May 14, 2020

Capstone Project – The Battle of Neighborhoods

Finding Best Residential Areas for Long-Stay Foreign Tourists Coming to Osaka

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1. Introduction

Osaka, where I spent my youth, is Japan's third largest city with more than 2.7 million people and has been the economic powerhouse of the Kansai region that covers the second largest metropolitan area in Japan with a regional GDP of approximately $US 714 billion (nominal, 2015). In recent years, with its unique vibrant and diverse neighborhoods, Osaka has become one of the most popular tourist destinations in Japan particularly among foreign visitors. In 2018, for example, the number of foreign visitors to Osaka totaled more than 11 million, a record high for the sixth straight year. Moreover, an increasing number of those tourists are repeated visitors and are looking for long-stay accommodations in rather non-traditional tourist areas. Although the inflow of foreign tourists has been halted due to the global outbreak of COVID-19, it is expected that the foreign tourists are coming back once we have overcome this pandemic.

The objective of this project is to identify the best residential areas for long-stay foreign tourists who are looking for convenient but not conventional tourist areas in Osaka through applying some of the machine learning methodologies and techniques I learned from this course. Although Osaka is still an important commercial and industrial hub in Japan, its economy has become to rely more on tourism in recent years, and thus being able to serve the needs of foreign visitors is essential for the future prospects of the city's economy. Osaka is comprised of a total of 24 wards. In this project, I have tried to find best residential areas for long-stay foreign visitors by leveraging the Foursquare location data.

Target Audience:

1. The primary target of this project are local travel agencies and tourist bureaus who want to attract more tourists to Osaka.
2. In addition, hotels and developers who want to invest and open new accommodations in different areas of Osaka would be interested in this project.

2. Data Sources

The following data were used to solve the aforementioned problem:

1. Ward Names of Osaka: Wikipedia page of Osaka (https://en.wikipedia.org/wiki/Osaka)
   Data on the ward names of Osaka, population, land area, and population density were scraped from a table of the Wikipedia page of Osaka.
2. Coordinates of All Wards: Geopy Client
   The coordinates of the 24 wards were obtained using geocoder class of Geopy client.

3. Location Data of Popular Venues: Foursquare (https://api.foursquare.com/v2/venues/)
   Data on popular venues in each ward and their categories were obtained using Foursquare API.

3. Methodology

3.1. Exploratory Data Analysis and Data Visualization

For the analysis of the data, I ran K-means clustering to cluster the wards and examine each cluster to find best residential areas for long-stay foreign tourists. But before segmenting and clustering the wards, the summary statistics of the wards were generated first after scraping a Wikipedia page of Osaka.

Table 1. Summary Statistics

Statistics	Ward	Population	Land Area (sq. km)	Population Density (per sq. km)
Count	24	24	24	24
Unique	24	--	--	--
Mean	--	114149.5	9.39	13768.5
Std. Dev.	--	37606.0	4.47	4495.7
Min	--	62872	4.39	3381.0
25%	--	82970.5	6.06	12333.3
50%	--	107277.5	8.38	14397.5
75%	--	131381.3	10.92	16853.3
Max	--	193282	20.61	20399.0

As mentioned, there were 24 wards in Osaka, and population-wise, Hirano-ku (or Hirano ward) is the largest with about 193 thousand people, whereas Taisho-ku is the smallest with about 63 thousand people. Osaka, as a whole, has a population of about 2.74 million people.

Table 2. Population by Ward

	Ward	Population
7	Hirano-ku	193282
23	Yodogawa-ku	182254
6	Higashiyodogawa-ku	176943
9	Jōtō-ku	167925
19	Sumiyoshi-ku	153425
10	Kita-ku	136602
8	Ikuno-ku	129641
5	Higashisumiyoshi-ku	126704
18	Suminoe-ku	120629
22	Tsurumi-ku	111501
16	Nishinari-ku	108654
13	Miyakojima-ku	107555
0	Abeno-ku	107000
15	Nishi-ku	103089
2	Chūō-ku	100998
17	Nishiyodogawa-ku	95960
1	Asahi-ku	90854
4	Higashinari-ku	83684
21	Tennōji-ku	80830
12	Minato-ku	80759
3	Fukushima-ku	78348
14	Naniwa-ku	74992
11	Konohana-ku	65086
20	Taishō-ku	62872

In terms of the land area, the largest ward is Suminoe-ku with 20.61 sq. km, whereas the smallest is the Naniwa-ku with 4.4 sq. km. The total land area of Osaka is 225.25 sq. km.

Table 3. Land Area by Ward

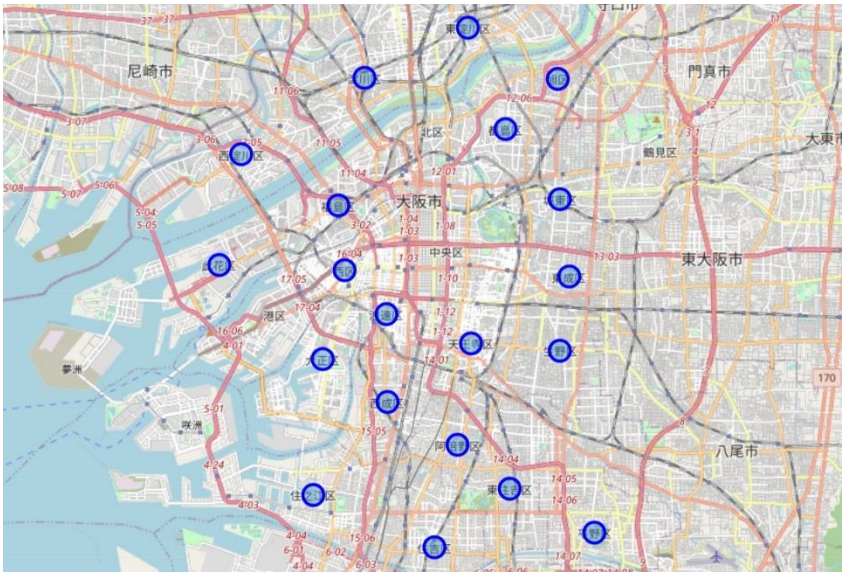
	Ward	LandArea_SqKm
18	Suminoe-ku	20.61
11	Konohana-ku	19.25
7	Hirano-ku	15.28
17	Nishiyodogawa-ku	14.22
6	Higashiyodogawa-ku	13.27
23	Yodogawa-ku	12.64
10	Kita-ku	10.34
5	Higashisumiyoshi-ku	9.75
20	Taishō-ku	9.43
19	Sumiyoshi-ku	9.40
2	Chūō-ku	8.87
9	Jōtō-ku	8.38
8	Ikuno-ku	8.37
22	Tsurumi-ku	8.17
12	Minato-ku	7.86
16	Nishinari-ku	7.37
1	Asahi-ku	6.32
13	Miyakojima-ku	6.08
0	Abeno-ku	5.99
15	Nishi-ku	5.21
21	Tennōji-ku	4.84
3	Fukushima-ku	4.67
4	Higashinari-ku	4.54
14	Naniwa-ku	4.39

It follows that the average population density in Osaka is 12,162 people per sq. km. Joto-ku is the most densely populated ward with 20,039 people per sq. km, whereas Konohana-ku is the least densely populated ward with 2,381 people per sq. km.

Table 4. Population Density by Ward

	Ward	PopDensity_perSqKm
9	Jōtō-ku	20039
15	Nishi-ku	19787
0	Abeno-ku	18440
4	Higashinari-ku	18433
13	Miyakojima-ku	17690
14	Naniwa-ku	17082
3	Fukushima-ku	16777
21	Tennōji-ku	16700
19	Sumiyoshi-ku	16322
8	Ikuno-ku	15489
16	Nishinari-ku	14743
23	Yodogawa-ku	14419
1	Asahi-ku	14376
22	Tsurumi-ku	13648
6	Higashiyodogawa-ku	13334
10	Kita-ku	13211
5	Higashisumiyoshi-ku	12995
7	Hirano-ku	12649
2	Chūō-ku	11386
12	Minato-ku	10275
17	Nishiyodogawa-ku	6748
20	Taishō-ku	6667
18	Suminoe-ku	5853
11	Konohana-ku	3381

Furthermore, a map of Osaka was created with its wards superimposed on it so as to inspect geographic details of the city and its 24 wards.



Map 1. Osaka City and its Wards

3.2. Cluster Analysis

To figure out the characteristics of the wards and classify them into similar groups based on the characteristics, cluster analysis was conducted. As the information about the characteristics, data on up to 100 popular venues (such as restaurants and supermarkets) within a radius of 1 km of the center of the ward was retrieved for each ward, using the Foursquare API. (The returned values of those popular venues are a function of the frequency of foot traffic at the time the query was made.)

There are 190 unique venue categories returned. As demonstrated in the following bar chart, the convenience store is the most frequently occurring or popular venue category in the 24 wards, followed by the Ramen (noodle) restaurant, Japanese restaurant, and Donburi (rice bowl) restaurant.

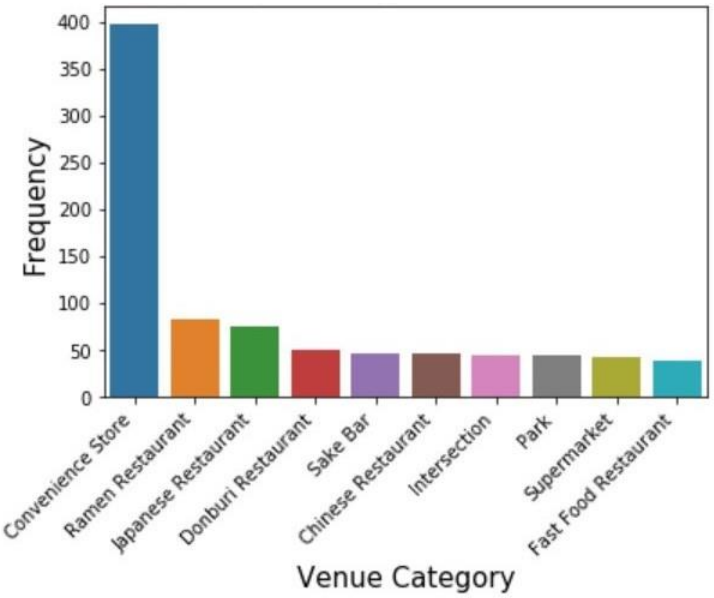
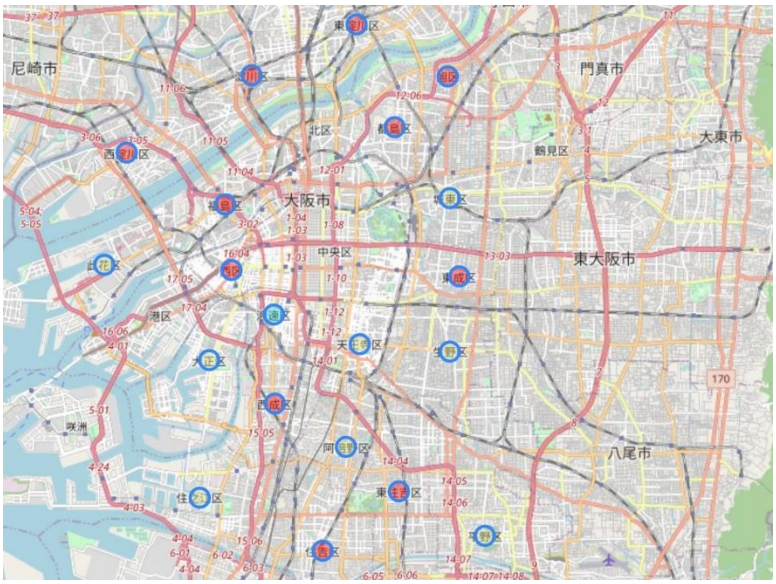


Chart 1. 10 Most Frequently Occurring Venues in the 24 Wards of Osaka

To further explore the wards, the top five venues for each ward were also examined. Except for Chuo-ku, Minato-ku, Naniwa-ku, and Tsurumi-ku, the convenience store tops the list of popular venues (although they are not shown here due to space limitation).

4. Results

Finally, using K-means clustering, all the 24 wards of Osaka were clustered into 4 groups based on the information about the popular venues, and the clusters were visualized in a map.



Map 2. Osaka City and its Four Clusters

Those results may help find the best residential areas for long-stay foreign tourists. First of all, Cluster 1 (composed of eleven wards including Nishi-ku and Yodagawa-ku) appears to have many casual eateries, such as Ramen and Donburi restaurants, and down-to-earth shops, such as grocery and clothing stores – not mentioning convenience stores.

Table 5. Cluster 1

	Ward	PopDensity_perSqKm	Latitude	Longitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue
1	Asahi-ku	14376	34.726483	135.546952	0	Convenience Store	Ramen Restaurant	Udon Restaurant	Train Station	Metro Station	Supermarket	Donburi Restaurant	Noodle House	Intersection
3	Fukushima-ku	16777	34.692104	135.474812	0	Convenience Store	Ramen Restaurant	Fast Food Restaurant	Intersection	Train Station	Donburi Restaurant	Shopping Mall	Supermarket	BBQ Joint
4	Higashinari-ku	18433	34.672912	135.550567	0	Convenience Store	Donburi Restaurant	Sake Bar	Grocery Store	Metro Station	Intersection	Ramen Restaurant	Pharmacy	Park
5	Higashisumiyoshi-ku	12995	34.615662	135.531096	0	Convenience Store	Intersection	Ramen Restaurant	Restaurant	Sushi Restaurant	Bus Stop	Shopping Mall	Pharmacy	Donburi Restaurant
6	Higashiyodogawa-ku	13334	34.740212	135.517432	0	Convenience Store	Ramen Restaurant	Train Station	Donburi Restaurant	Chinese Restaurant	Supermarket	Drugstore	Japanese Restaurant	Fast Food Restaurant
13	Miyakojima-ku	17690	34.712703	135.529697	0	Convenience Store	Park	Ramen Restaurant	Donburi Restaurant	Restaurant	Japanese Restaurant	Fast Food Restaurant	Bakery	Chinese Restaurant
15	Nishi-ku	19787	34.674598	135.476774	0	Convenience Store	Shopping Mall	Train Station	Japanese Restaurant	Ramen Restaurant	Baseball Stadium	Clothing Store	Supermarket	Fast Food Restaurant
16	Nishinari-ku	14743	34.639074	135.490813	0	Convenience Store	Shopping Mall	Grocery Store	Train Station	Chinese Restaurant	Fast Food Restaurant	Donburi Restaurant	Supermarket	Japanese Restaurant
17	Nishiyodogawa-ku	6748	34.705938	135.442936	0	Convenience Store	Grocery Store	Park	Intersection	Clothing Store	Train Station	Japanese Restaurant	Shopping Mall	Fast Food Restaurant
19	Sumiyoshi-ku	16322	34.599765	135.506426	0	Convenience Store	Grocery Store	Chinese Restaurant	Platform	Ramen Restaurant	BBQ Joint	Diner	Noodle House	Fast Food Restaurant
23	Yodogawa-ku	14419	34.726613	135.483397	0	Convenience Store	Ramen Restaurant	Sake Bar	Supermarket	Donburi Restaurant	Japanese Curry Restaurant	Japanese Restaurant	Shopping Mall	Fast Food Restaurant

Interestingly, Cluster 2 is made up of just one ward, Tsurumi-ku. This cluster features many scenic lookouts, parks, and trails, in addition to bus stops and train stations.

Table 6. Cluster 2

	Ward	PopDensity_perSqKm	Latitude	Longitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue
22	Tsurumi-ku	13648	35.480132	139.693663	1	Bus Stop	Scenic Lookout	Park	Train Station	Trail	Pool	Yoshoku Restaurant	Food Court	Gift Shop

Cluster 3 (composed of Chuo-ku, Minato-ku, and Namiwa-ku) seems to have a large concentration of traditional eating places, such as Sushi, Japanese, and Soba restaurants.

Table 7. Cluster 3

	Ward	PopDensity_perSqKm	Latitude	Longitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue
2	Chūō-ku	11386	35.666255	139.775565	2	Sushi Restaurant	Japanese Restaurant	Monjayaki Restaurant	Soba Restaurant	Italian Restaurant	Bakery	Coffee Shop	Ramen Restaurant	Seafood Restaurant
12	Minato-ku	10275	35.643227	139.740055	2	Japanese Restaurant	Chinese Restaurant	Italian Restaurant	Soba Restaurant	Coffee Shop	Sake Bar	Indian Restaurant	BBQ Joint	Bistro
14	Naniwa-ku	17082	34.662830	135.490485	2	Café	Hotel	Sake Bar	Japanese Restaurant	Coffee Shop	Grocery Store	Udon Restaurant	Ramen Restaurant	BBQ Joint

Cluster 4 (composed of the remaining nine wards including Abeno-ku and Kita-ku) has a lot of convenience stores, supermarkets, and casual restaurants, including Ramen and fast food restaurants.

Table 8. Cluster 4

	Ward	PopDensity_perSqKm	Latitude	Longitude	Cluster Labels	1st Most Common Venue	2nd Most Common Venue	3rd Most Common Venue	4th Most Common Venue	5th Most Common Venue	6th Most Common Venue	7th Most Common Venue	8th Most Common Venue	9th Most Common Venue
0	Abeno-ku	18440	34.627501	135.514095	3	Convenience Store	Grocery Store	Bakery	Supermarket	Park	Shopping Mall	Café	Donburi Restaurant	Sake Bar
7	Hirano-ku	12649	34.603715	135.559027	3	Convenience Store	Chinese Restaurant	Ramen Restaurant	Japanese Restaurant	Italian Restaurant	Donburi Restaurant	Supermarket	Metro Station	Udon Restaurant
8	Ikuno-ku	15489	34.653003	135.547722	3	Convenience Store	Ramen Restaurant	Chinese Restaurant	Drugstore	Intersection	Italian Restaurant	Korean Restaurant	Udon Restaurant	Clothing Store
9	Jōtō-ku	20039	34.693887	135.547769	3	Convenience Store	Supermarket	Ramen Restaurant	Restaurant	Fast Food Restaurant	Grocery Store	Chinese Restaurant	Park	Intersection
10	Kita-ku	13211	35.755838	139.736687	3	Convenience Store	Park	Ramen Restaurant	Intersection	Sake Bar	Japanese Restaurant	Grocery Store	Museum	History Museum
11	Konohana-ku	3381	34.676245	135.435550	3	Convenience Store	Intersection	Train Station	Theme Park Ride / Attraction	Park	Hotel	Bus Stop	American Restaurant	Theme Park
18	Suminoe-ku	5853	34.614132	135.466545	3	Convenience Store	Fast Food Restaurant	Ramen Restaurant	Japanese Restaurant	Drugstore	Donburi Restaurant	Discount Store	BBQ Joint	Light Rail Station
20	Taishō-ku	6667	34.650640	135.469570	3	Convenience Store	Pier	Chinese Restaurant	Shopping Mall	Fast Food Restaurant	Grocery Store	Donburi Restaurant	Ramen Restaurant	Discount Store
21	Tennōji-ku	16700	34.655043	135.518370	3	Convenience Store	Donburi Restaurant	Japanese Restaurant	Historic Site	Coffee Shop	Ramen Restaurant	Sake Bar	BBQ Joint	Tonkatsu Restaurant

5. Discussion

As mentioned, an increasing number of foreign tourists are looking for long-stay accommodations in convenient but rather non-traditional tourist areas in Osaka. Judging from the above findings, therefore, I would suggest Cluster 2 or Tsurumi-ku has the most potential for long-stay foreign visitors to Osaka. Unlike many other wards, it has a lot of green space like parks and trails. Besides, it is conveniently located and close enough to busy business and shopping districts, as suggested by the frequently occurring Foursquare venue categories of bus stops and train stations. (Indeed, it takes only five minutes to Kyobashi, and about 20 minutes either to Umeda or Shinsaibashi.)

Caveats: The K-means clustering outcome is influenced by the number of clusters and the selection of initial centroids. As a consequence, the above result could be a local optimum rather than a global one. Moreover, the clustering in this analysis was conducted using the most popular venue data obtained from Foursquare alone, and thus ignores all other factors

that foreign tourists might consider essential, such as crime and cost of living. Finally, there are other clustering techniques in machine learning, such as mean-shift clustering and density-based spatial clustering of applications with noise (DBSCAN). Since the outcome may vary depending on the method, it is important to apply the most appropriate method to the available data.

6. Conclusion

To identify the best residential areas for long-stay foreign tourists, this project applied the K-means clustering technique to the Foursquare location data of popular venues and found Tsurumi-ku as the best candidate. As a next step, this project may take into account other potentially important factors, such as crime and cost of living, to improve the precision of the analysis.