Empirical study on cycle lane network using bike sharing data: the case of Shanghai

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Contents

1

Introduction

Research background

Advantage of Cycling

- ✓ Save energy
- ✓ Relieve traffic congestion
- ✓ Flexible to use
- ✓ Easy to park
- ✓ Solve the “last mile” problem

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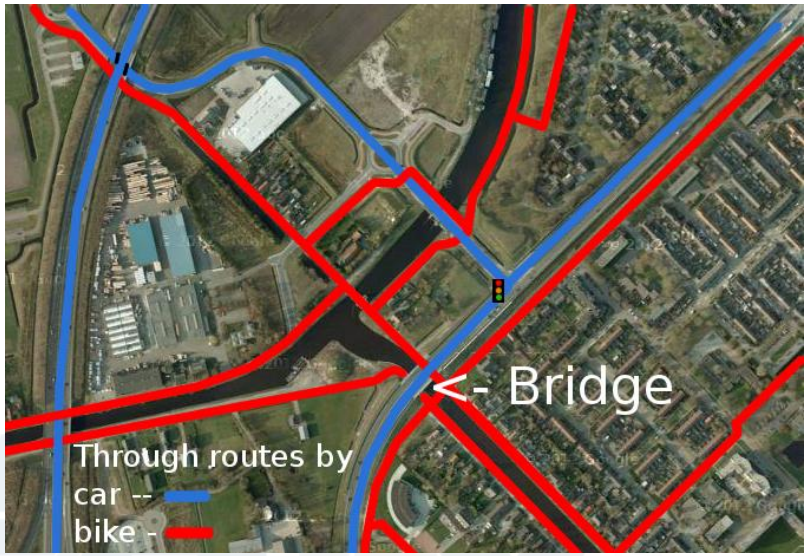
Booming of shard bikes

- Cycling demand is increasing
- Infrastructure like the cycle lane network can not effectively fulfill the cycling demand

Cycle lanes abroad: Denmark

Perfect infrastructures

- Bicycle lanes separated from motor vehicle lanes are generally set.
- Some busy roads bicycles share paths with motor vehicles with cycle lanes clearly marked on the surface.



Independently set

- Many bike lanes will be set up completely independently with direct routine instead of along the existing road.
- Urban core areas are only open to pedestrians and cyclists, with motor vehicles restricted.

Government planning and the actuality

01 ***Shanghai Metropolitan Transport White Paper (2002)***

Mentioned about the construction of non-motorized lane network.

02 ***Shanghai's Non-motorized Traffic System Planning (2007)***

Proposed setting "slow cores", "slow islands" and "slow corridors" in central urban areas of Shanghai.

03 ***Urban overall planning of Shanghai (2017-2035)***

- Increase the allocation of non-motor vehicle rates and establish non-motorized vehicle access network.
- Improve flexibility, continuity and functionality of non-motorized traffic network.

Bicycle share rate in Shanghai

In 1986

34.4%

In 2004

25.2%

In 2014

7.2%

Source: The Second, Third and Fifth Comprehensive Traffic Survey in Shanghai

Challenges and opportunities

Challenges

1. **Cycling demand is increasing.**
2. **Drawbacks of current cycle lane network: cycle lanes are lack of width, continuity and road share rate.**

Research direction

1. **Discover the spatial and temporal mobility patterns of shared bikes usage.**
2. **Discovering the flaws of current cycle lane network and its improvement suggestions.**

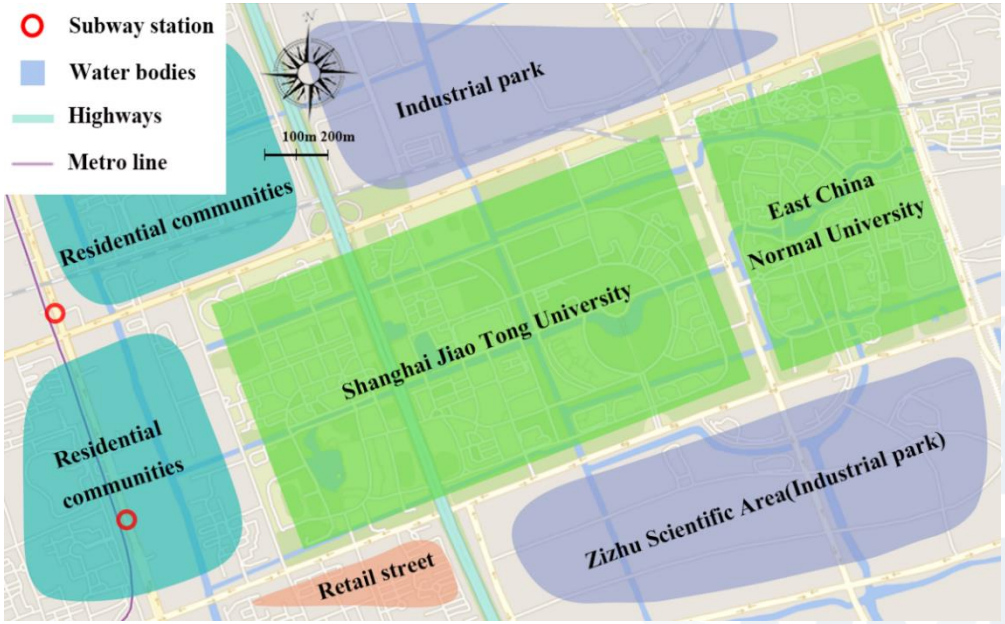
2

Data and methodology

Study areas and their zoning

(1) Shanghai Jiao Tong University and its surrounding area:

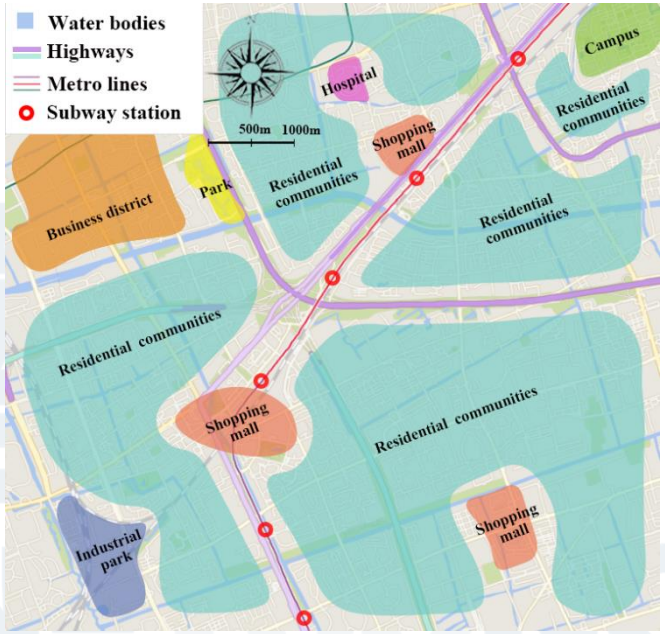
- Suburban low-density area
- A well circulated cycling network
- Rasterized into 100x100 rectangle grids



First study area（5km*2.7km）
Land use diagram

(2) Xinzhuang subway station and its surrounding area:

- Urban high-density area
- Unknown for cycling properties
- Rasterized into 80x80 grids

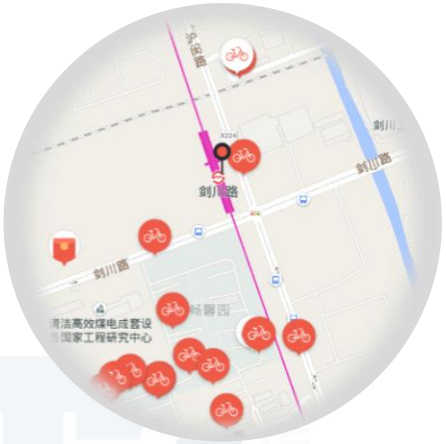


Second study area（7km*6km）
Land use diagram

Data description

Bike sharing data： (Record the available bikes (not in use) on hourly basis)

- First study area：2017.7.6-2017.9.22
- Second study area：2017.9.30-2017.11.11



- Each data entry records the bike id, type, geographical locations and time-zone.
- Time-zones are divided into Morning(6:00-13:00), Afternoon(14:00-18:00) and Night(19:00-23:00)。

Bike Ids	Longitude	Latitude	Biketype	Time	Timezone
0200011625#	121.4501332	31.0360122	1	7:00:00	Moring
0210084016#	121.3830957	31.1244704	999	15:00:00	Afternoon
0210086190#	121.3987916	31.1220635	2	20:00:00	Night

Examples of bike sharing data

Data description

POI（Point of Interest）data from *Baidu Map*：

POIs can provide us with useful information of study areas, especially land use pattern, which is essential in understanding the traits of grids and their interconnections in cycle lane network.

- POI labels include transportation infrastructures, government agencies, residential areas, restaurants, medical and educational institutions.
- Each POI data entry includes POI name, address, longitude, latitude and label.

POI_Name	POI_Address	Longitude	Latitude	Label
Gui Jiang Road Bridge	Xuhui District, Shanghai	121.417804	31.151726	Transport
Shu Xiang Court	Xuhui District,Shanghai	121.434544	31.144554	Estate
Xinguang Police Station	Primus Road No.505	121.393421	31.129078	Government

Example of POI data

Graphic clustering: Louvain Method

Louvain Method is based on the **modularity community detection algorithm,** which can detect strongly connected elements in network and group these elements into a "community" (i.e. cluster). **Modularity** describes the closeness between elements. Louvain Method is a **greedy optimization** algorithm.

In **bike sharing system**, a community (i.e. cluster) refers to a **self-sustained zone** where cycling activities are performed from one location to another within the zone.

Steps:

1. Each point is regarded as a community.
2. Merge nearby points to community (according to max modularity increasement).
3. Regard new community as points to iterate with original weight until convergence.

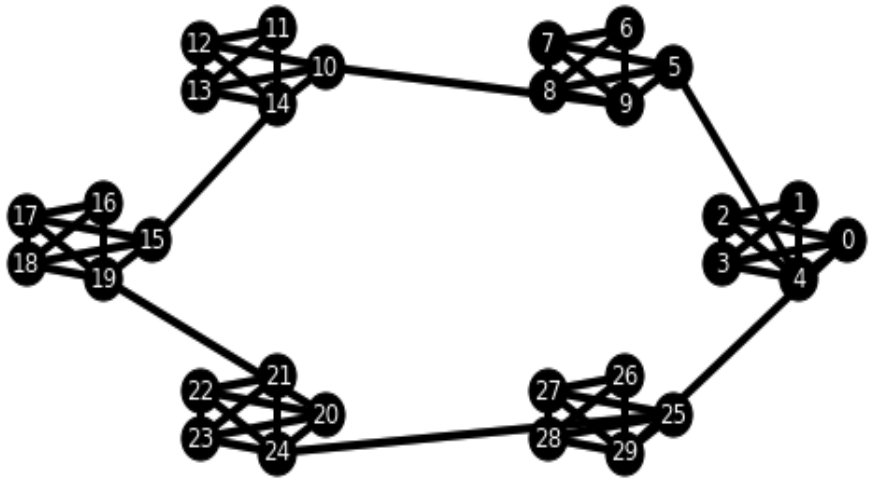


Diagram for Louvain Method

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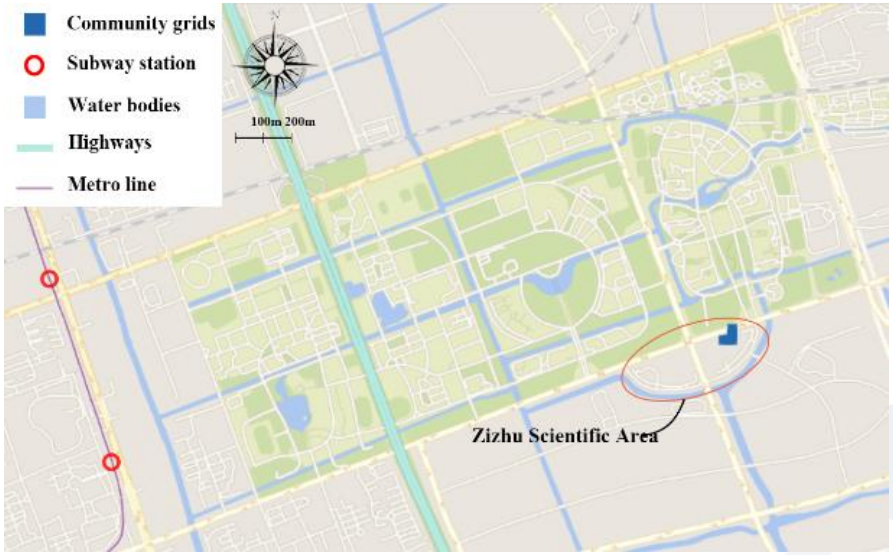
Results and findings

Significant cycling mobility patterns

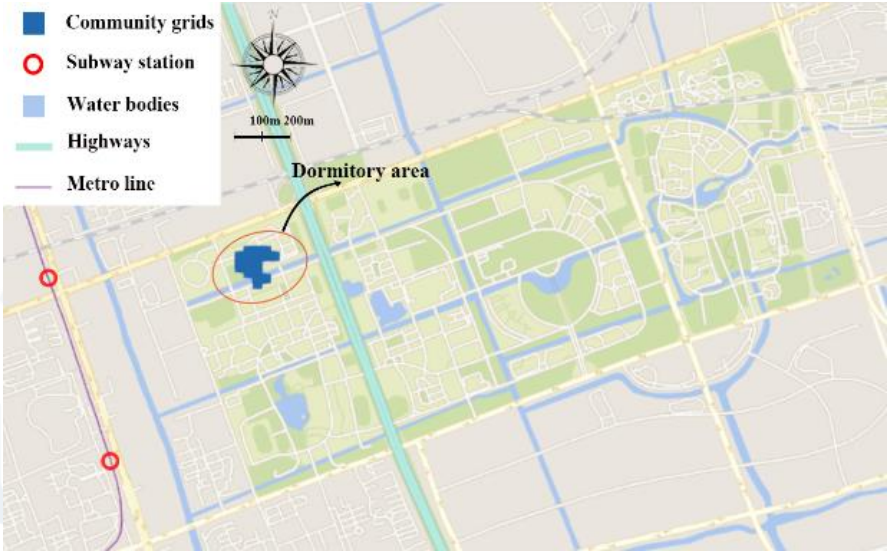
We applied Louvain method on the first study area and generated 561 communities in total. Four significant community configurations are discovered: adjacent-grid, radial-pattern, grouped and unseparated communities.

(1) Adjacent-gird communities

- **Features：** Grids located geographically close form a community cluster.
- **Analysis：** Rebalanced by system operators; reflect short-distance cycling demand.



Zizhu Scientific Area

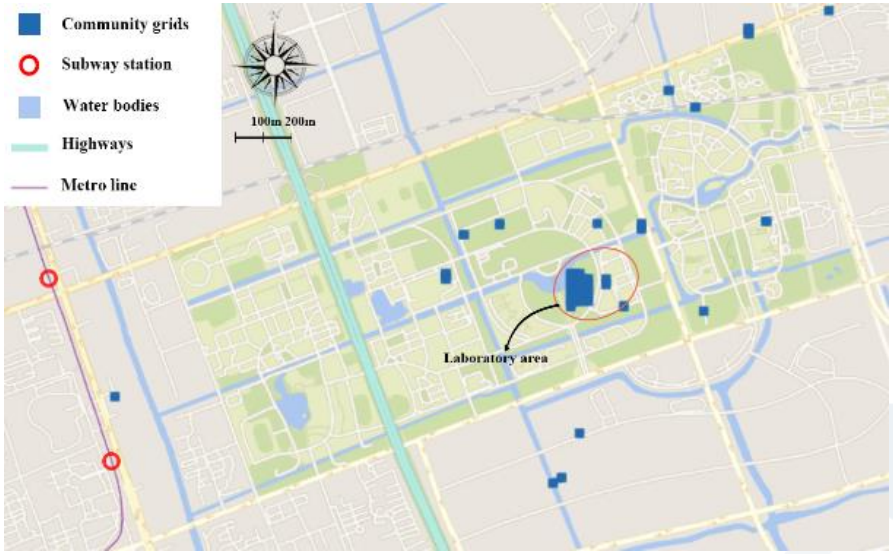


Dormitory area in the campus

Significant cycling mobility patterns

(2) Radial-pattern communities

- **Features：** Remote grids disperse radially from the central bulk.
- **Analysis：** Central bulk indicates short-distance cycling mobility demand; remote grids demonstrate the long-distance cycling mobility demand.
- The grids in the central bulk are usually important POIs, reflecting the importance of POIs in community formation.



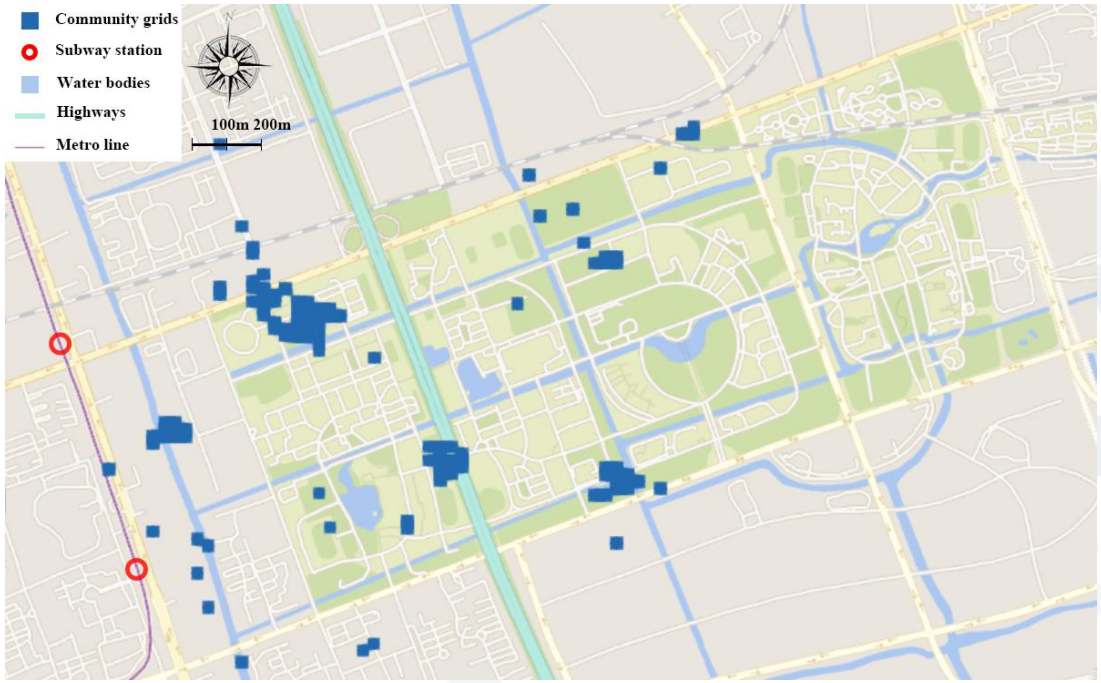
Research center

Industrial park

Significant cycling mobility patterns

(3) Grouped communities

- **Features：** Consist of multiple adjacent-grid and radial-pattern sub-communities.
- **Analysis：** Unveil the connections between two or more community clusters and a higher coherence of the whole study area.

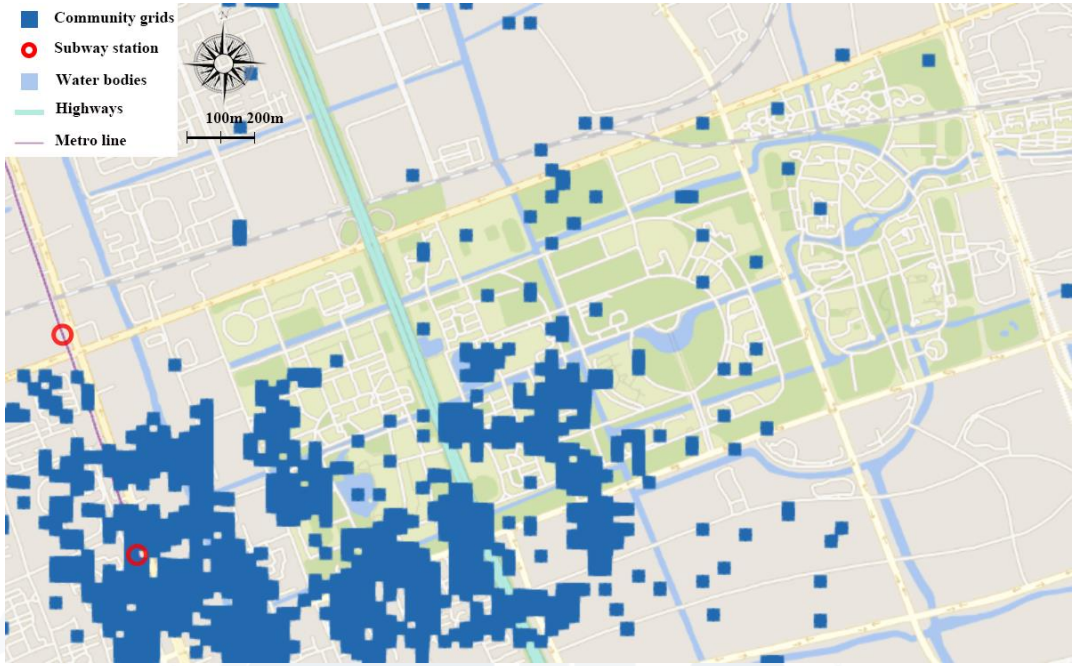


Example of grouped communities in the first study area

Significant cycling mobility patterns

(4) Unseparated communities

- **Features：** An entire cluster formed by a large set of grids within a certain area.
- **Analysis：** Connections between all the grids in the community are at the same level and all grids are fully connected.
- The existence of this community pattern can reflect the influence that the surrounding environment has on the formation of the communities.



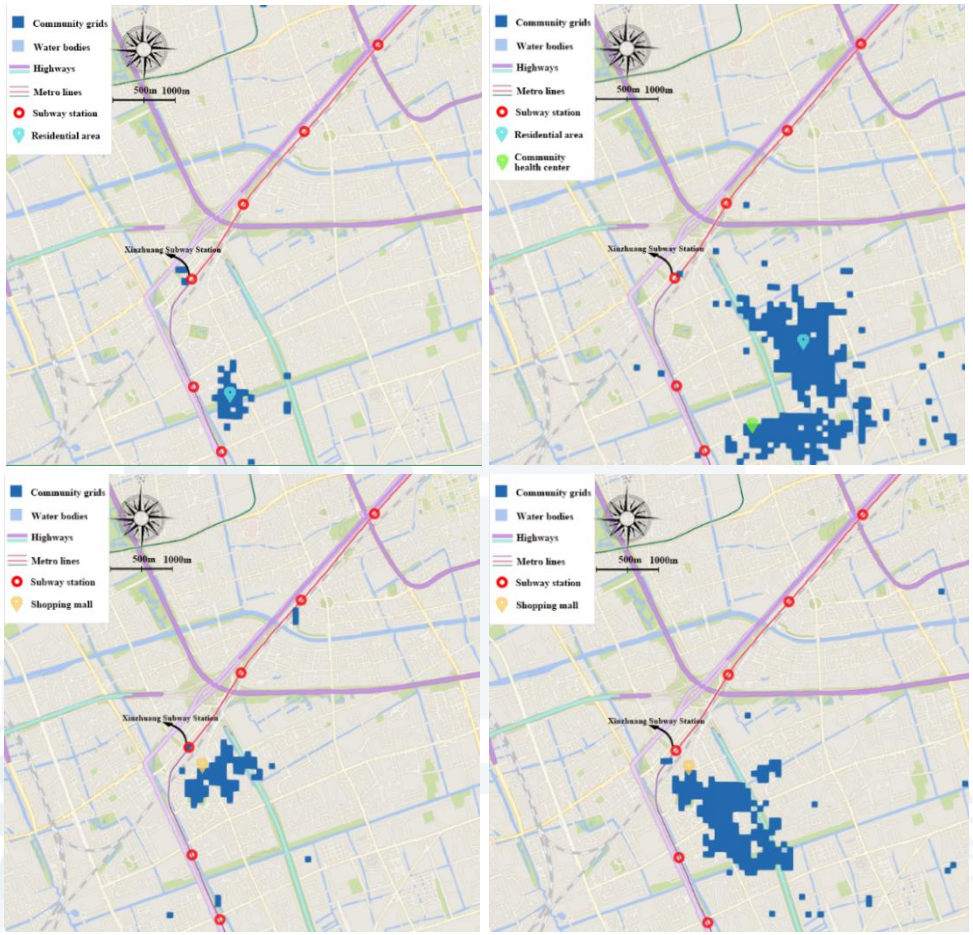
Example of unseparated communities in the first study area

Factors of cycle lane network designing

We further employ the Louvain method on the second study area and find three factors related to designing of cycle lane network.

(1) POIs in network designing

- **Features:** Xinzhuang subway station has a strong connection with its nearby POIs as it belongs to variant communities, even though it is marginal in these four communities.
- **Network designing:** Planning cycle lane network should care about both the accommodation of cycle lanes within or between large bulks and the coordination of POIs.

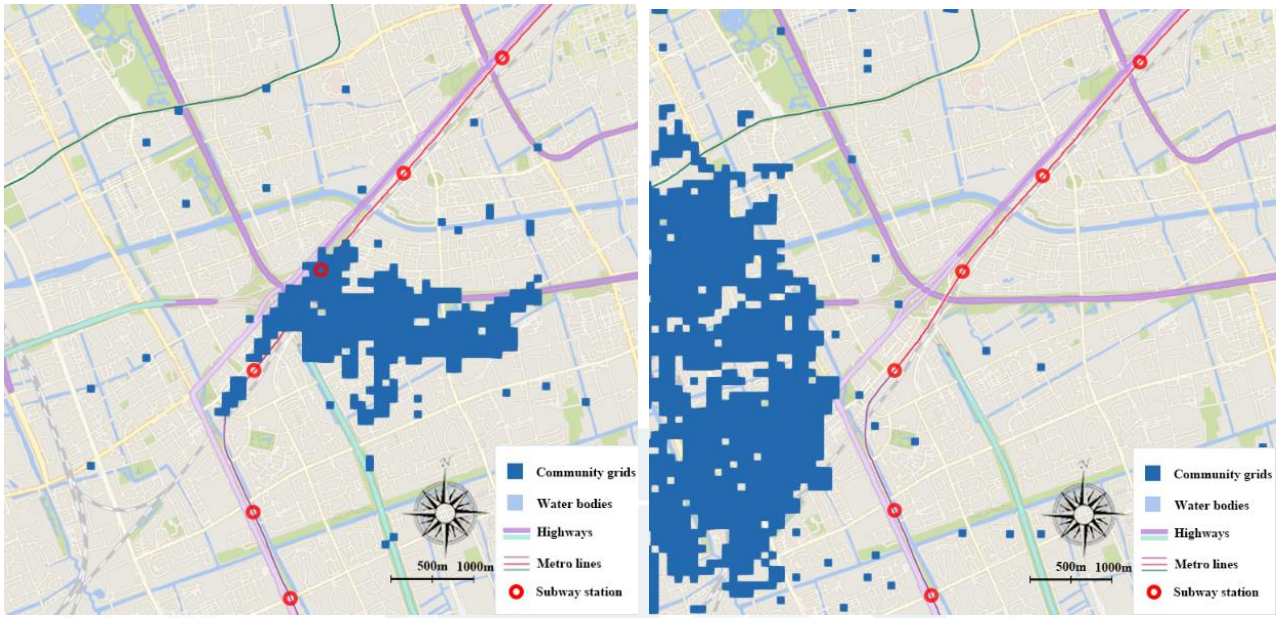


Community connection between subway station and nearby POIs

Factors of cycle lane network designing

(2) Geographic barriers

- **Features:** Some communities reflect their interaction with the surroundings, like being geologically blocked by highways, metro-lines or rivers.
- **Network designing:** Improve the integration of the cycling infrastructure with urban land use and other transportation systems.



(a)Blocked by highways and subway (b)Blocked by highways and rivers

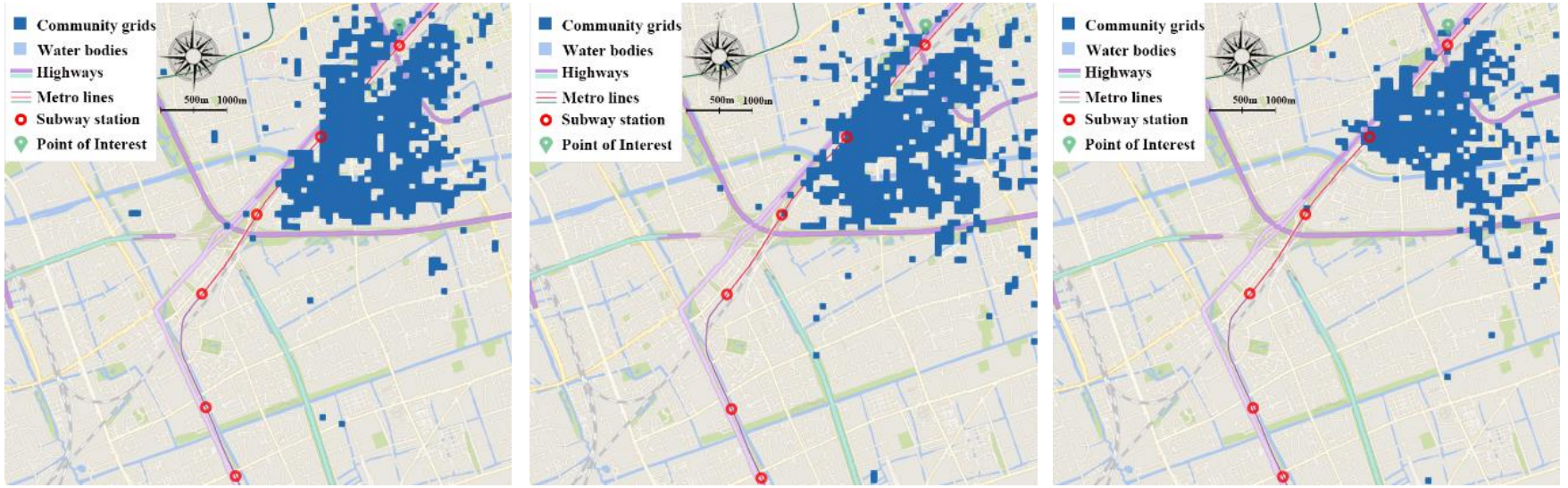
Examples of geographic barrier by urban land use

Factors of cycle lane network designing

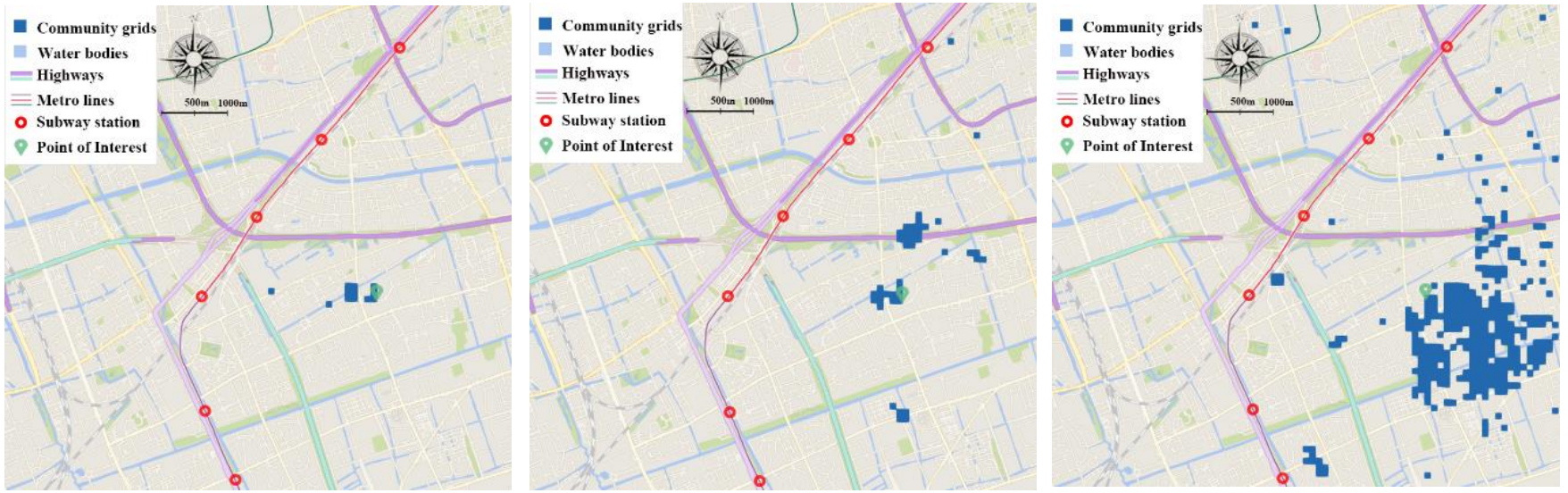
(3) Temporal variance of communities

We use POIs to represent the spatial traits in order to find the temporal variance of communities in a specific area.

- **Features:**
  - **Time-invariant:** Most POIs have the same or similar community distributions among three time-zones.
  - **Time-variant:** Communities have different orientations to grow and different distribution shapes among three time-zones.
- **Network designing:** POIs with time-variant communities are usually not the center of radial-pattern or grouped communities and play a role of junction between those time-variant communities. They might be suitable for cycling traffic flow monitoring.



POI with time-invariant communities



POI with time-variant communities

Problems of current cycle lane network

1. **Cycle lanes are not well connected in the form of a network structure.**

2. **The existing cycle lane network turns out to be an isolated system without sound integration with urban land use.**

4

Policy recommendations

Policy implications and recommendations

Introduction of electronic bike parking fences

- ✓ Take locating techniques, like GPS, to stipulate typical parking positions. Help to administrate dockless shared bikes collectively, and better control the distribution and rebalancing of shared bikes.
- ✓ Electronic bike parking fences are nodes in the network to connect cycle lanes. Centers of radial-pattern communities and bulks in grouped communities can actually play the role.

Integrated planning of land use and cycle lane network

- ✓ Remove geographic barriers and connect separated communities, including building up some overpasses or tunnels, like the “Bikesnake” established in Copenhagen.
- ✓ Make sure the coverage of important POIs in the cycle lane network.

Policy implications and recommendations

Setting up restricted areas for shared bikes

- ✓ Shanghai municipal government has published *Guidance on Encouraging and Standardizing the Development of the Internet Renting Bicycles* and imposed regulations on cycling behaviors, including nonstandard cycling and arbitrary parking.
- ✓ There are a number of crowded, historical but narrow roads in the downtown of Shanghai with an indispensable walking environment, calling for restriction. Help to protect the preserved historical areas and reduce accidents for areas with high safety risks.

Traffic monitoring of important POIs

- ✓ POIs with time-variant communities implicate the variation of bicycle flow. These important POIs are typical spots needing to be monitored with different measures at different time in order to prevent accidents.

Policy implications and recommendations

Construction of a bike sharing data platform

- ✓ Construction of a bike sharing data platform can help us better understand the full perspective of the existing cycle lane network and assist us in network designing.
- ✓ Policy makers can carry out massive data mining processes to discover the flaws of the existing cycle lane network of the whole Shanghai, then design a new one with the methodology and policy suggestions given above.

Research production

[1] Conference paper: Dingyi Zhuang, Jian Gang Jin, Yifan Shen, Wei Jiang, (2018) *An empirical study on cycle lane network using bike sharing data: the case of Shanghai,* the seventh International Conference on Transportation and Logistics (2018 T-LOG) (**Accepted**)

[2] SCI journal: Dingyi Zhuang, Jian Gang Jin, Yifan Shen, Wei Jiang, *An empirical study on cycle lane network using bike sharing data: the case of Shanghai,* Transportation Research Part A: Policy and Practice (**To be submitted**)

[3] Policy recommendation: Jian Gang Jin, Dingyi Zhuang, Yifan Shen, Wei Jiang, *Manage and control shared bikes to build a new cycle lane network*, Shanghai Research Institute for Urban Governance (**To be submitted**)

Thanks