New Kumon learning centre in Toronto

Instruction

Kumon is a popular training organization for children and specialized in teaching math and reading for preschool and high school students.

Currently, there are 22 Kumon learning centers in city of Toronto. If the business operator plans to open another one in Toronto, where would be the best place?

In the project, I am going to use the neighborhood demographic data (student population data) from Statistics Canada and location data from Foursquare to answer the question and find an optimal location to open the new Kumon learning center.

Data Source

In the project, four data sources will be used and listed at below. The new open Kumon location will be determined by the number of children and distance to the existing Kumon centers. The decision criteria are based on the number of student in each neighborhood and the shortest distance to any existing Kumon location. More students and longer distance in one neighborhood indicate that neighborhood needs a new center.

1. Foursquare location data.

   Foursquare data is filtered on venue name "Kumon" to obtain the information of current Kumon training centers, such as name, ID and location (latitude & longitude)...

	name	categories	address	cc	city	country	crossStreet	distance	formattedAddress	labeledLatLngs	lat	lng	postalCode	state	id
0	Kumon Chinatown	School	222 Spadina	CA	Toronto	Canada	NaN	885	[222 Spadina, Toronto ON, Canada]	[{'label': 'display', 'lat': 43.65121499425781...	43.651215	-79.397518	NaN	ON	52d18824498e8eb7a6bdf6cd
1	kumon	Student Center	NaN	CA	NaN	Canada	NaN	2238	[Canada]	[{'label': 'display', 'lat': 43.66840744018555...	43.668407	-79.406548	NaN	NaN	51cb6468498e4e78127bcbd6
2	Kumon Math & Reading Centre	Office	543A Parliament St	CA	Toronto	Canada	NaN	2035	[543A Parliament St, Toronto ON M4X 1P7, Canada]	[{'label': 'display', 'lat': 43.66628839598942...	43.666288	-79.368539	M4X 1P7	ON	56cbf740498ec00479e05ad2
3	Leaside Kumon Centre	General College & University	660 Eglinton Ave. E	CA	Toronto	Canada	At Bayview	6585	[660 Eglinton Ave. E (At Bayview), Toronto ON,...	[{'label': 'display', 'lat': 43.71265519621539...	43.712655	-79.376916	NaN	ON	4ba7bcebf964a520b5ae39e3
4	kumon	Student Center	NaN	CA	Toronto	Canada	NaN	5345	[Toronto ON, Canada]	[{'label': 'display', 'lat': 43.701421, 'lng':...	43.701421	-79.397362	NaN	ON	5792a600498e3e47ff7f4d48

2. Statistics Canada Data.

Population demographic data is available from Statistics Canada website, which contains rich information on each neighborhood. The number of student data will be one of the primary inputs to determine if that neighborhood needs a learning center.

	index	CENSUS_YEAR	GEO_CODE (POR)	GEO_LEVEL	GEO_NAME	GNR	GNR_LF	DATA_QUALITY_FLAG	ALT_GEO_CODE	DIM: Profile of Forward Sortation Areas (2247)	Member ID: Profile of Forward Sortation Areas (2247)	Notes: Profile of Forward Sortation Areas (2247)	Dim: Sex (3): Member ID: [1]: Total - Sex	Dim: Sex (3): Member ID: [2]: Male	Dim: Sex (3): Member ID: [3]: Female
0	8	2016	01	0	Canada	4.0	5.1	20000	01	0 to 14 years	9	NaN	5839565	2992920	2846650
1	2255	2016	A0A	2	A0A	4.2	9.1	0	01A0A	0 to 14 years	9	NaN	6685	3375	3315
2	4502	2016	A0B	2	A0B	4.1	10.1	10	01A0B	0 to 14 years	9	NaN	2090	1060	1030
3	6749	2016	A0C	2	A0C	4.1	8.6	0	01A0C	0 to 14 years	9	NaN	1405	735	670
4	8996	2016	A0E	2	A0E	4.2	8.1	0	01A0E	0 to 14 years	9	NaN	2745	1425	1325

3. Toronto neighborhood Data.

It contains the Toronto neighborhood name and listed by FSA / Postal code.

	Postcode	Borough	Neighbourhood
0	M1A	Not assigned	Not assigned
1	M2A	Not assigned	Not assigned
2	M3A	North York	Parkwoods
3	M4A	North York	Victoria Village
4	M5A	Downtown Toronto	Harbourfront

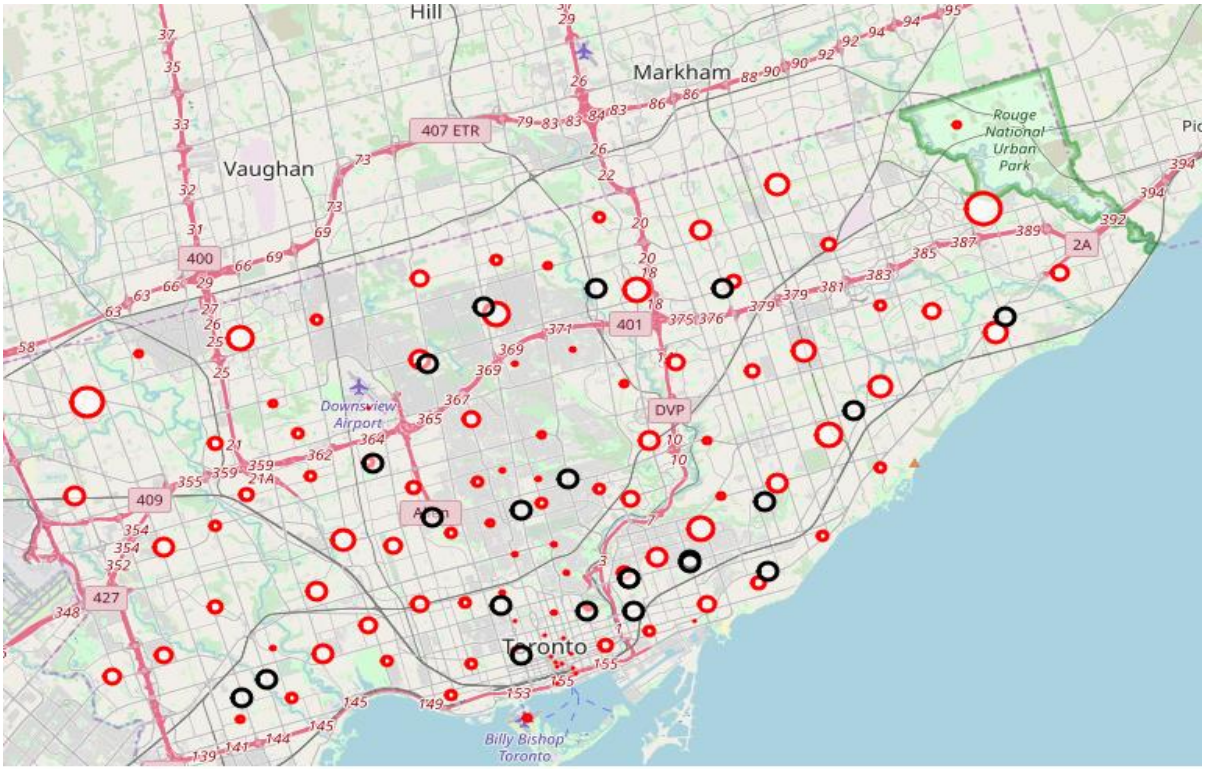
4. Geographic location data.

Data file of latitude and the longitude coordinates for Toronto neighborhoods, which will be merged with Toronto neighborhood data and Statistics Canada to obtain the Toronto neighborhood data with information on name, geo location and number of children.

	Postal Code	Latitude	Longitude
0	M1B	43.806686	-79.194353
1	M1C	43.784535	-79.160497
2	M1E	43.763573	-79.188711
3	M1G	43.770992	-79.216917
4	M1H	43.773136	-79.239476

Methodology

In the map below, Kumon learning centers are marked by black circles and Toronto neighborhoods are represented by red circles. The size of neighborhood circles is proportional to its population of children. The bigger a circle means more children in that neighborhood.



In order to find the optimal location for opening new Kumon learning centre, the function of sum of weighted nearest distance is defined as following. In the project, Brute-force method from “scipy” package is used. The idea is to try to sampling new locations from entire Toronto area and to find the one that minimize the sum of population weighted distance.

$$\text{Sum of weighted nearest distance} = \sum_{i,j=0}^{m,n} (Number\ of\ children) * (Distance\ to\ nestest\ Kuman)$$

Where m = Number of Toronto neighborhoods, n = Number of existing Kumons+1

Geographical data of each Toronto neighbourhood

Toronto Neighborhood, Geographical location data and Statistics Canada data were joined by FSA or Postal codes. The following table is example of merged geographical data of each neighbourhood with child population.

	Postcode	Borough	Neighbourhood	Child age 0-14 Pop Size	Latitude	Longitude
0	M1B	Scarborough	Rouge,Malvern	11535	43.806686	-79.194353
1	M1C	Scarborough	Highland Creek,Rouge Hill,Port Union	5245	43.784535	-79.160497
2	M1E	Scarborough	Guildwood,Morningside,West Hill	7570	43.763573	-79.188711
3	M1G	Scarborough	Woburn	5590	43.770992	-79.216917
4	M1H	Scarborough	Cedarbrae	3870	43.773136	-79.239476

Kumon learning centre data

	name	categories	address	cc	city	country	crossStreet	distance	formattedAddress	labeledLatLngs	lat	lng	postalCode	state	id
0	Kumon Chinatown	School	222 Spadina	CA	Toronto	Canada	NaN	885	['222 Spadina', 'Toronto ON', 'Canada']	[{'label': 'display', 'lat': 43.65121499425781...	43.651215	-79.397518	NaN	ON	52d18824498e8eb7a6bdf6cd
1	kumon	Student Center	NaN	CA	NaN	Canada	NaN	2238	['Canada']	[{'label': 'display', 'lat': 43.66840744018555...	43.668407	-79.406548	NaN	NaN	51cb6468498e4e78127bcbd6
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Neighbourhoods with calculate nearest distance to Kumon centre

	Postcode	Borough	Neighbourhood	Child age 0-14 Pop Size	Latitude	Longitude	current_minimum_distance_km	current_minimum_distance
0	M1B	Scarborough	Rouge,Malvern	11535	43.806686	-79.194353	4.240719	0.038720
1	M1C	Scarborough	Highland Creek,Rouge Hill,Port Union	5245	43.784535	-79.160497	2.584909	0.028644
2	M1E	Scarborough	Guildwood,Morningside,West Hill	7570	43.763573	-79.188711	0.703611	0.006914
3	M1G	Scarborough	Woburn	5590	43.770992	-79.216917	2.595850	0.032282
4	M1H	Scarborough	Cedarbrae	3870	43.773136	-79.239476	4.421224	0.038470
5	M1J	Scarborough	Scarborough Village	7210	43.744734	-79.239476	5.173075	0.014510

Results

The new center should be placed at [43.72501224557055, -79.55011423863259]. Total sum of weighted distance achieved is 10281.87, which is the optimal point to open the new Kumon centre (showed as blue circle).

Discussion

This research consider only child population and Neighborhood to Kumon distance two factors to decide new Kumon location, however in real world, there are a lot of more factors need to be considered, E.g, house hold income, parent education level, transportation, and location availability, etc. For example, the location selected in the project is the international airport, which is not available to open any new business. But for the study purpose, I made the scenario very simple and ignored all the complex factors.

Conclusion

From the graph above, we can observe that the new location does make sense. Since the north-west area has no any existing Kumon centres and the student population nearby that area is quite large. Despite the simplification of problem, it's still a good learning project to utilize what we learned from the past modules.

Appendix (Data source reference)

Foursquare data API:

https://api.foursquare.com/v2/venues/search?

Statistics Canada data:

https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page_Download-Telecharger.cfm?Lang=E&Tab=1&Geo1=CMACA&Code1=535&Geo2=PR&Code2=35&Data=Count&SearchText=Caledon%20East&SearchType=Begins&SearchPR=01&B1=Population&TABID=1

Data File Definitions by Forward Sortation Areas (2247)

Member

1. Population, 2016 (1)
2. Population, 2011 (2)
3. Population percentage change, 2011 to 2016
4. Total private dwellings (3)
5. Private dwellings occupied by usual residents (4)
6. Population density per square kilometre
7. Land area in square kilometres
8. Total - Age groups and average age of the population - 100% data (5)
9. 0 to 14 years
10. 0 to 4 years
11. 5 to 9 years
12. 10 to 14 years
13. 15 to 64 years
14. 15 to 19 years
15. 20 to 24 years
16. 25 to 29 years
17. 30 to 34 years
18. 35 to 39 years
19. 40 to 44 years
20. 45 to 49 years
21. 50 to 54 years
22. 55 to 59 years
23. 60 to 64 years
24. 65 years and over
25. 65 to 69 years
26. 70 to 74 years
27. 75 to 79 years
28. 80 to 84 years
29. 85 years and over
30. 85 to 89 years
31. 90 to 94 years
32. 95 to 99 years
33. 100 years and over
34. Total - Distribution (%) of the population by broad age groups - 100% data

35. 0 to 14 years
36. 15 to 64 years
37. 65 years and over
38. 85 years and over
39. Average age of the population
40. Median age of the population (6)
41. Total - Occupied private dwellings by structural type of dwelling - 100% data (7)
42. Single-detached house
43. Apartment in a building that has five or more storeys
44. Other attached dwelling (8)
45. Semi-detached house
46. Row house
47. Apartment or flat in a duplex
48. Apartment in a building that has fewer than five storeys
49. Other single-attached house
50. Movable dwelling (9)
51. Total - Private households by household size - 100% data (10)
52. 1 person
53. 2 persons
54. 3 persons
55. 4 persons
56. 5 or more persons
57. Number of persons in private households
58. Average household size
59. Total - Marital status for the population aged 15 years and over - 100% data (11)
60. Married or living common law
61. Married
62. Living common law
63. Not married and not living common law
64. Never married
65. Separated
66. Divorced
67. Widowed
68. Total - Census families in private households by family size - 100% data (12)
69. 2 persons
70. 3 persons
71. 4 persons
72. 5 or more persons
73. Average size of census families
74. Total number of census families in private households - 100% data
75. Total couple families
76. Married couples
77. Common-law couples
78. Total lone-parent families by sex of parent
79. Female parent
80. Male parent
81. Total - Couple census families in private households - 100% data
82. Couples without children

83. Couples with children
84. 1 child
85. 2 children
86. 3 or more children
87. Total - Lone-parent census families in private households - 100% data
88. 1 child
89. 2 children
90. 3 or more children
91. Total - Persons not in census families in private households - 100% data
92. Total - Private households by household type - 100% data (13)
93. One-census-family households
94. Without children in a census family (14)
95. With children in a census family (15)
96. Multiple-census-family households
97. Non-census-family households
98. One-person households
99. Two-or-more person non-census-family households
100. Total - Knowledge of official languages for the total population excluding institutional residents - 100% data (16)

Toronto neighborhood data:

https://en.wikipedia.org/wiki/List_of_postal_codes_of_Canada:_M

Geographic location data:

http://cocl.us/Geospatial_data