KYUSHU UNIVERSITY

A study on dynamic trend of urban hotspots using SNS data

Main contributions:

- A new SNS-based method for identifying urban hotspots
- The dynamic changing trend of urban hotspots
- The driving factors of dynamic trend of urban hotspots

Yujie Ren, Shichen Zhao, Kyushu University

Department of Urban Design, Planning and Disaster Management

Graduate School of Human-Environment Studies

Contact: *ren.yujie.994@s.kyushu-u.ac.jp, 080-7982-6567*

概要:
In order to explore the emergence and formation mechanism of urban hotspots, this study collected Sina Weibo check-in data to design an urban hotspot identification method, and analyzed the dynamic trend of the location, attribute, and function of urban hotspots in the central area of Nanjing.
The results showed that: (1) There are 309 urban hotspots in the downtown area of Nanjing, which respectively bear the functions of daily living space, public service areas, tourist attractions and entertainment centers. (2) From the perspective of location, the urban hotspots will explode to the city's commercial center and tourist attractions along the main road in the afternoon of non-working days. (3) In terms of basic attributes, the number, area and popularity of urban hotspots obey the characteristics of reaching maximum value on weekends and holidays (4) From the perspective of functional changes, the urban hotspots centered on well-known universities and parks will merge into large urban hotspots of entertainment centers in the afternoon of non-working days; the edge of urban large-scale entertainment center urban hotspots will differentiate and derive some small-scale urban hotspots of daily life spaces; the urban scenic spots around the residential area will be converted into daily life spaces in the weekday morning to undertake the leisure activities of the surrounding residents.
In addition, through qualitative and quantitative analysis of the driving factors of the dynamic change of urban hotspots, we found that large-scale population migration and the commuting mode of residents may be the main reason of urban hotspot displacement, and the population density and accessibility of public transportation facilities are the main driving forces on the number, area and popularity of urban hotspots.
This work takes urban researchers one more step toward detecting urban hotspots real-timely.

KYUSHU UNIVERSITY

Introduction: Motivation of understanding of urban hotspot dynamically

- **Dynamic urban hotspots had shown a significant impact on urban system.**
- *The aggregation of **public facilities** is the main reason for the change of **housing price** (Leung et al., 2006);*
- *High density tourist flow and **scenic spots** will affect the operation of urban **transportation system** (Nilsson et al., 2000);*
- *The passenger flow of urban central **business district** is also dynamically related to urban $PM_{2.5}$ emission (Traversi et al. 2009).*

- **The research on urban hotspots remained room for improvement.**
- *The research on urban hotspots based on **theoretical methods** and **econometric models** can not **accurately** identify the number and scope of hotspots (Gulia et al. 2017).*
- *The clustering research based on **POIs** from **digital maps** neglects the **dynamics** of urban residents and the **real-time situation** of using these hotspots (SM et al., 2019).*

KYUSHU UNIVERSITY

Methodology: The detailed technical scheme of this study

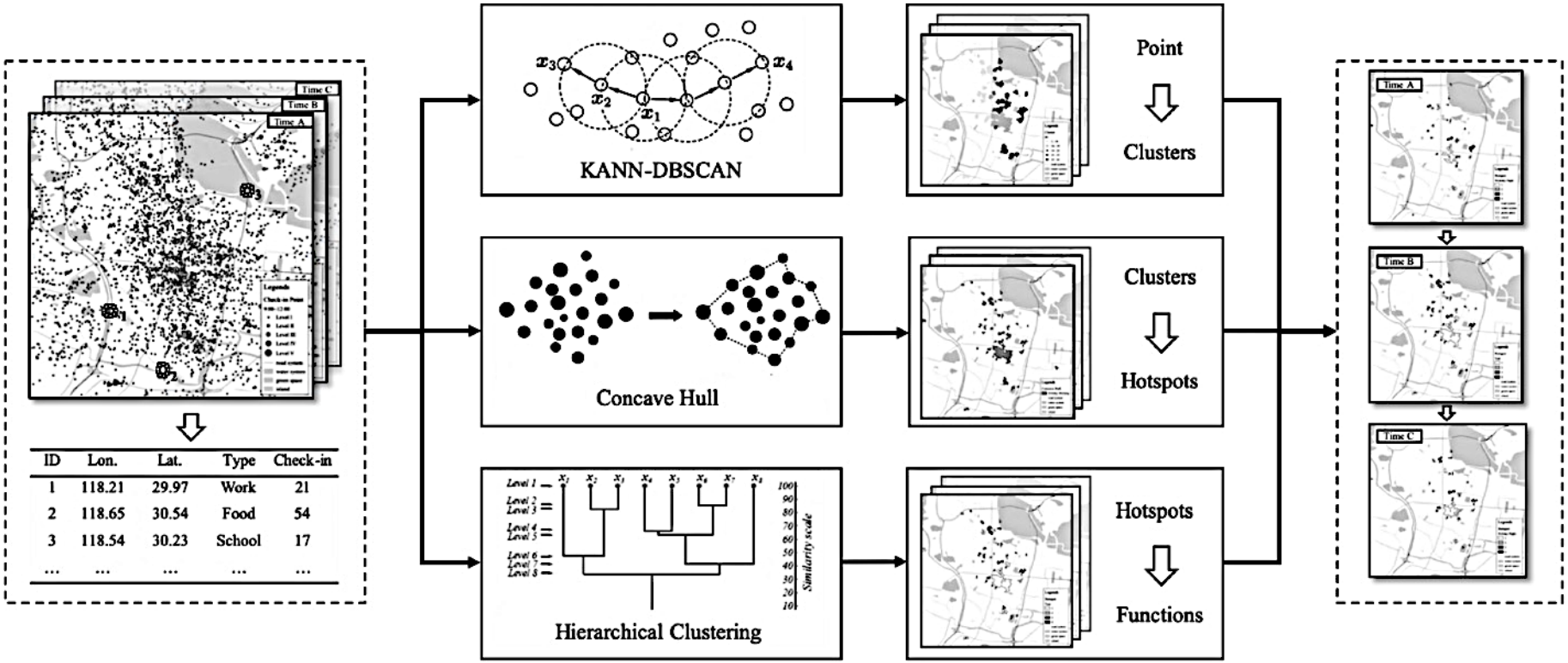


Figure 1. Technical scheme

KYUSHU UNIVERSITY

Methodology: Sina Weibo check-in data

Table 1. Basic information of check-in data

Date	Time	Leisure	Others	Public service	Residence	Tourism	Transportation	Work	Sum
2014.04.27	06:00-12:00	63479	18029	51519	19233	11336	26367	11595	201558
2014.04.27	12:00-18:00	128024	33883	109489	35052	19279	51333	21126	398186
2014.04.27	18:00-24:00	84169	23173	70310	24467	17880	33772	14558	268329
2014.04.29	06:00-12:00	55714	20372	59175	26653	10920	26620	12299	211753
2014.04.29	12:00-18:00	58616	27255	66721	33039	11654	30383	17720	245388
2014.04.29	18:00-24:00	40370	16459	42125	23496	8429	23524	9934	164337
2014.05.01	06:00-12:00	65841	16040	45755	19519	11873	32697	10736	202461
2014.05.01	12:00-18:00	84430	24759	63591	28885	17846	42292	16025	277828
2014.05.01	18:00-24:00	127069	37535	91992	42091	26154	77797	22483	425121

The original check-in points are divided by the Weibo platform into 200 types, this study merged the original types into **7 activity categories** (see details from Table 1) according to land use regulations, check-in activities and Yan et al.'s work *(Yan et al., 2019)*.

A total of 2,394,961 SNS check-in data was collected in the core area of Nanjing from Sina Application Programming Interface (API) using a crawler tool written in Python.

Methodology: How to cluster the check-in points into groups?

In order to find the hotspots accurately, a new method of self-adaptive determination of DBSCAN algorithm parameters (***KANN-DBSCAN***) is selected. In this algorithm, candidate *Eps* parameters are generated by *K-means* nearest neighbor method, and corresponding *MinPts* parameters are obtained by mathematical expectation *(Bharti, 2019)*.

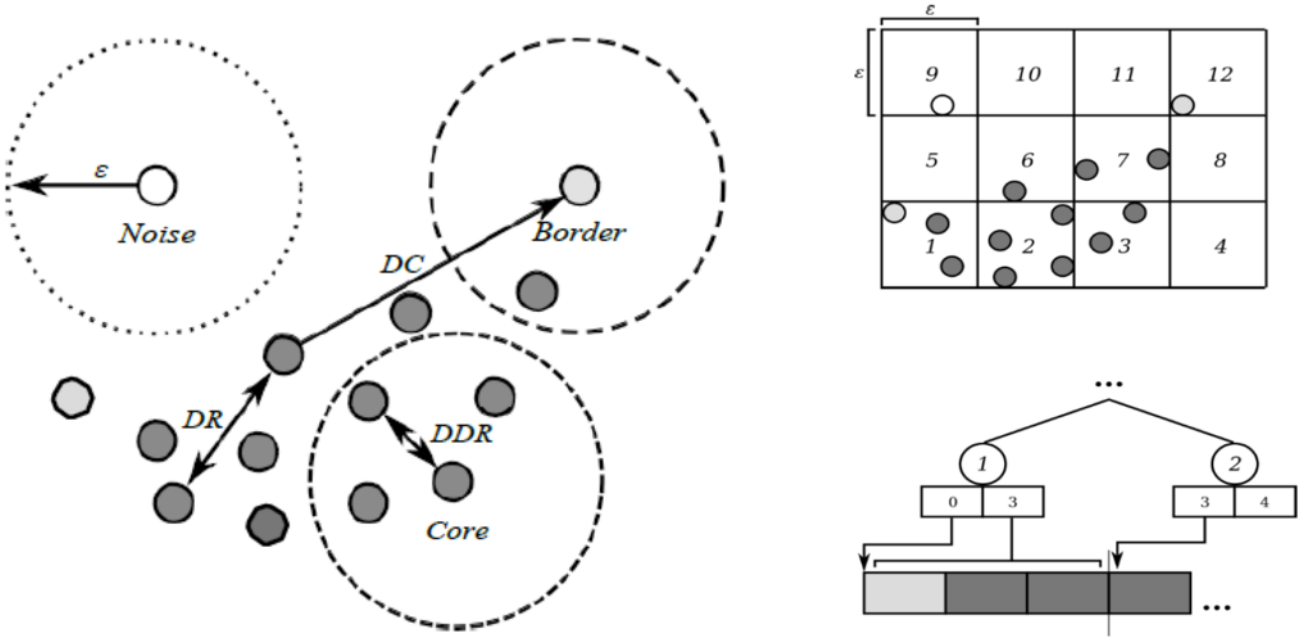


Figure 2. KANN-DBSCAN clustering with *MinPts = 4*

In this work, the KANN-DBSCAN algorithm was run in RStudio 3.6 with R language.

Methodology: How to detect the of scope of urban hotspots?

After clustering all check-in points into clusters and removing noise points, this work had to forward another step to detect the ***scope of each urban clusters***. Drawing the boundary for a cloud of points had always been the main research field for the computer vision (CV). Among all the related CV algorithms, ***convex hull*** and ***concave hull*** are the two most popular ones.

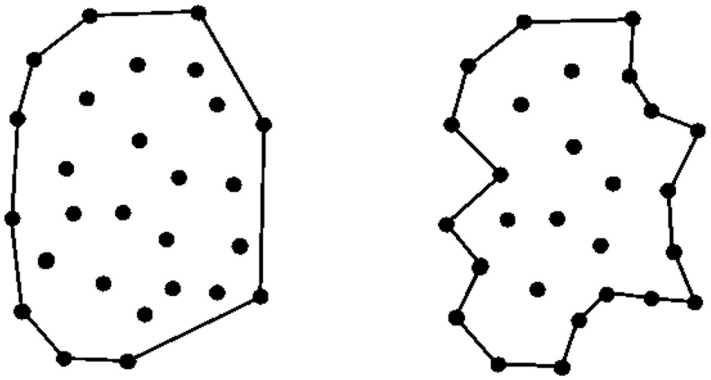


Figure 4. Convex hull (left) and concave hull (right)

The concave hull has shown a great performance in dealing with real world problems, like detecting the urban boundaries *(Craig, 2017)*. As a result, in this work, the concave hull of check-in clusters was defined as the urban hotspots, and the number of check-in activities and area of the hulls were defined as the popularity and area of urban hotspots.

KYUSHU UNIVERSITY

Results: Spatial distribution of urban hotspots

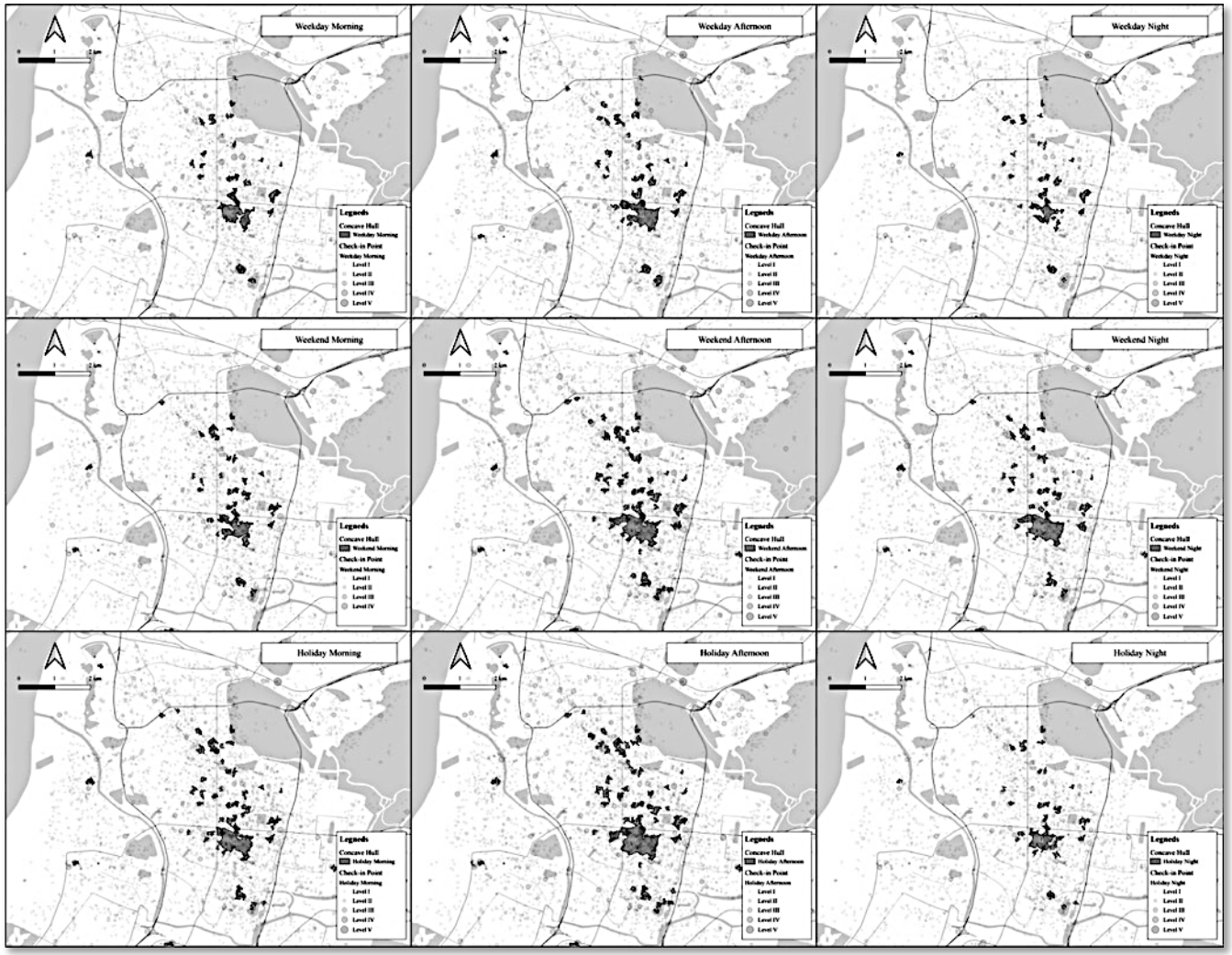


Figure 5. The spatial distribution of urban hotspots (total of 309)

KYUSHU UNIVERSITY

Results: Spatial distribution of urban hotspots

Using the urban hotspot extraction method designed in this work, a total of ***309 urban hotspots*** were extracted from the Weibo data of 9 time periods in the central area of Nanjing.

As can be seen from the above picture, the urban hotspots in Nanjing's main urban area are mainly distributed in ***Nanjing Xinjiekou commercial circle, Hunan Road commercial circle, Confucius Temple scenic spot, Arctic Pavilion scenic spot, and Nanjing Station square***. Moreover, the location, quantity, area, and even popularity of urban hotspots have continuously changed over time.

In addition, by comparing the results of this case study with the results of traditional research and ***Nanjing urban and rural land layout planning***, it is found that this method can accurately and efficiently identify urban hotspots and determine their functions.

KYUSHU UNIVERSITY

Results: Functional orientation of urban hotspots

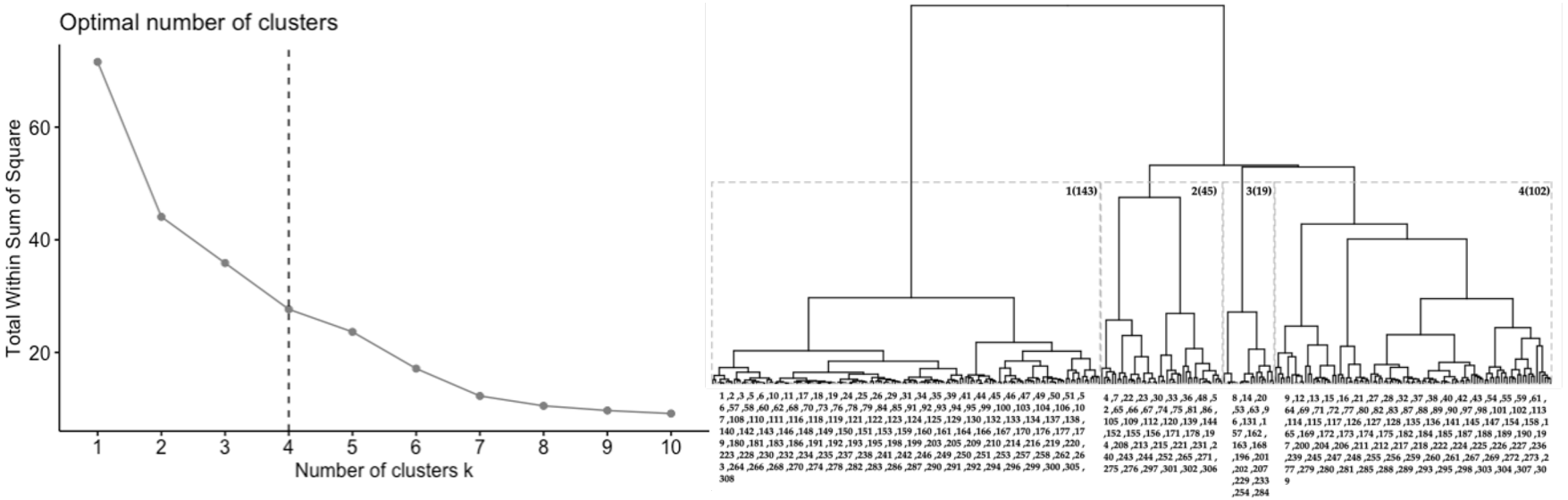


Figure 6. The result of HCA

After the identification of urban hotspots in downtown of Nanjing, ***the proportion of 7 types of check-in points was counted for the further HCA***. As seen in Figure 6, the result of optimal number calculating showed that the 309 urban hotspots should be classified into ***4 groups***. The hierarchy of HCA was shown in Figure 6. The prime result showed that, most of the urban hotspots were grouped into group 1 and 4, up to 143 and 102. These two groups of urban hotspots occupied 46.3% and 33.0% of the total, respectively. Group 3 account for the least number of urban hotspots of 19.

KYUSHU UNIVERSITY

Results: Functional orientation of urban hotspots

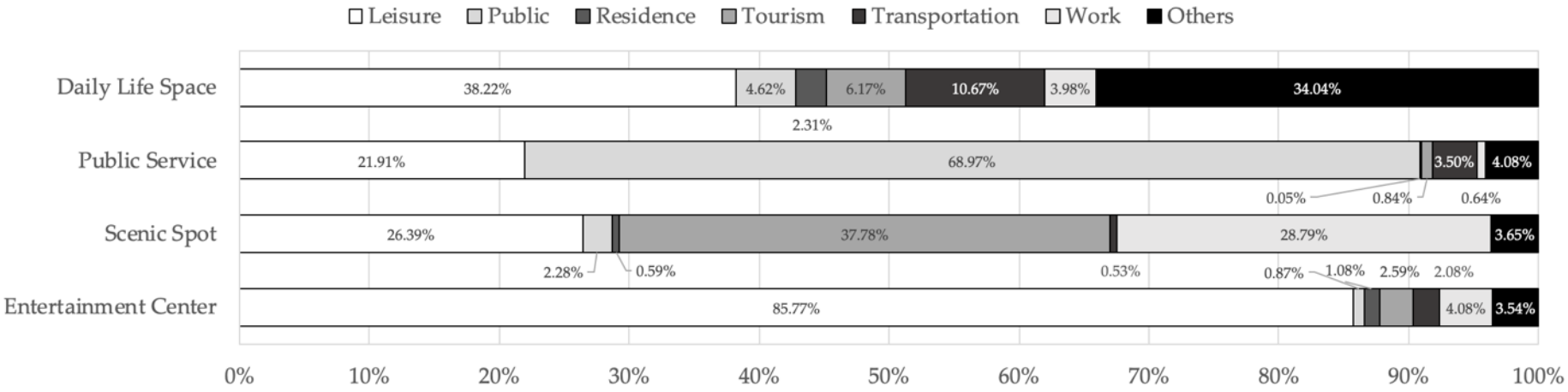
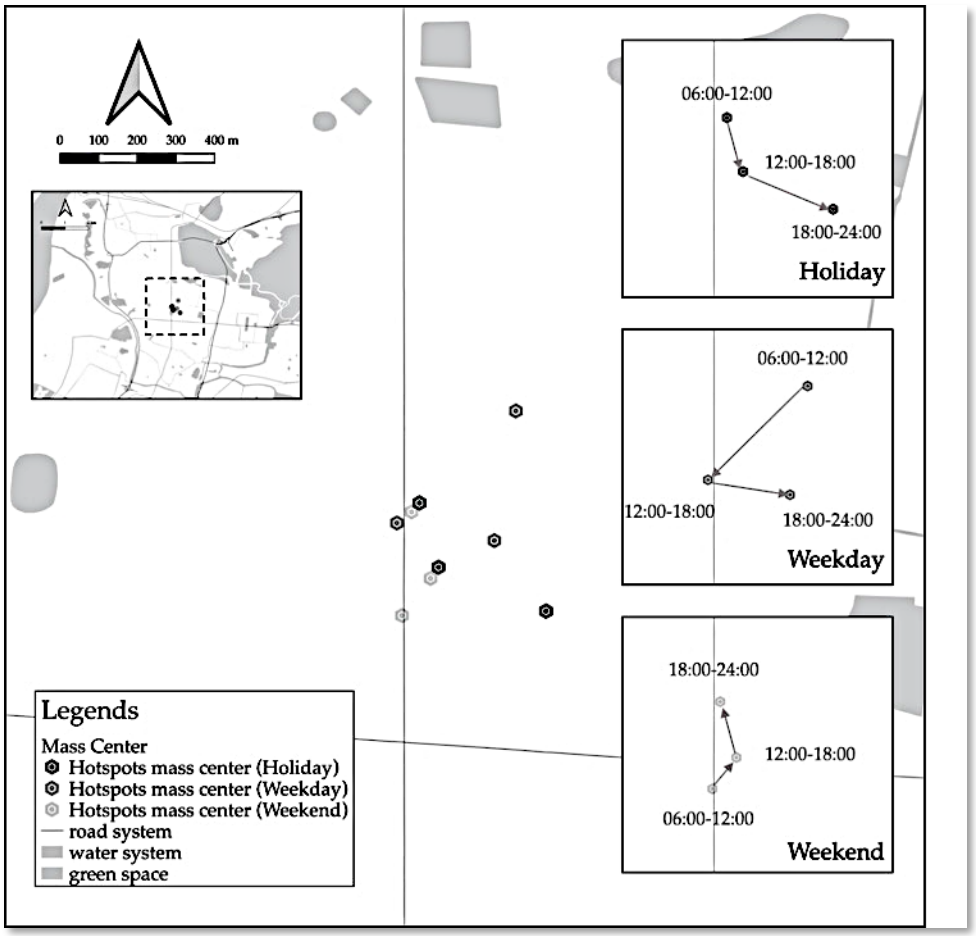


Figure 7. The functional orientation of urban hotspots

We implemented a case study in the central urban area of Nanjing and identified ***309 urban hotspots*** in the experimental area during 2014.04.27 to 2015.05.01. In addition, we also found that these urban hotspots undertook the functions of ***daily living space, public service area, tourist attractions and entertainment center***.

KYUSHU UNIVERSITY

Results: Dynamic trend of location of urban hotspots



The results showed that:

(1) From *the perspective of migration direction*, the migration direction o f three days (holiday, weekend and workday) showed completely diffe rent characteristics.

(2) *In terms of migration path length*, t he shortest migration path length (344.7m) is on April 27, 2014 (week end), and the longest migration pat h length (720.8m) is on April 29, 20 14 (weekday).In addition, the migr ation path of hotspots mass center i n holiday is 509.0m.

Figure 8. The migration path of mass centers of urban hotspots

KYUSHU UNIVERSITY

Results: Dynamic trend of amount of urban hotspots

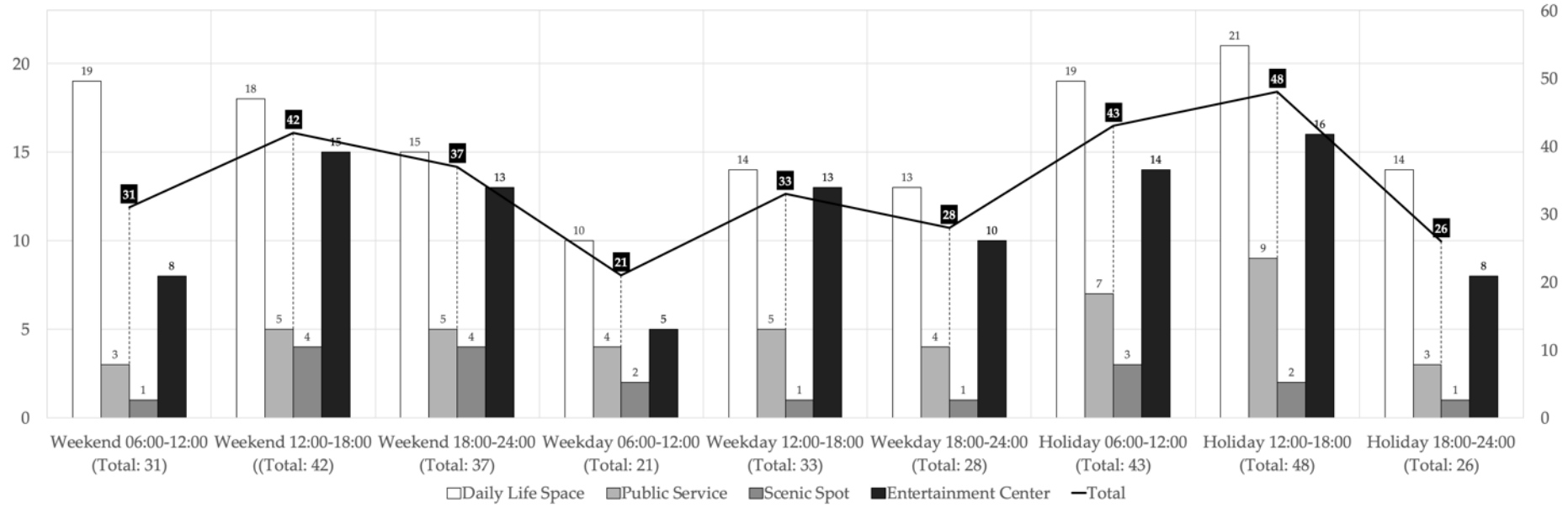


Figure 9. Dynamic trend of amount of urban hotspots

(1) In general, during the study period, the urban hotspots in the main urban area of Nanjing are mostly on ***holiday (117)*** and ***weekend (110),*** while the number of urban hotspots on weekday was less than the other two days, only 82.

(2) Specifically, the morning and afternoon of the holiday and the afternoon of the weekend are the periods with the largest number of urban hotspots.

KYUSHU UNIVERSITY

Results: Dynamic trend of area of urban hotspots

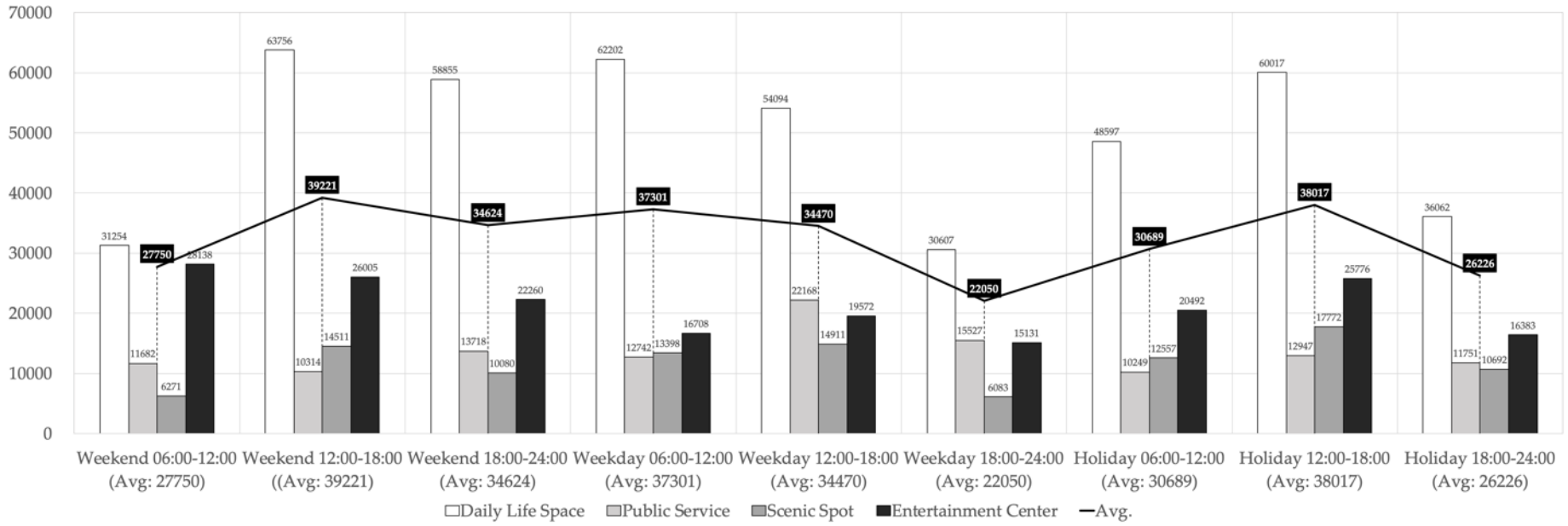


Figure 10. Dynamic trend of area of urban hotspots

(1) In general, the average area of urban hotspots in the study period is the largest on ***weekend***, the second on ***holiday***, and the smallest on weekday, 34442.28m^2, 32703.91m^2 and 30953.80m^2, respectively.

(2) Specifically, the average area of urban hotspots in holiday afternoon, weekday morning and weekend afternoon were relatively larger, all over 36000m^2. Followed by the ***weekday afternoon and weekend night***, the average area in these periods were about 35000m^2.

KYUSHU UNIVERSITY

Results: Dynamic trend of popularity of urban hotspots

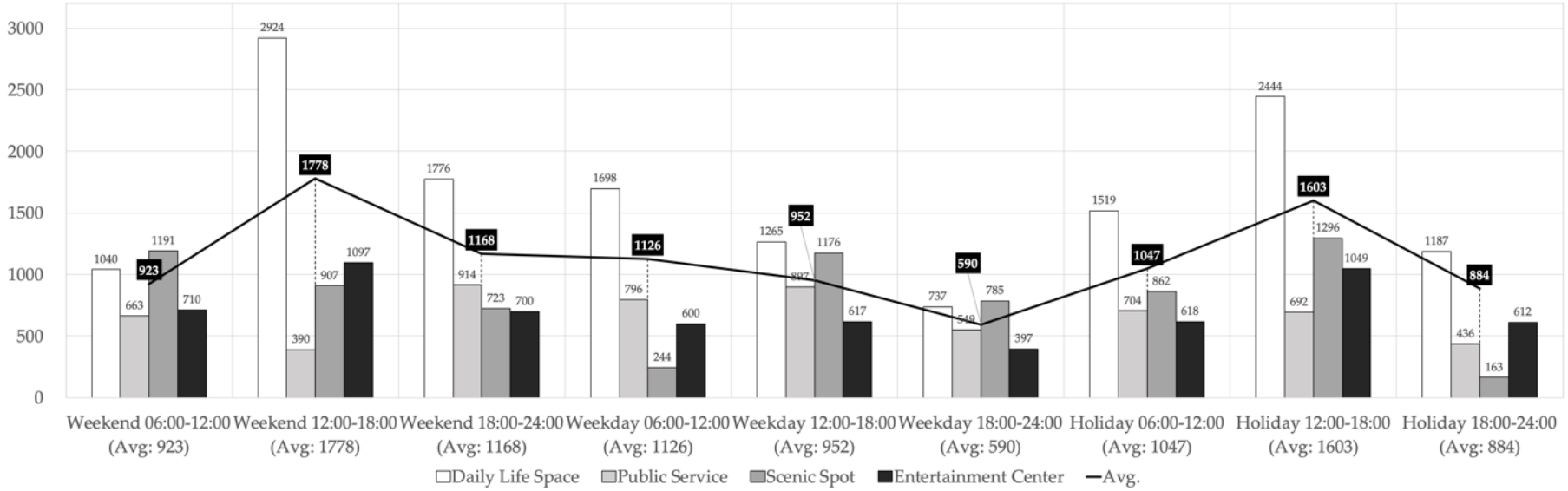


Figure 11. Dynamic trend of popularity of urban hotspots

(1) In general, the distribution characteristics of popularity of urban hotspots was close to their number, ***showing that weekend and holiday were much higher than weekday***.

(2) Specifically, the average popularity of urban hotspots on holiday and weekend was ***extremely high in the afternoon (the maxima appeared on the afternoon of the weekend***, reaching 1777.50) and ***relatively low in the morning and evening***.

KYUSHU UNIVERSITY

Results: Dynamic trend of function of urban hotspots

Figure 12. Dynamic trend of function of urban hotspots

KYUSHU UNIVERSITY

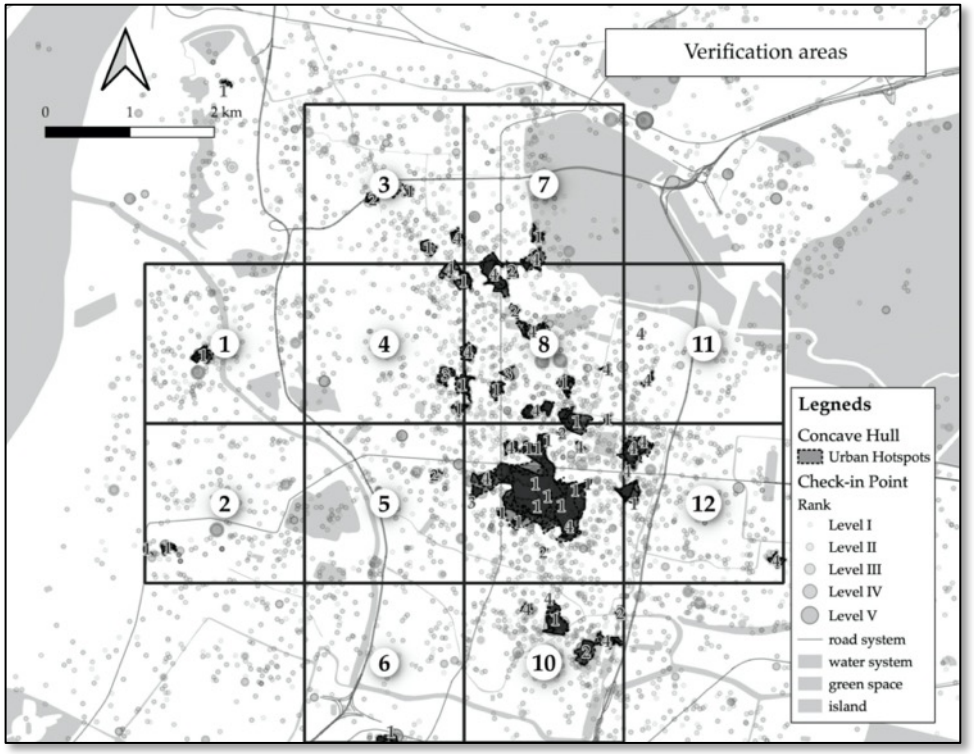
Results: Dynamic trend of function of urban hotspots

Functionally, the overall function structure of urban hotspots showed the characteristics of ***holiday and weekday consistency, and the proportion of urban hotspots with scenic spots and daily living space functions increases on weekends.*** Specifically, in some special urban spaces, the functions of urban hotspots changed over time:

1. *Urban hotspots centered on **well-known universities and parks** in the city merge into large urban hotspots of entertainment centers in the afternoon of non-working days.*
2. *The edge of **urban large-scale entertainment center** urban hotspots will differentiate and derive some small-scale urban hotspots of daily life spaces.*
3. *The urban hotspots of **scenic spots around the residential area** will be converted into daily life spaces in the weekday morning to undertake the leisure activities of the surrounding residents.*
4. *The functions of urban hotspots, such as daily life spaces and entertainment centers, **are frequently transformed from each another**.*

KYUSHU UNIVERSITY

Results: The driving factors of dynamic trend of urban hotspots



In this study, we selected Pearson correlation coefficient method to quantitatively analyze the correlation between prime variables like ***number (NUM) , area (AREA), popularity (POP)*** of urban hotspots and built environment variables like ***population density (PD), building density (BD), road density (RD), bus station density (SD) and distance from the city center (CD)*** in 12 research objects at different dates and periods.

Figure 13. Verification area of the correlation analysis

KYUSHU UNIVERSITY

Results: The driving factors of dynamic trend of urban hotspots

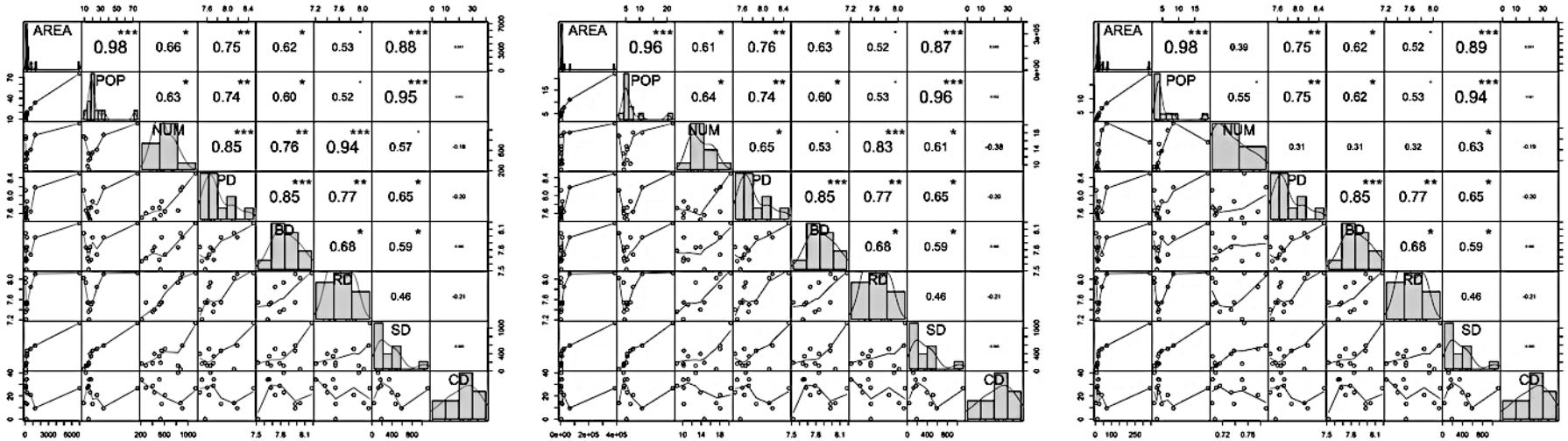


Figure 14. Correlation matrix in different date
(Weekend-Left; Weekday-Middle; Holiday-Right)

The results of correlation analysis further showed that: (1) ***urban areas with high population density tend to generate more urban hotspots*** during holidays, while areas with high road density tend to generate more urban hotspots during weekends and weekdays. (2) The more the number of ***public transport stations in urban space, the higher the area and popularity of urban hotspots***. (3) The area with higher building density and the area close to the center of the city are also the hotspots of the city.

KYUSHU UNIVERSITY

Results: The driving factors of dynamic trend of urban hotspots

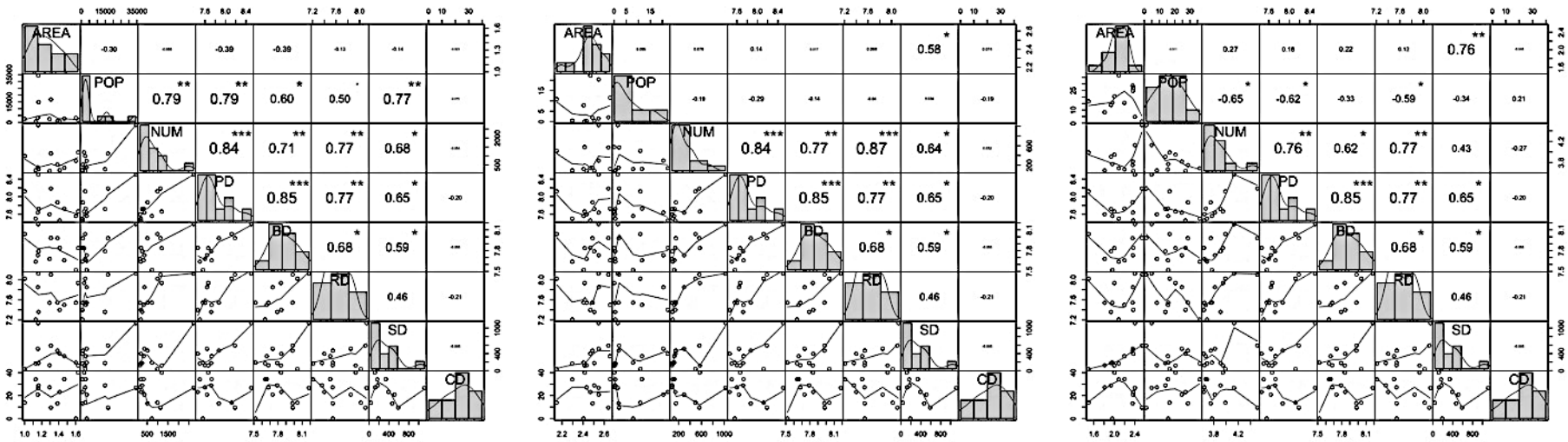


Figure 15. Correlation matrix in different time
(Morning-Left; Afternoon-Middle; Evening-Right)

The results of the above correlation analysis further show that: (1) It is more ***difficult to grasp the time of the emergence of urban hotspots than to predict the date***. (2) In the three periods, there is ***no strong or significant correlation between the attributes of urban hotspots and the elements of urban built environmen***t at night.

KYUSHU UNIVERSITY

Conclusions: What had been found throughout this research?

Through the KANN-DBSCAN and SNS data based urban hotspots detecting architecture designed in this study, the dynamic trend of the urban hotspots in downtown, Nanjing was deiminated. The main conclusions are as follows:

1. *We designed a method of urban hotspot extraction based on SNS sign in data, which could identify the **shape, area, quantity, popularity and function** of urban hotspot.*

2. *By analyzing the changes of various attributes of urban hotspots in the study period, we found that urban hotspots had the following dynamic trend: From the perspective of location, **the hotspots in the city will explode to the city's commercial center and tourist attractions along the main road** in the afternoon of non-working days. In terms of basic attributes, **the number, area and popularity of urban hotspots obey the characteristics of reaching maximum value on weekends and holidays** (especially in the afternoon). Functionally, the overall function structure of urban hotspots showed the characteristics **of holiday and weekday consistency,** and the proportion of urban hotspots with scenic spots and daily living space functions increases on weekends.*

3. *Through qualitative and quantitative analysis of the driving factors of the dynamic change of urban hotspots, we found that **large-scale population migration (and the commuting mode of residents) in urban space may be the main cause of urban hotspot displacement**. In addition, **population density and accessibility of public transportation facilities are the main influential factors on the number, area and popularity of urban hotspots**. The invisible function of the urban spaces can explain the change of urban hotspot function.*

KYUSHU UNIVERSITY

Q&A