



Uncovering City Structure from Urban Big Data

Presented by

Qiuyuan Yang

Outline

1 / Background

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1. Background



- City structure refers to the arrangement of urban space with respect to the set of relationships arising out of urban form and its underlying interactions which are composed of people, materials and information.
- ✓ City structure has strong effects on transportation, economic growth, social equity, and sustainable urban development.
- ✓ The improvement of transportation systems, the complexity of human movements, and the distribution of urban activities represent the changing of urban function and form.

2. Related Work (Functional zone detection)



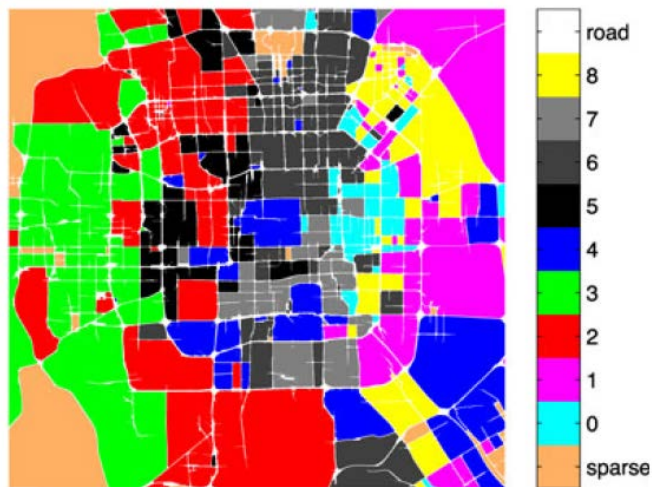
- Yuan *et al.*^[1]
 - Method: cluster the segmented regions into functional zones using mobility and location mined from latent activity trajectories
 - Area: Beijing
 - Dataset: points of interest (POI), O/D of taxi trajectories, O/D of public transit data
 - Time: 2011, weekdays and weekends

[1] N J Yuan, Y Zheng, X Xie, et al. Discovering urban functional zones using latent activity trajectories[J]. IEEE Transactions on Knowledge and Data Engineering, 2015, 27(3): 712-725.

2. Related Work (Functional zone detection)



- Result:



[c8]: emerging residential areas

[c7]: old neighborhoods

[c6]: developed residential areas

[c5]: developed commercial/entertainment areas

[c4]: historical interests/parks

[c3]: nature areas

[c2]: science/education/technology areas

[c1]: emerging commercial/entertainment areas

[c0]: diplomatic/embassy areas

2. Related Work (Functional zone detection)



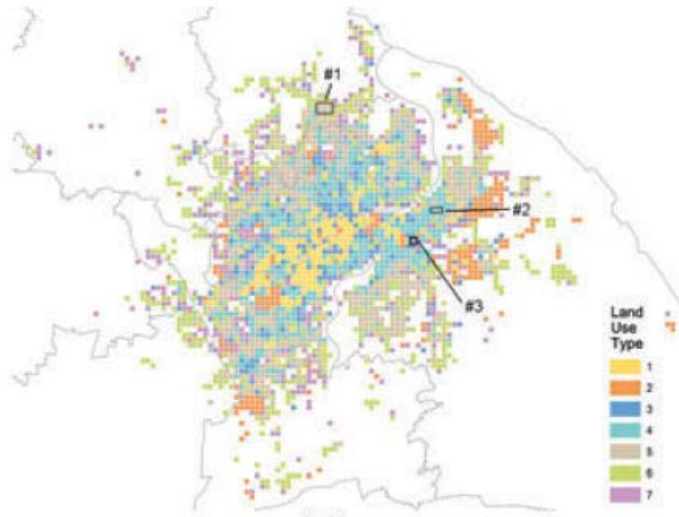
- Liu *et al.*^[2]
 - Method: classify land use based on spatial interaction patterns between places
 - Area: Shanghai
 - Dataset: O/D of taxi trip data
 - Time: June 1, 2009 to June 21, 2009, weekdays

[2] X Liu, C Kang, L Gong, et al. Incorporating spatial interaction patterns in classifying and understanding urban land use[J]. International Journal of Geographical Information Science, 2015: 1-17.

2. Related Work (Functional zone detection)



- Result:



- [1]: Urban commercial and business area
- [2]: Business and industrial area
- [3]: Civic and transportation land use
- [4]: Urban residential area
- [5]: Outskirt urban residential area
- [6]: Suburban residential area
- [7]: Other land use area with few taxi trips

[2] X Liu, C Kang, L Gong, et al. Incorporating spatial interaction patterns in classifying and understanding urban land use[J]. International Journal of Geographical Information Science, 2015: 1-17.

2. Related Work (Functional zone detection)



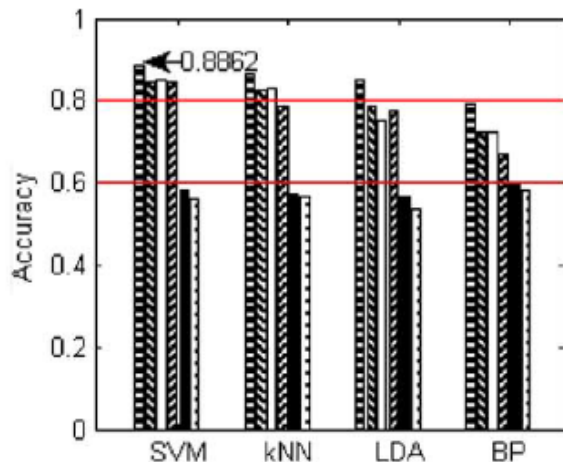
- Pan *et al.*^[3]
 - Method: predict social function of a urban area by temporal and spatial dynamics of taxi pick-up/set-down number
 - Area: Hangzhou
 - Dataset: O/D of taxi traces
 - Time: April 1, 2009 to April 20, 2010

[3] G Pan, G Qi, Z Wu, et al. Land-use classification using taxi GPS traces[J]. IEEE Transactions on Intelligent Transportation Systems, 2013, 14(1): 113-123.

2. Related Work (Functional zone detection)



- Result:



✓ Six taxi drivers labeled social function of regions

- [1] station
- [2] campus
- [3] hospital
- [4] scenic spot
- [5] commercial district
- [6] entertainment district
- [7] office building
- [8] residential district

2. Related Work (City Spatial-Temporal Analysis)



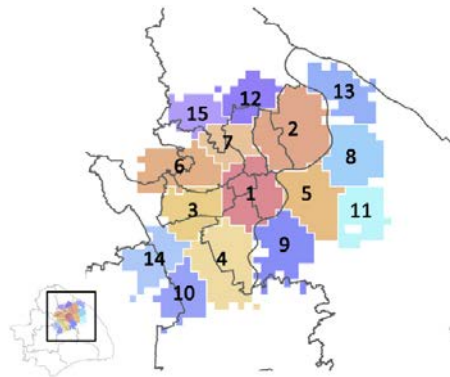
- Liu *et al.*^[4]
 - Method: reveal a two-level polycentric city considering the differences between taxi trip distance
 - Area: Shanghai
 - Dataset: O/D of taxi trip data
 - Time: June 1, 2009 to June 4, 2009

[4] X Liu, L Gong, Y Gong, et al. Revealing travel patterns and city structure with taxi trip data[J]. Journal of Transport Geography, 2015, 43: 78-90.

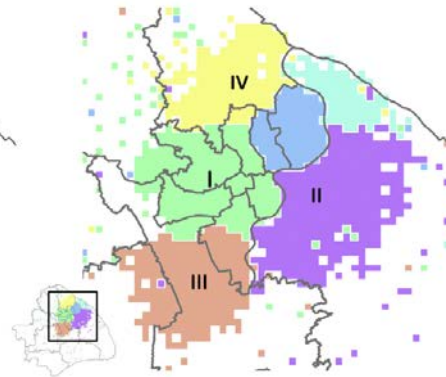
2. Related Work (City Spatial-Temporal Analysis)



- Result:



Level One Zones (L1Zs)



Level Two Zones (L2Zs)

- ✓ L1Z and L2Z boundaries are not consistent with district-level administrative boundaries
- ✓ In rural districts, L1Z boundaries are consistent with town/sub-district boundaries
- ✓ Administrative boundary shapes intra-urban movements, especially in less-developed areas

[4] X Liu, L Gong, Y Gong, et al. Revealing travel patterns and city structure with taxi trip data[J]. Journal of Transport Geography, 2015, 43: 78-90.

2. Related Work (City Spatial-Temporal Analysis)



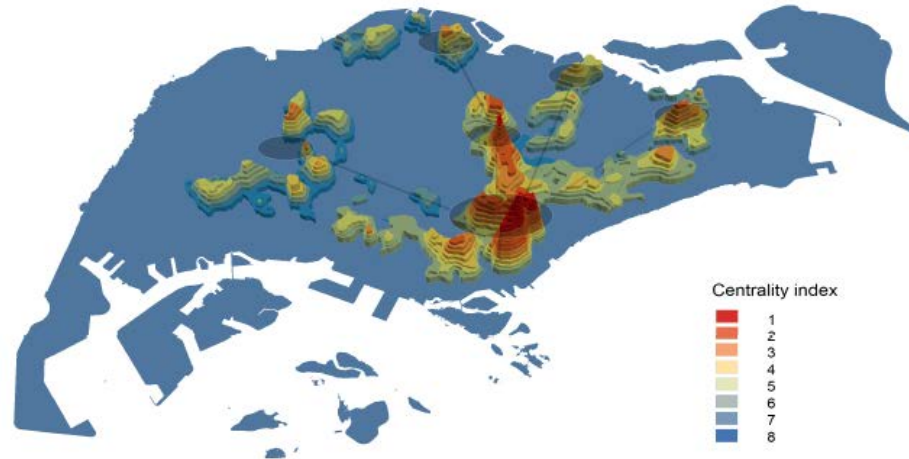
- Zhong *et al.*^[5]
 - Method: detect central areas of urban activities
 - Area: Singapore
 - Dataset: travel survey data
 - Time: 2008

[5] C Zhong, S M Arisona, X Huang, et al. Identifying spatial structure of urban functional centers using travel survey data: a case study of Singapore[C]. Proceedings of The First ACM SIGSPATIAL International Workshop on Computational Models of Place. 2013: 28-33.

2. Related Work (City Spatial-Temporal Analysis)



- Result:



- ✓ biggest center, sub centers
- ✓ in line with Singapore's essential planning concept

[5] C Zhong, S M Arisona, X Huang, et al. Identifying spatial structure of urban functional centers using travel survey data: a case study of Singapore[C]. Proceedings of The First ACM SIGSPATIAL International Workshop on Computational Models of Place. 2013: 28-33.

2. Related Work (City Spatial-Temporal Analysis)



- Zhong *et al.*^[6]
 - Method: detect changes in urban movement using daily transportation data
 - Area: Singapore
 - Dataset: O/D of smart card data
 - Time: September 2010, April 2011, September 2012, weekdays

[6] C Zhong, S M Arisona, X Huang, et al. Detecting the dynamics of urban structure through spatial network analysis[J]. International Journal of Geographical Information Science, 2014, 28(11): 2178-2199.

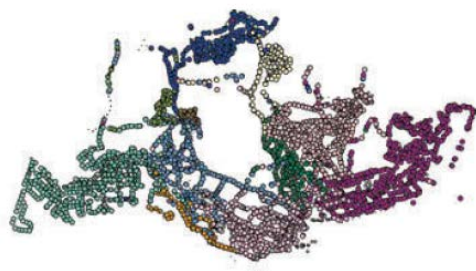
2. Related Work (City Spatial-Temporal Analysis)



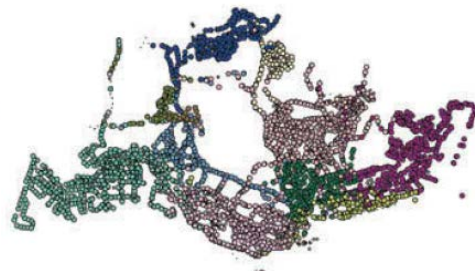
- Result:



Communities in 2010



Communities in 2011



Communities in 2012

- ✓ a new community emerged (2010 - 2011), an isolated area disappeared (2011 – 2012)
- ✓ rapid urban development process, more polycentric

[6] C Zhong, S M Arisona, X Huang, et al. Detecting the dynamics of urban structure through spatial network analysis[J]. International Journal of Geographical Information Science, 2014, 28(11): 2178-2199.

3. City Structure



■ Motivation

- Method: **identification + analysis**
- Area: Hangzhou
- Dataset: urban big data (**bus trajectory, bus route table, taxi trajectory, road networks, POI**)
- Time: 2014, 2015

3. City Structure



■ Identification

- Machine Learning: DL, TF-IDF, PCA, LDA, EM, KDE
- Feature
 - ✓ Bus: line number, trip number, stop number, terminal number, dwell time, speed, ...
 - ✓ Taxi: status, trip number, speed, ...
 - ✓ POI: number in each category, unique number, ...

3. City Structure



■ Analysis

- Network Science
 - ✓ Hub / Center: diversity, density, centrality, ...
 - ✓ Boundary: administrative boundary, subway line, shape, ...
 - ✓ Distribution: layout, relationship, ...

4. Next Step



- Do preliminary experiment to identify city structure
- Extract more useful feature, adjust parameters
- Learning more about network science



Thanks

Presented by

Qiyuan Yang