Determining the station catchment area with walking distance distribution

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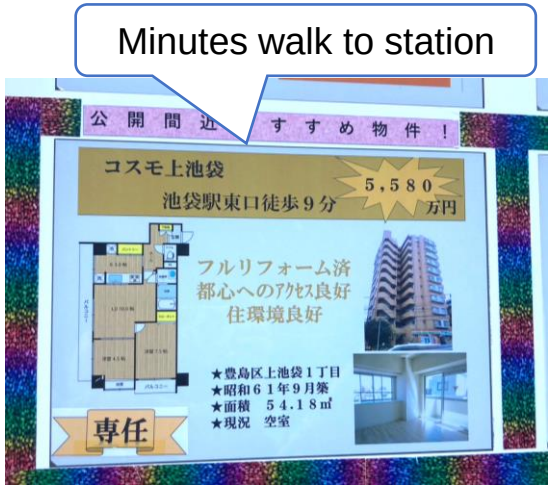
Center for Real Estate Innovation The University of Tokyo

Importance of station catchment area

- **Impact of Transportation Hubs on Urban Development**
  - Stations serve as critical transportation hub.
    - Attract a diverse population of residents and visitors.
    - Urban design in major Japanese cities is centered around stations.
- **The Economic Significance of Station Proximity**
  - Distance to stations plays a vital role in various economic activities related to real estate.
    - Office rent, hotel accommodation rates, residential property prices, and parking fees.

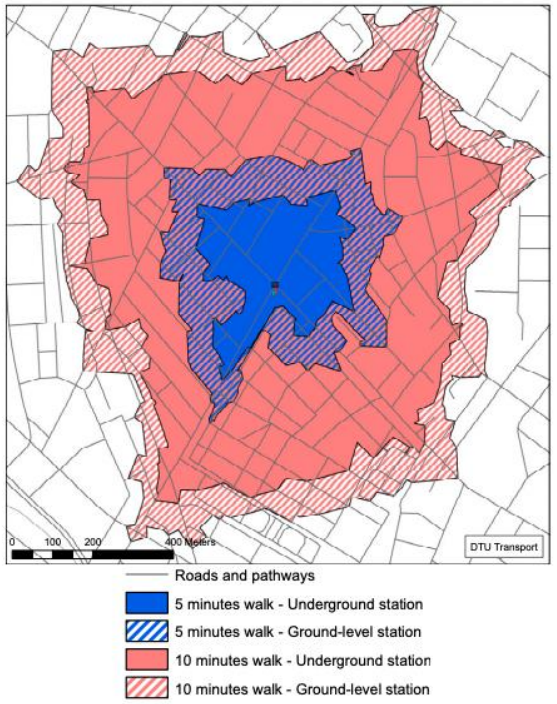
- It is important to define **station catchment area**
  - access to station on foot



Advertisement of housing

Define of station catchment areas

- **Deductive definition of station catchment area**
  - Spatial calculation under the assumption for movement
  - Distance metrics:
    - Euclid/Manhattan distance
    - Network distance…
- The size of the catchment area are depending on the environment around the station.
  - Facility location, Population composition
  - Walkability(Wide of pedestrian, Green-space..)
- Data-driven approaches are necessary to determine the correct station catchment area
  - Using GPS trajectory data



Catchment area using network distance
（J. L. E. Andersen & A. Landex.(2008)）

Previous studies

- Survey-Based Data:(Biba.et.al. 2010, Pueboobpaphan.et.al. 2022)
  - Limitation in investigating the actual distance.
  - Costly and not easily updated frequently for monitoring.

- GPS data for Trip Length Analysis:(Zuo et al. 2018)
  - They designed a GPS-based survey only for their research,
  - The number of samples needed to be more to discuss the differences among stations.

Our Research Motivation:

Monitoring of catchment areas in many stations from GPS-based big trajectory data.

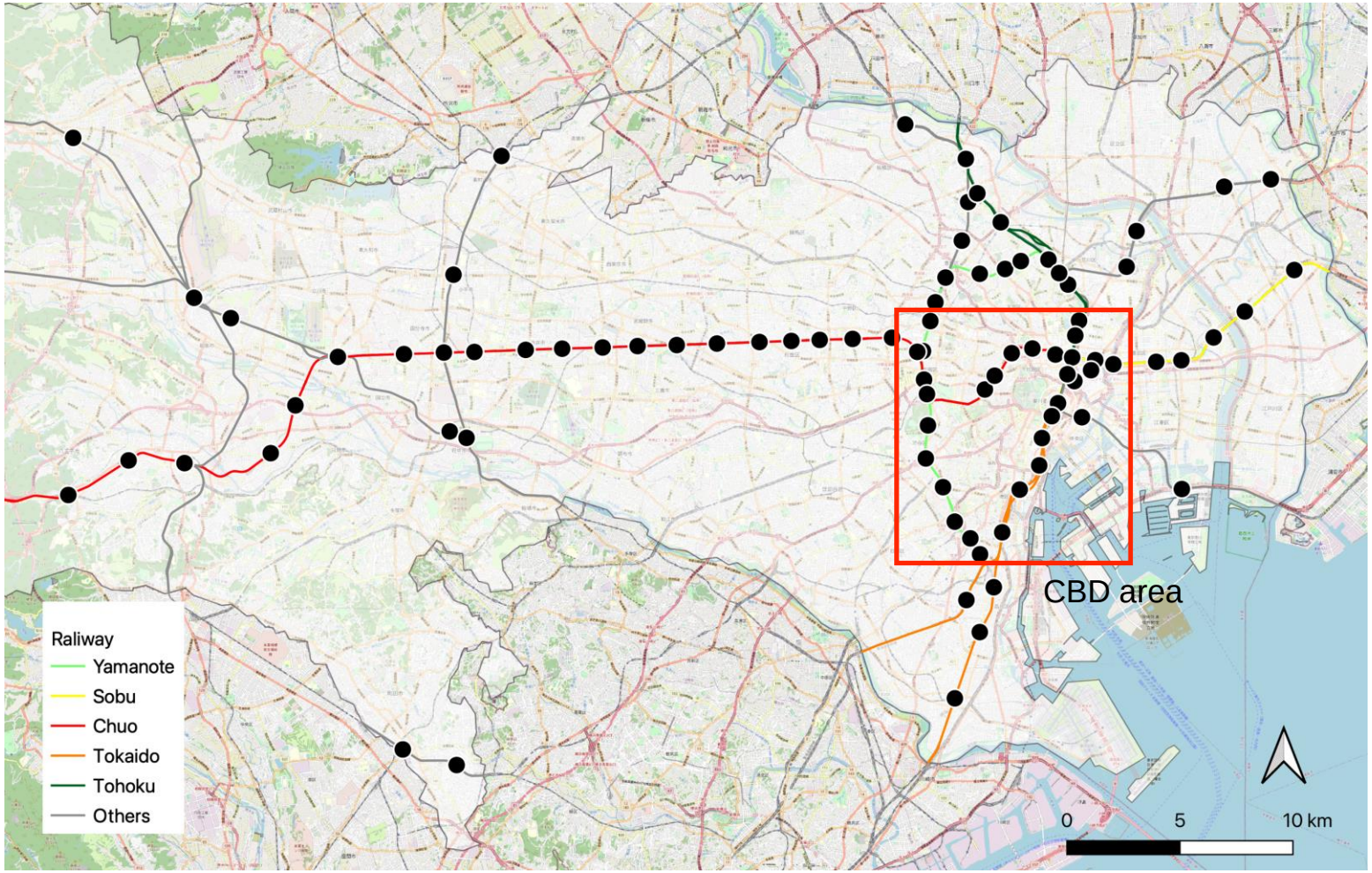
Aim of research

- **Objective:**
  - Investigate walking distance to railway stations using GPS-based Big Data in Tokyo
  - Understand ranges and distribution of distances within the station catchment area
    - Classification of stations from distance distribution

- **Contributions:**
  - Provide method of processing and analyzing detailed spatial-temporal Information:
    - Use individual trajectories to gather fine-scale spatiotemporal information from stations.
    - Categorize stations based on distance distribution and analyze catchment area range.
  - The Value of analysis in Tokyo:
    - Mature city (High TOD Level, Walkability, Aging of population)

Target area

- 88 stations in Tokyo across 15 lines operated by Japan Railway (JR).



GPS data source

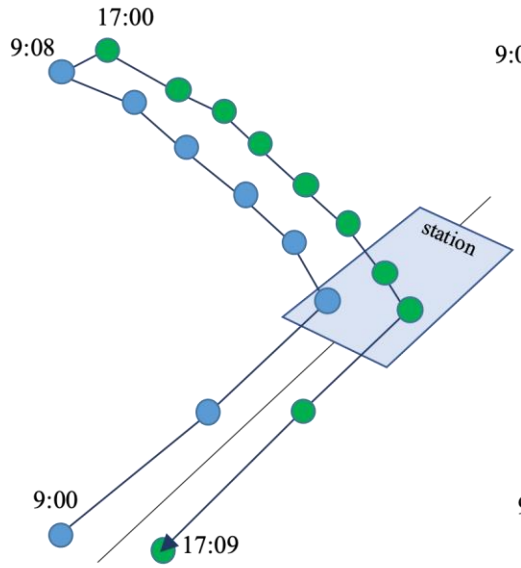
- Point-type floating population data (Agoop Corp. 2019).
  - Large-scale and fine-grained point data from smartphone
  - It is used for understanding travel behavior (Joo et al. 2022, Kato et al. 2022, Yamagata et al. 2019)

- Data attributes
  - User ID, time, latitude, and longitude
  - Intervals of data transmission are less than 10 minutes

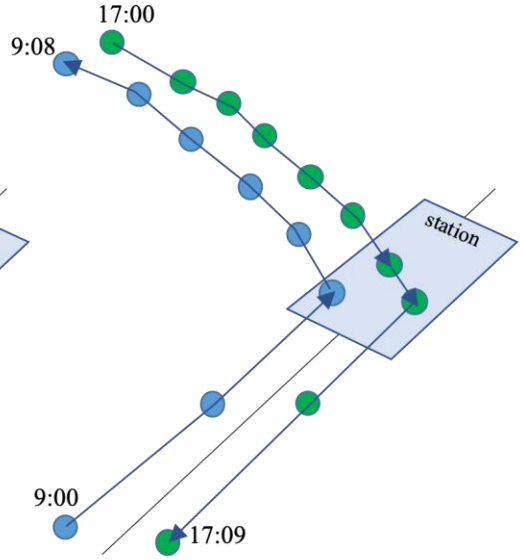
- Period
  - April 16 to April 29, 2019, between 6:00 and 24:00.
  - Approximately 1.2 million unique user IDs in the target metro area.

GPS data processing

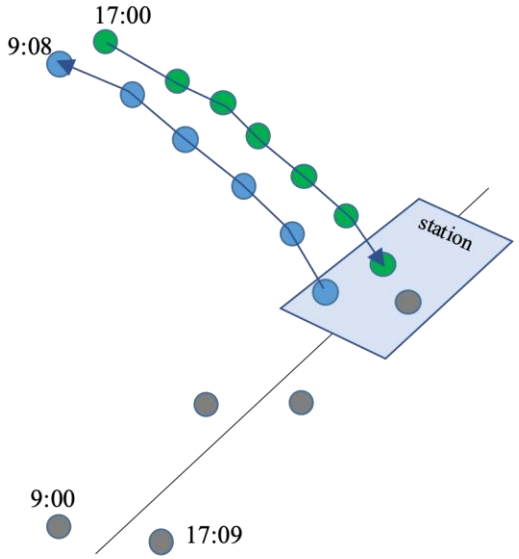
- Extracting the walking trip with three steps



1.Connect in each user ID points in chronological order

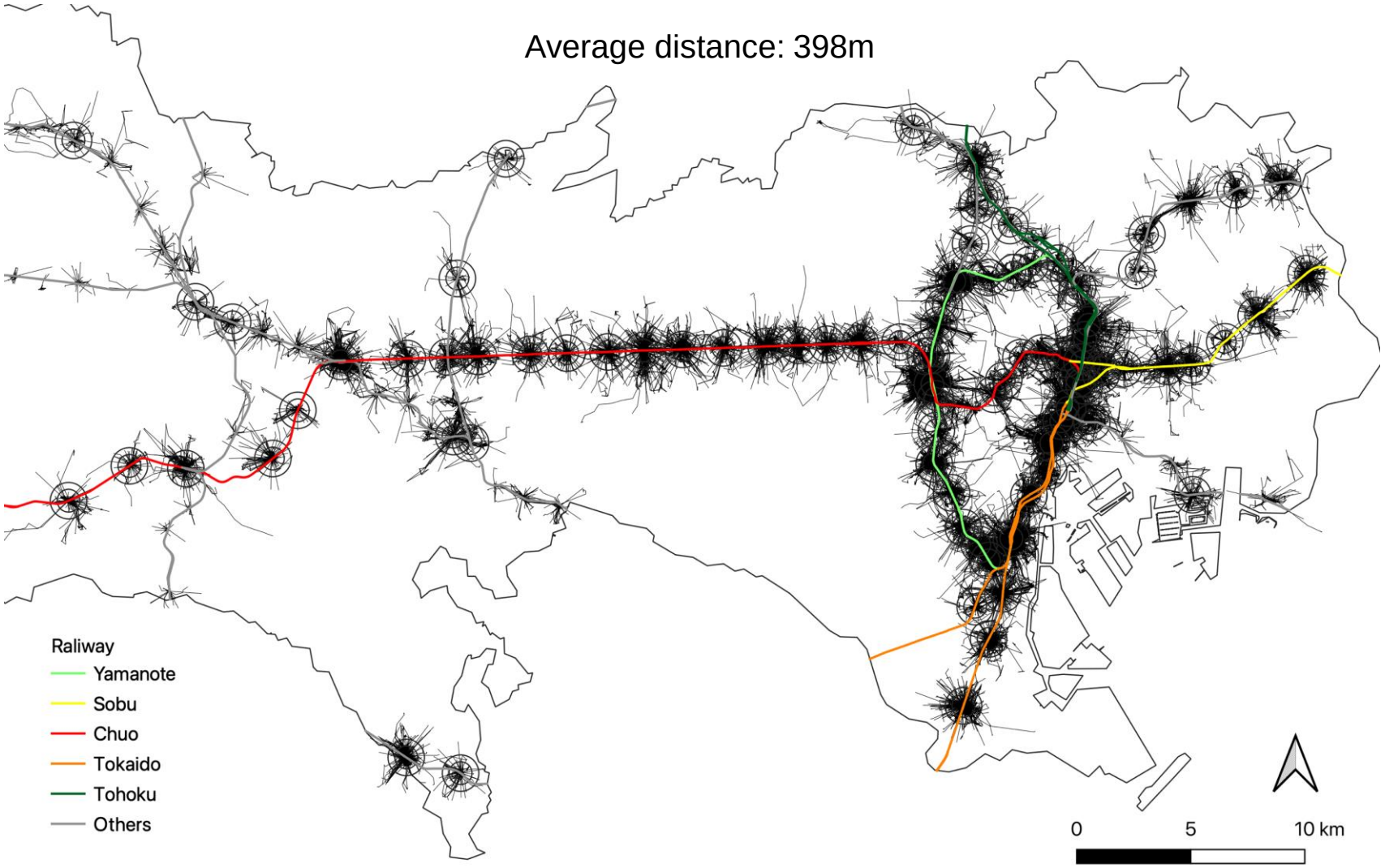


2.Separate lines



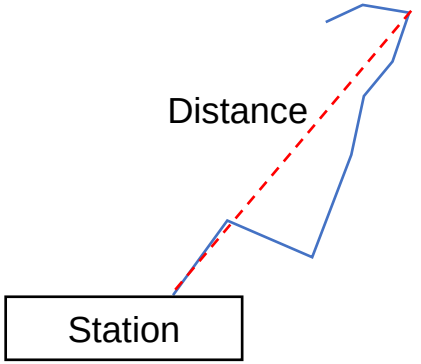
3.Select walking trips

Average distance: 398m

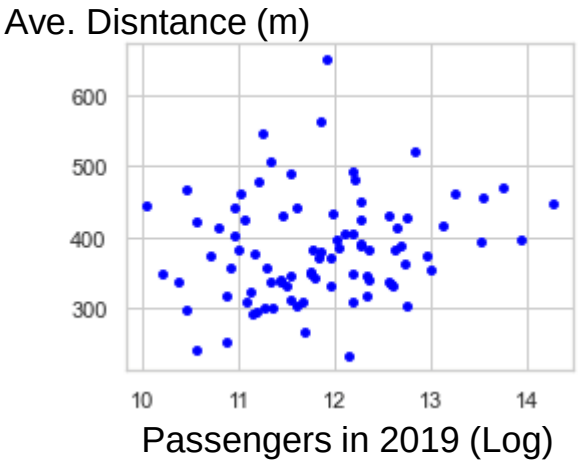


Walking trip distance

- Distance of walking trip is Euclid distance from station polygon to the farthest point

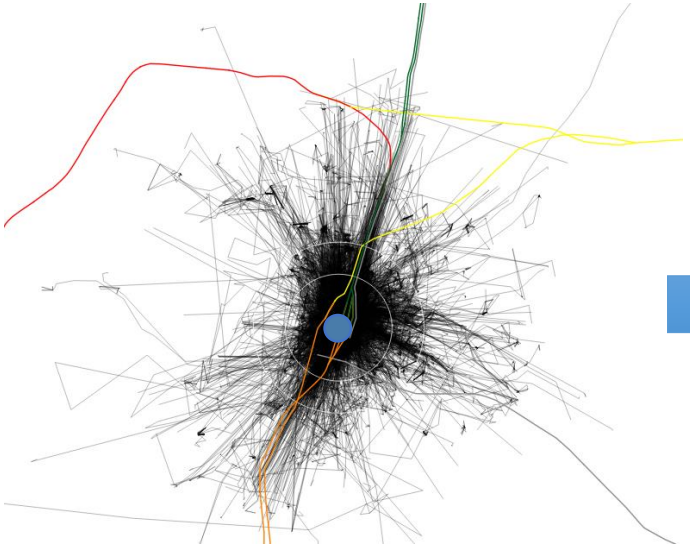


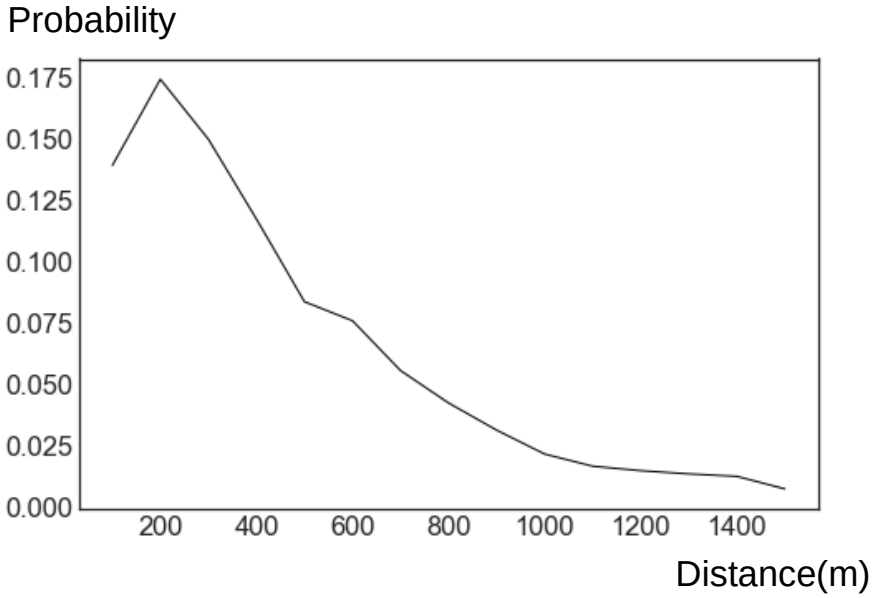
- It is no clear relationship between distance and size of station.



Walking distance distribution

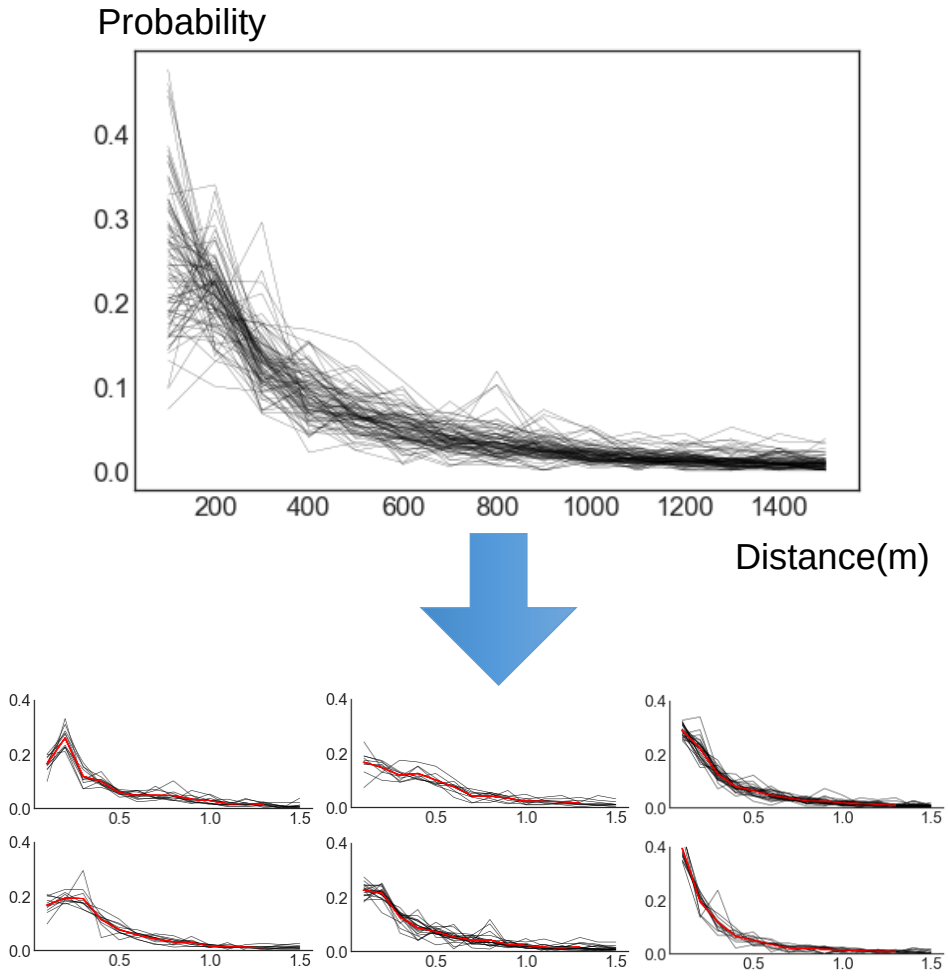
- Create a probability distribution (walking distance distribution) by summing trip lengths for each distance band
    - Characterize each station by probability decay





Distance distribution

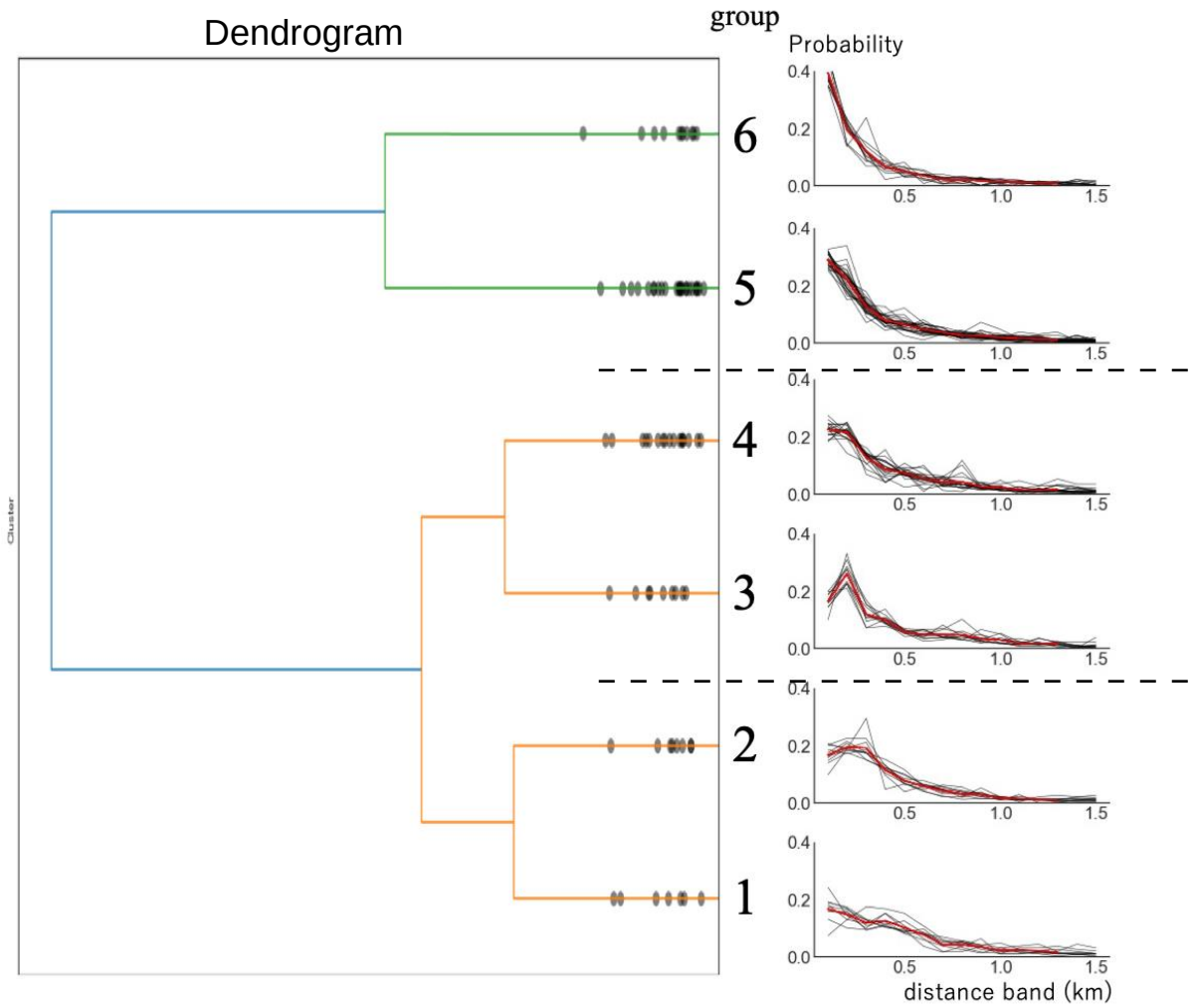
- Walking distance distributions of the 88 stations
  - Trend of more short-distance trips but the rate of decay in trip frequency varies among stations.
- Classify the walking distance distribution pattern



Result of classification

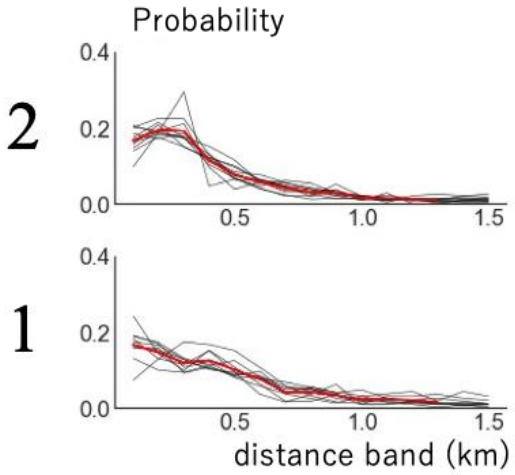
- 6 groups based on hierarchical clustering method(Dendrogram).

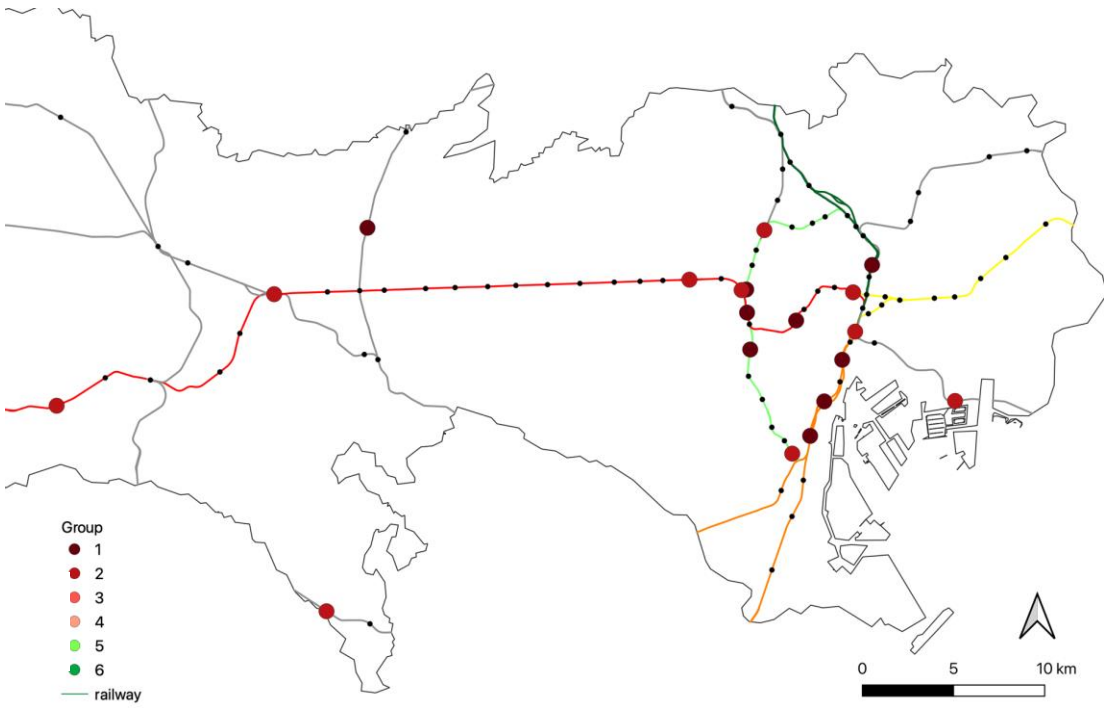
- Trend of catchment
  - Large: Group1,2
  - Middle: Group3,4
  - Small: Group5,6



Spatial distribution of groups

- Large catchment areas(Group 1, 2)
  - Group2 has relatively concentrated distribution until 500 m.
  - Almost locate in CBD area



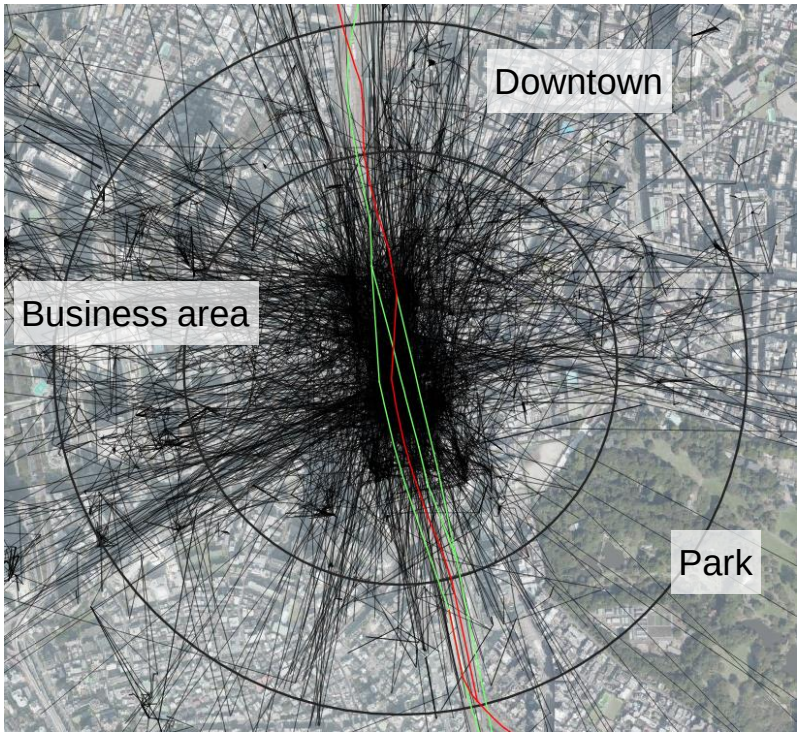


Spatial distribution of groups

- Large catchment areas(Group 1, 2)
  - Large station in CBD
  - Business area, Downtown are near station

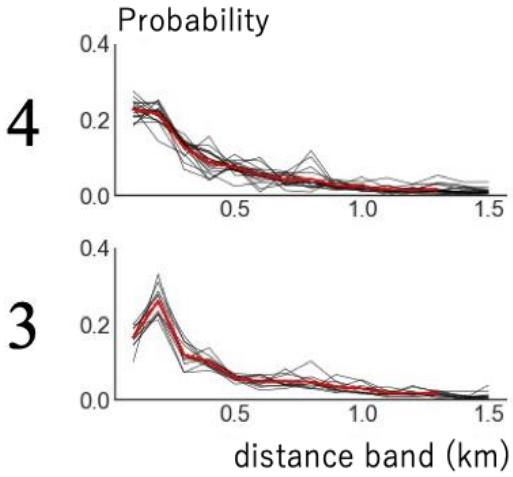
https://livejapan.com/ja/in-tokyo/in-pref-tokyo/in-shinjuku/article-a0001085/

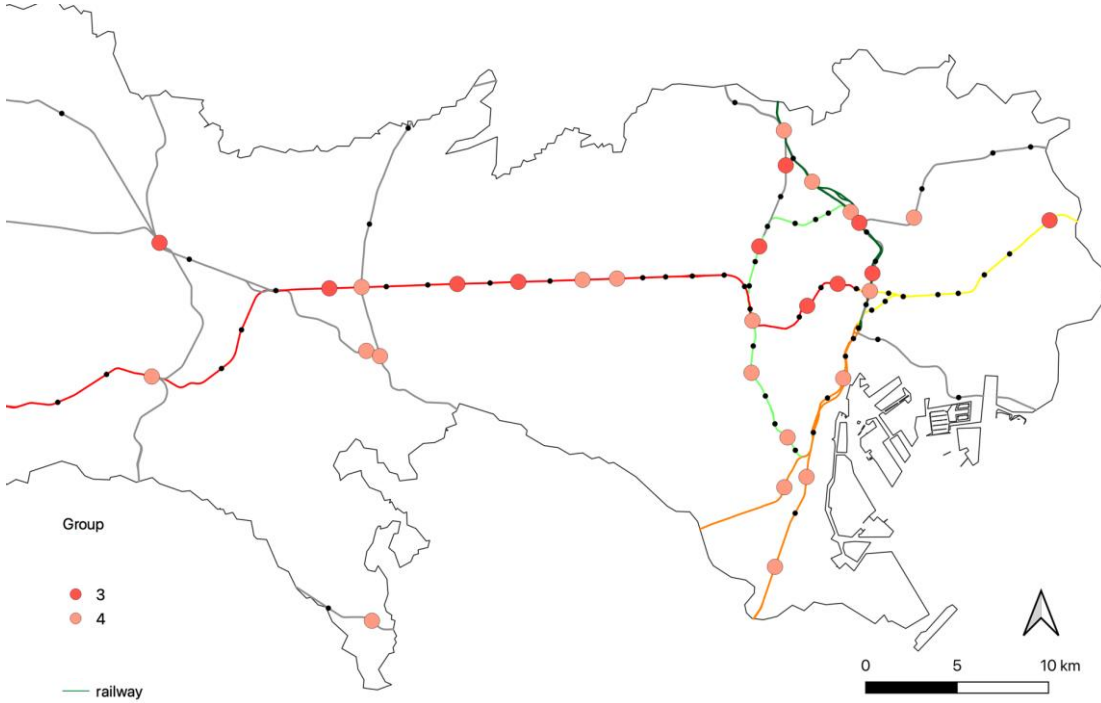
Shinjuku station (Group 1)



Spatial distribution of groups

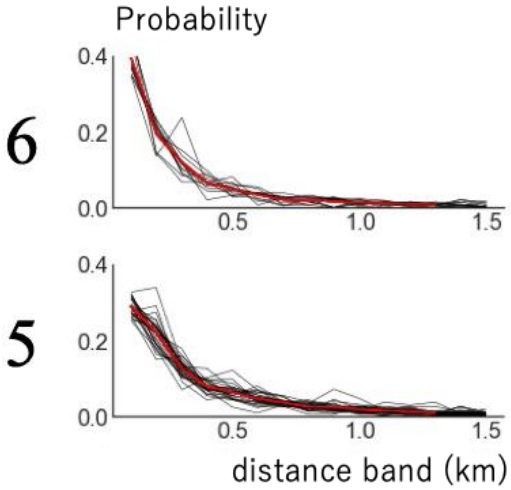
- Middle catchment areas(Group 3,4)
  - Catchment area are shorter than Group1,2
  - Group3 has higher concentrated distribution within 200 m.

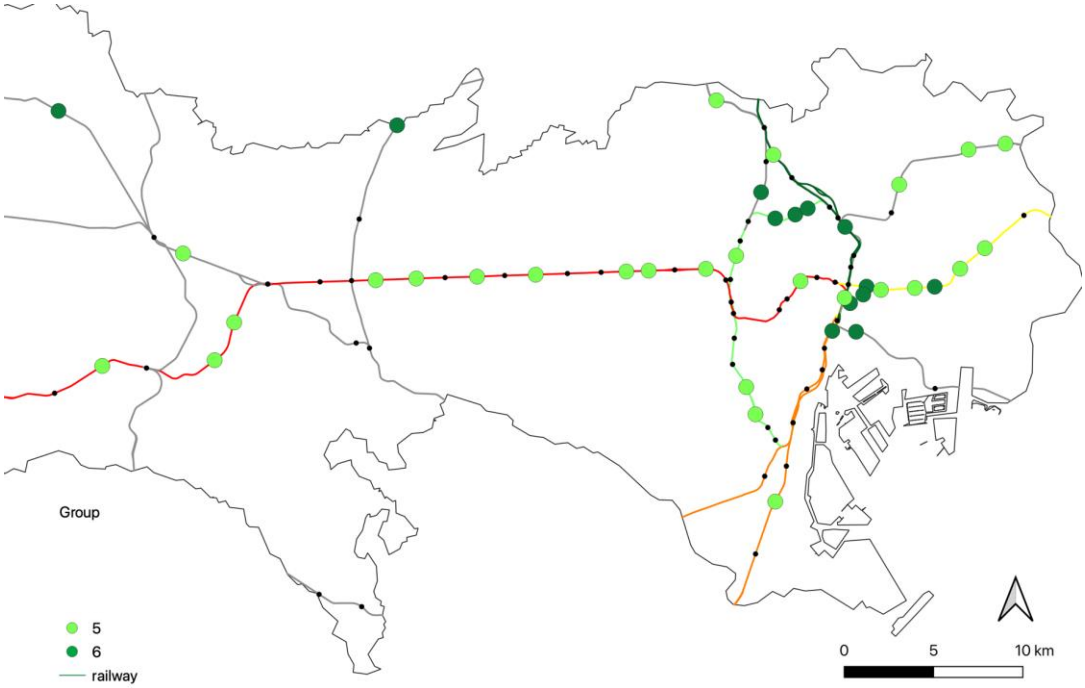




Spatial distribution of groups

- Small catchment areas (Group 5,6)
  - Short average distances They are almost residential area around stations.





Conclusion

- This study examines station catchment areas in Tokyo, considering walking distance for Transit-Oriented Development (TOD).

- **Key findings include:**

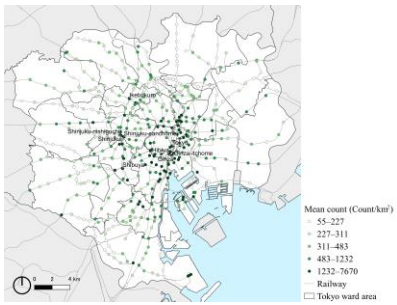
1. GPS-based Walking Distance Analysis
   - GPS analysis accurately identifies walking distances from stations, enabling effective monitoring of spatial planning effects.
2. Variation in average walking distance
   - Average walking distances vary by location, ranging from 233m to 651m for target stations, informing built environment and transit service considerations.
3. Importance of Distance Distribution
   - Distance distribution analysis provides valuable insights beyond averages, resulting in the classification of transit stations into six groups with similar average distances but different distributions.

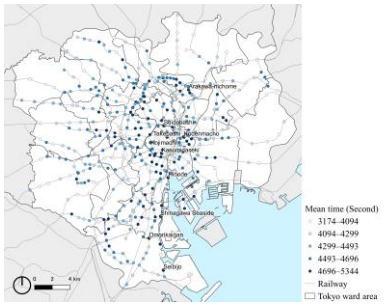
On-going works

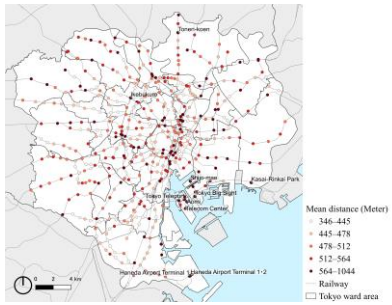
- **Why was the catchment area created?**
  - Development Pedestrian Movement Index
  - Impact of TOD attributes (road network, facility density etc.) varied walking pattern

Daisuke Hasegawa, Sunyong Eom, Tsutomu Suzuki.(2023).“Determining the Transit Catchment Area and Distance Distribution”,
The 18th International Conference on Computational Urban Planning and Urban Management(CUPUM2023), 2023

Eom, S., Kim, H., Hasegawa, D., & Yamada, I. (2024). “Pedestrian movement with large-scale GPS records and transit-oriented-development attributes”. *Sustainable Cities and Society*, 102, 105223.
https://doi.org/10.1016/j.scs.2024.105223
Press Release： https://www.t.u-tokyo.ac.jp/en/press/pr2024-01-31-001







Pedestrian Movement Index (Count, Time, Distance)

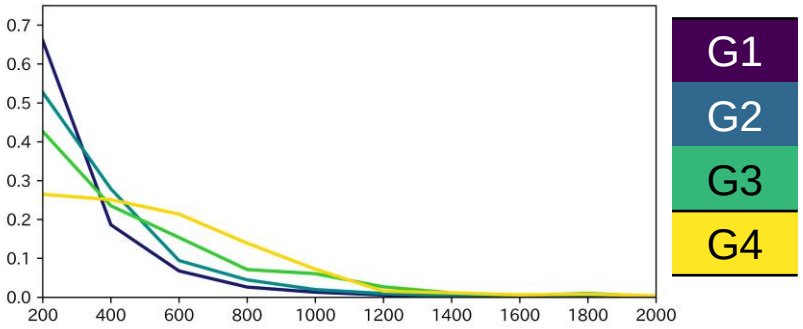
Density: (Pop density.FAR)
Destination: (Land use, POI)
Diversity: (Entropy of land use)
Design: (Intersection, Street)
Distance to transit:
(Transit frequency, neighboring station)

TOD attributes(5Ds)

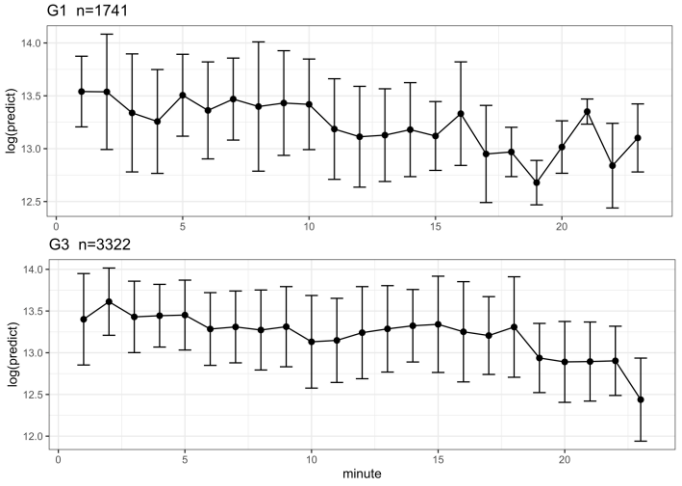
On-going works

- **What is the impact of the expansion of the catchment area?**
  - Impact of station catchment area varied housing price

Daisuke Hasegawa, Sunyong Eom, Tsutomu Suzuki.(2023)“Determining the Station Catchment Area and Measuring Distance Distribution”,Center for Spatial Information Science Joint Research Presentation Meeting (CSIS DAYS2023), 2023 (Best presentation award)



Groups of walking distance distribution



Each group housing price

Quantifying the impact of improved walkability

Thank you for your attention