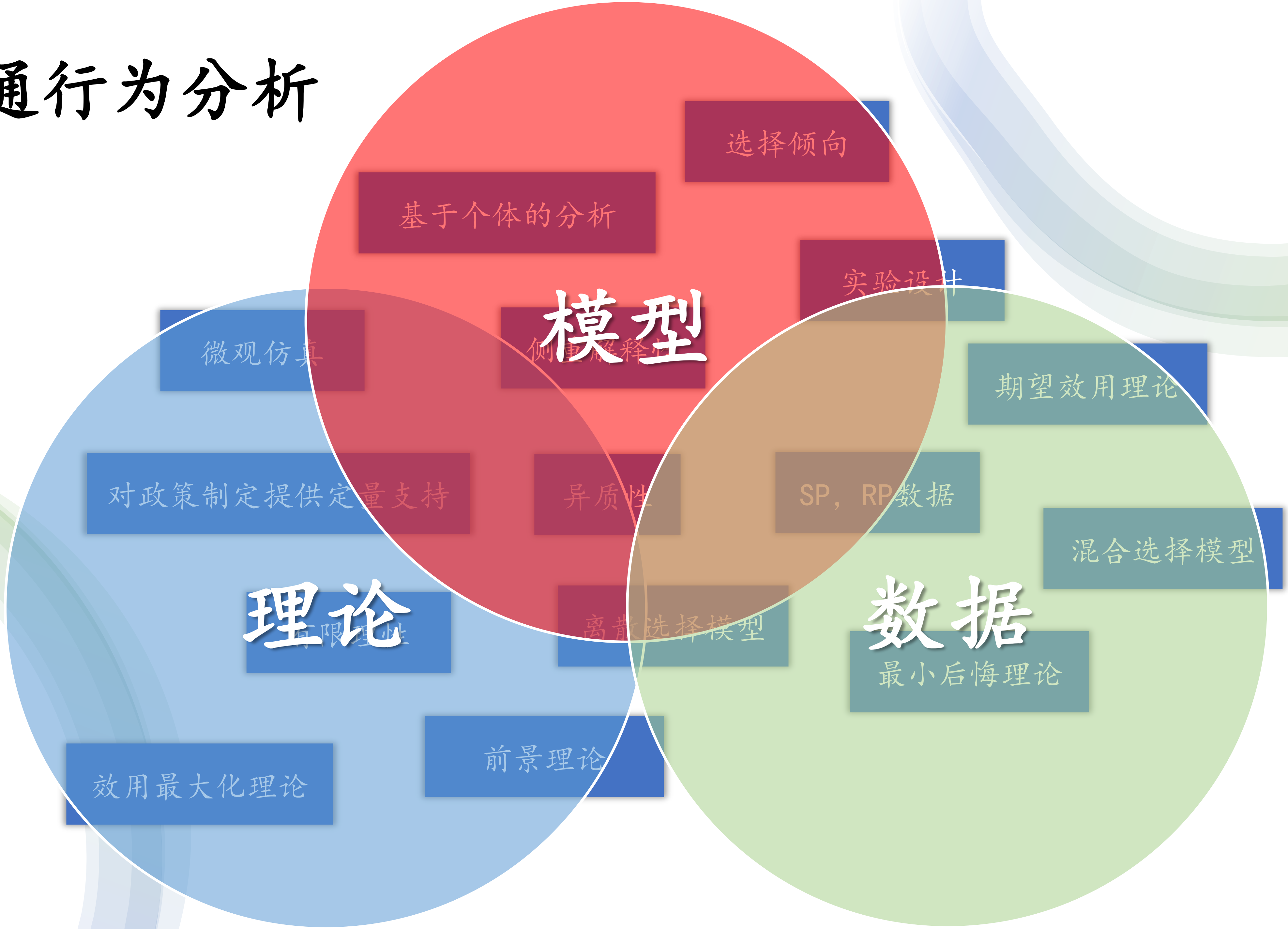
- Cycling data
- GPS data from smart phones
- Weather data

GPS Taxi data

Flickr, Twitter data

** For the relevant publications of each component, please refer to our website.*

交通行为分析

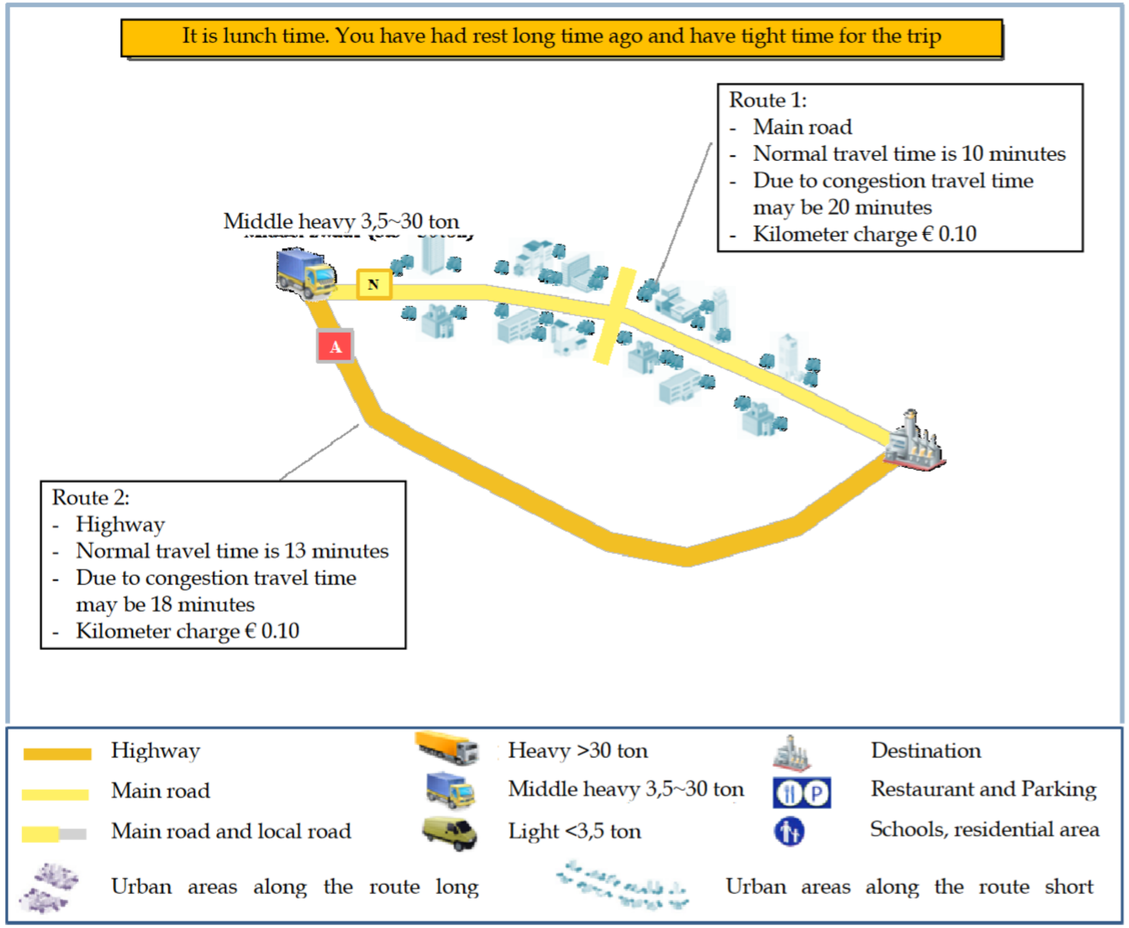


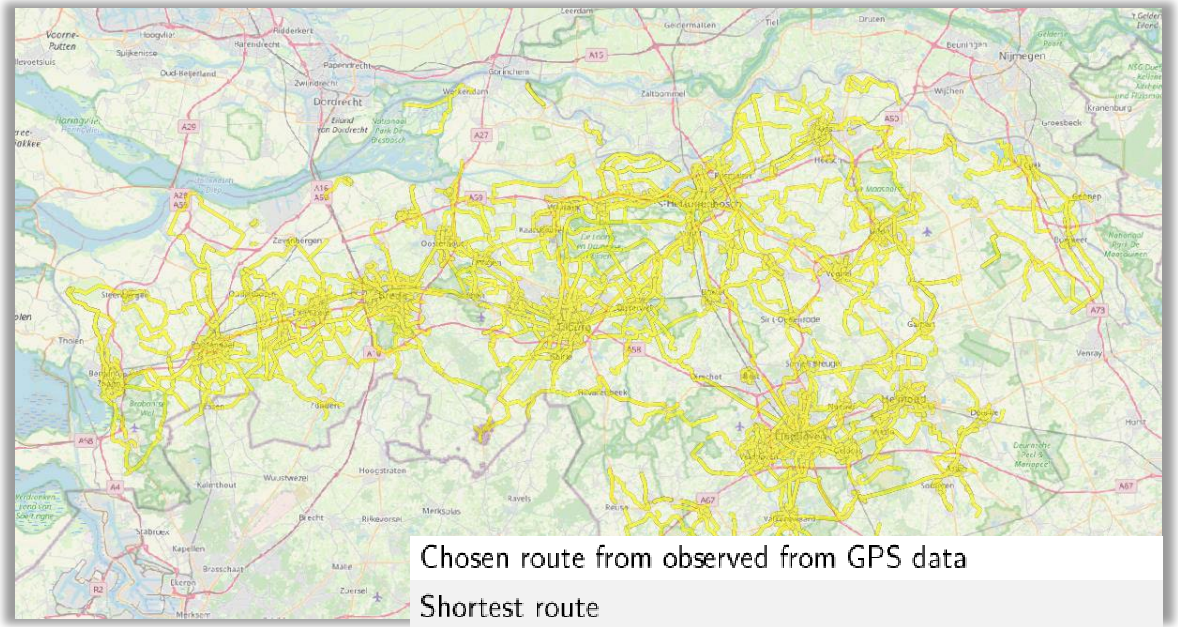
模型
理论
数据
选择倾向
基于个体的分析
实验设计
侧重解释性
微观仿真
期望效用理论
对政策制定提供定量支持
异质性
SP，RP数据
混合选择模型
有限理性
离散选择模型
最小后悔理论
前景理论
效用最大化理论

Mobility decision

Route choice as an example

- Route choice using SP data





- Route choice using RP data

Chosen route from observed from GPS data
Shortest route
Fastest route
Least links route
Most attractive environment route
Environment attractiveness as distance weight
Most attractive cycle path route
"Primary cycle route" (PSR) categorization as distance weight
Shortest path when link lengths are randomly varied +/- 50%
Shortest path when link lengths are randomly varied +/- 50%, with opposite effect of A9

Dane, G., Feng, T., Luub, F. & Arentze, T. (2019) Route Choice Decisions of E-bike Users: Analysis of GPS Tracking Data in the Netherlands, Geospatial Technologies for Local and Regional Development, 109-124, DOI:10.1007/978-3-030-14745-7_7

Feng, T., Arentze, T. & Timmermans, H.J.P. (2013) Capturing preference heterogeneity of truck drivers' route choice behavior with context effects using a latent class model. *European Journal of Transport and Infrastructure Research*. 13, 4, 259-273.

Mobility decision
Route choice as an example

- Route choice using neural network

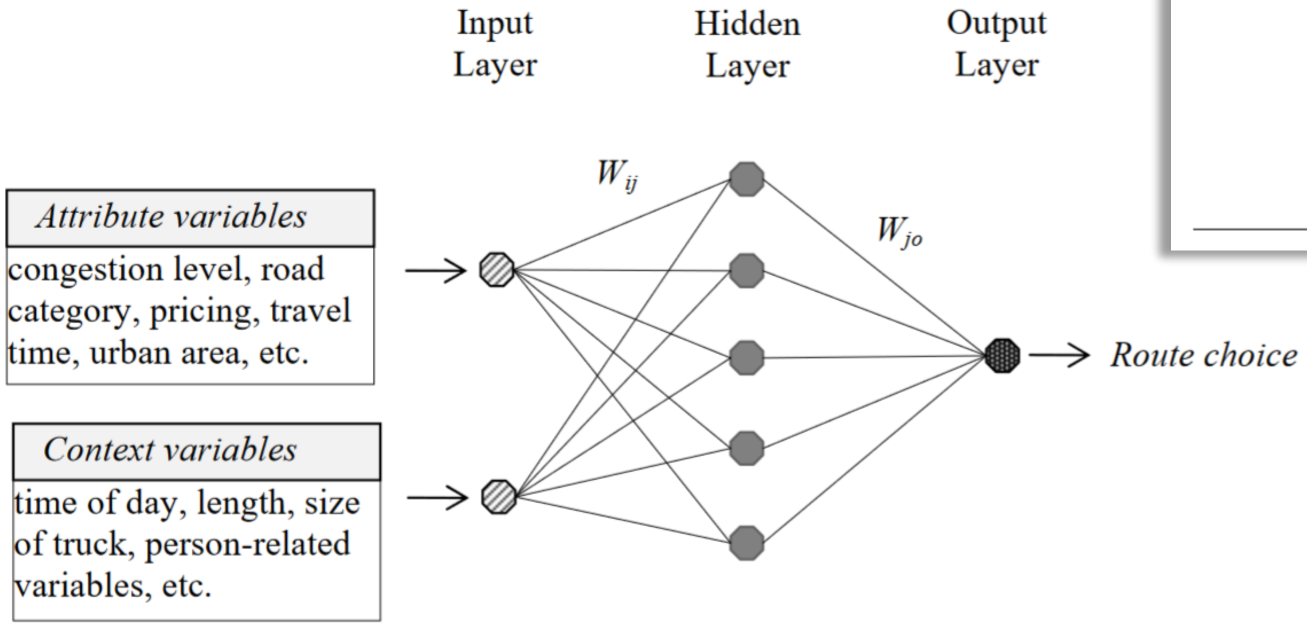


Table 4 Result of relative importance of variables

Groups	Variables	Importance
Attribute variables	Congestion	4.49
	Road category	12.43
	Pricing	11.07
	Bonus	16.71
	Passing through urban area	13.78
	Having restaurant facility	6.12
Context variables	Normal travel time difference	6.67
	Time of day	3.74
	Size of truck	8.43
	Distance to destination	6.44
	Time since rest	4.96
	Time window	5.16

$$RI_i = \frac{C_i}{\sum_{i=1}^{M} C_i}$$

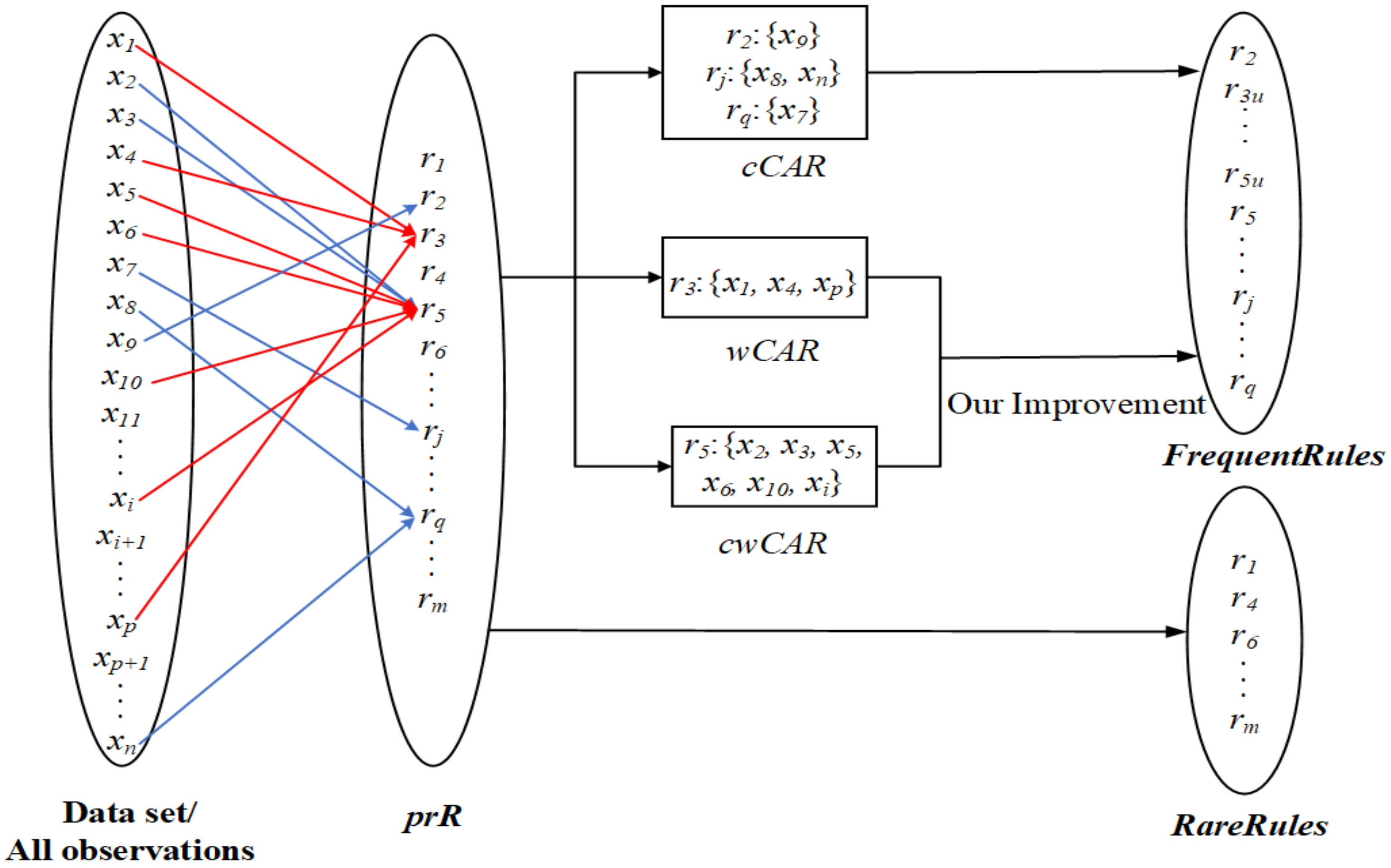
?

Feng, T., Arentze, T. & Timmermans, H.J.P. (2011) Assessing the relative importance of input variables for route choice modeling: a neural network approach. Journal of the Eastern Asia Society for Transportation Studies, 9, 341-353.

Mobility decision

Transportation mode choice with improved rule sets

- Discrete choice models vs. data mining approach



	CARM	CARIG	CBA	DT	MNL
C_1	92.4	82.8	77.3	76.0	73.3
C_2	93.4	99.4	90.2	92.8	79.9
C_3	92.5	96.1	85.3	86.2	75.3
C_4	88.5	72.6	67.9	61.2	63.2
C_5	87.8	90.1	77.1	78.4	77.6
Avg.	**91.1**	**88.7**	**80.6**	**77.6**	**74.3**

Zhang, J., Feng, T., Timmermans, H.J.P. & Lin, Z. Improved Imputation of Rule Sets in Class Association Rule Modeling: Application to Transportation Mode Choice. Transportation. (forthcoming)

Mobility decision

Housing, job and transportation

Data mining

$$U_{nit} = V_{nit} + \varepsilon_{nit}$$

Choice modeling

Status quo:

$$U_{n1t} = \beta_{1o} + \sum_{k=1}^{K}\left(\bar{\beta}_k + \sigma_k + \sum_{m=1}^{M}\theta_{km}z_{nm}\right)x_{n1kt} + \lambda_1 Q_{n1} + \varepsilon_{n1t}$$

Move house :

$$U_{n2t} = \beta_{2o} + \sum_{k=1}^{K}\left(\bar{\beta}_k + \sigma_k + \sum_{m=1}^{M}\theta_{km}z_{nm}\right)x_{n2kt} + \lambda_2 Q_{n2} + \varepsilon_{n2t}$$

...

$$U_{n6t} = \beta_{6o} + \sum_{k=1}^{K}\left(\bar{\beta}_k + \sigma_k + \sum_{m=1}^{M}\theta_{km}z_{nm}\right)x_{n6kt} + \lambda_2 Q_{n2} + \varepsilon_{n6t}$$

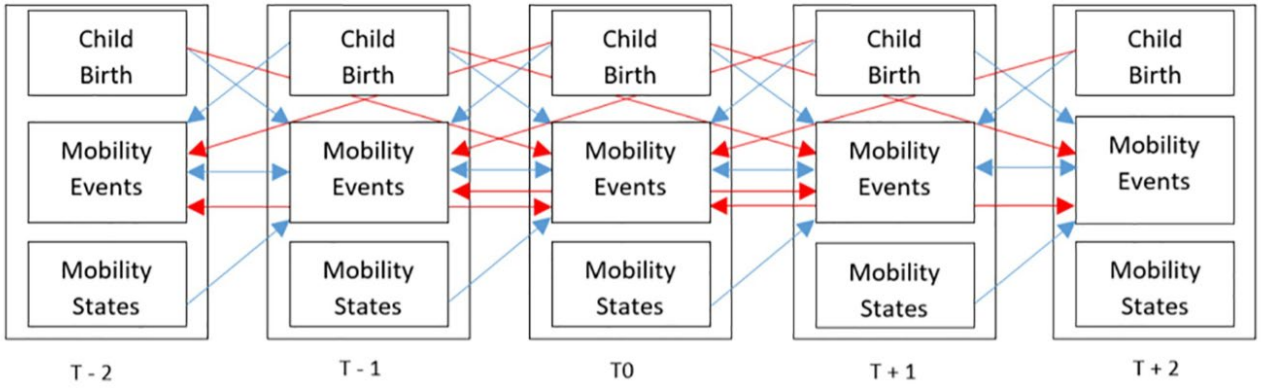
...

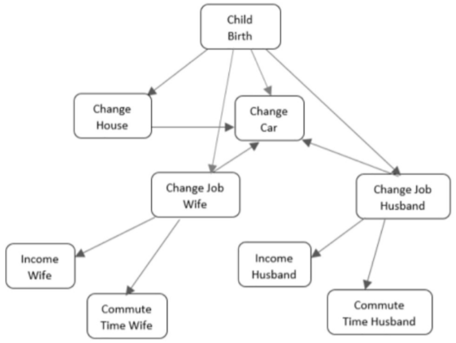
Change job :

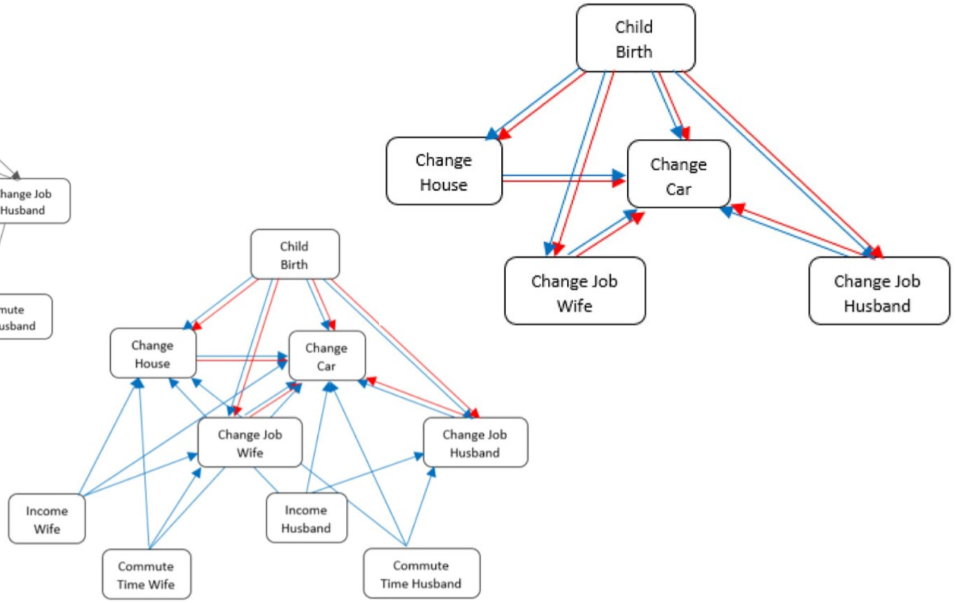
$$U_{n7t} = \beta_{7o} + \sum_{k=1}^{K}\left(\bar{\beta}_k + \sigma_k + \sum_{m=1}^{M}\theta_{km}z_{nm}\right)x_{n7kt} + \lambda_3 Q_{n3} + \varepsilon_{n7t}$$

...

$$U_{n11t} = \beta_{11o} + \sum_{k=1}^{K}\left(\bar{\beta}_k + \sigma_k + \sum_{m=1}^{M}\theta_{km}z_{nm}\right)x_{n11kt} + \lambda_3 Q_{n3} + \varepsilon_{n11t}$$







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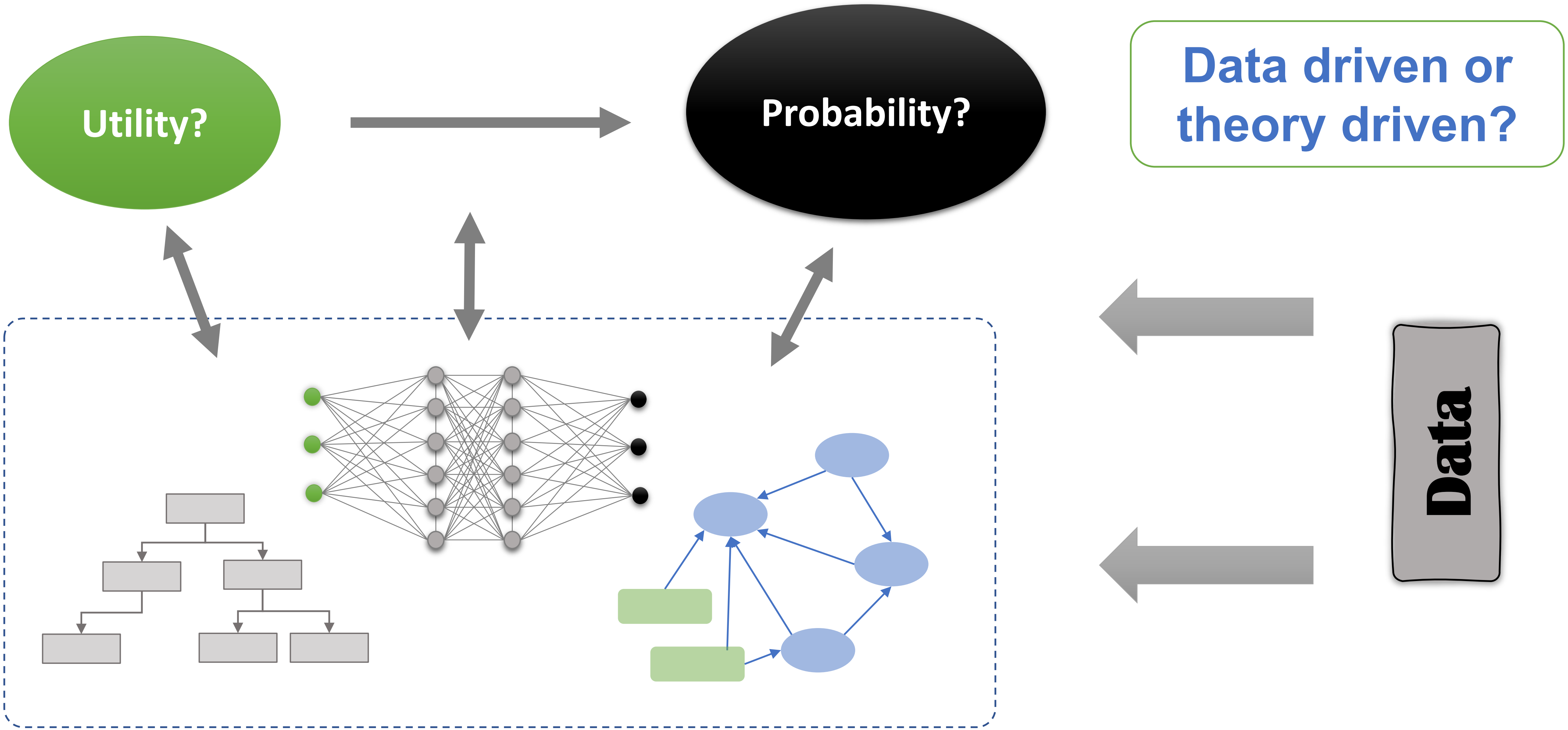
Guo, J., Feng, T., Timmermans, H. (2020) Temporal interdependencies in mobility decisions over the life course: a household-level analysis using dynamic Bayesian networks. Journal of Transport Geography. 10.1016/j.jtrangeo.2019.102589

Synergy between choice modeling & AI

Choice theory + machine learning



感谢大家的倾听！

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Contact: taofeng@hiroshima-u.ac.jp, t.feng@tue.nl

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冯 涛 (Tao Feng)
Professor, Urban and Data Science
Graduate School of Advanced Science and Engineering, Hiroshima University, Japan
広島大学先進理工系科学研究科　理工学融合プログラム　開発科学分野
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张 峻屹
Professor, Mobilities and Urban Policy Lab
モビリティ・都市政策研究室

藤原章正
Professor, Transportation Engineering Lab
交通工学研究室

冯 涛
Professor, Urban and Data Science Lab
城市与数据科学研究室