Finding optimal locations for an Adult Day Care Center in Queens

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1. Introduction/Business Problem

1.1. Background

According to a 2018 U.S. Census Bureau report, in 2035 "there will be 78 million people 65 years and older compared to 76.4 million under the age of 18." [1]. With the growing aging population, the need for adult day care is also growing. Adult day care is basically the same as child care, except that here we deal with adults. People who attend adult day care live at home and can take care of themselves. They are looking for a place to go where they can spend their time and meet other people. It has been known that recreational activities and social stimulation improve or maintain physical and cognitive functions, so this will help them stay active and healthier longer, both physically and mentally. At the adult day care centers seniors will be provided with meals, have activities, do exercises, socialize, and some would provide transportation to and from the home.

1.2. Problem

In this project we will try to find an optimal location for an adult day care center in the Queens Borough of New York City whose main focus will be on recreational activities and social stimulation for the elderly population who would otherwise stay at home alone. The recreational activities would include: daily exercise regimes in a local park (tai chi, yoga, pilates, walking), while the social stimulation would consists of arts and crafts, music, games (bingo, scrabble, etc.) and general socialization and conversations to form friendly relationships. Only in case of a bad weather daily exercise regimes would be performed indoor. The center would have a nurse on-site so that participants' vital signs can be checked and evaluated regularly. The center would also fill prescriptions at a local pharmacy if participants request such service. In addition, the center would provide healthy meals and snacks and transportation to participants.

Since the center would provide daily exercise regimes, we prefer locations as close to parks as possible. To avoid competition, we don't want to be in a proximity of existing adult day care centers. To be able to fill prescriptions we want to be in a proximity of a pharmacy.

Specifically, since we want to be as close to parks as possible our problem will be to identify parks in Queens satisfying the following 2 conditions:

1. No existing adult day care center within 1 km of the park latitude and longitude coordinates.
2. At least one pharmacy within 2 km of the park latitude and longitude coordinates.

1.3. Interest

This report will be targeted to stakeholders interested in opening such adult day care center in Queens. It may be of interest also to entrepreneurs who want to start adult day care business. According to the Administration on Aging, one out of every eight Americans is over the age of 65 [2]. This increase of the senior population in America offers excellent opportunities in the adult day care industry.

2. Data

Based on definition of our problem, we need locations of parks, pharmacies and adult day care centers in Queens, New York City. To limit neighborhoods to Queens we will use New York City Neighborhood dataset (https://geo.nyu.edu/catalog/nyu_2451_34572). This dataset contains 5 boroughs and neighborhoods that exist in each borough as well as the latitude and longitude coordinates of each neighborhood. We can conveniently access this data from this web address: https://cocl.us/new_york_dataset. Foursquare location data will be used to get locations of parks and pharmacies venues in Queens. Since the Foursquare data does not list adult day care centers in Queens we will obtain locations of these centers from this https://data.cityofnewyork.us/Social-Services/Department-for-the-Aging-DFTA-Social-Adult-Day-Car/32cj-z7va dataset on the NYC OpenData website. This dataset is a listing of registered agencies providing Social Adult Day Care Services with hours of operation in New York City. It currently has 328 rows and 34 columns. We will limit this data to the Queens Borough locations.

Below is a small snapshot for the first 9 columns:

ProviderType	DFTA ID	ProgramName	SponsorName	ProgramAddress	ProgramCity	ProgramState	Postcode	Borough
SOCIAL ADULT DAY CARE SERVICES	S53601	ROYAL COMMUNITY CARE CENTER INC.	Royal Community Care Center Inc.	192-08 JAMAICA AVE	HOLLIS	NY	11423	Queens
SOCIAL ADULT DAY CARE SERVICES	S5101	WOODHAVEN ADULT DAYCARE INC	Woodhaven Adult Daycare Inc	96-01 JAMAICA AVE	WOODHAVEN	NY	11421	Queens

3. Methodology

The distance calculation between two Global Positioning System (GPS) locations is a core of our problem. To calculate distance between two GPS locations we can't use Euclidean distance since we have to deal with a sphere, or an oblate spheroid to be exact. We need to look at geodesic distances. There are different ways to handle this calculation problem. We will use Haversine formula [3] to complete the task. The Python implementation of this formula can be found in the reference [4].

Our approach will be 3 steps approach.

First, we will cluster pharmacies and parks in Queens using k-means clustering method. Our intuition here is that an optimal location for an adult day care center would be probably around a park that belongs to a cluster where parks and pharmacies are mixed together. So clustering will provide a first cut of potential candidate parks. To determine k in k-means clustering we will use "elbow" method [5]. The inertia attribute will be used to identify the sum of squared distances of samples to the nearest cluster center. As k increases, the sum of squared distance tends to zero. If the plot looks like an arm, then the elbow on the arm is optimal k.

Second, for each park we will proceed, using Haversine formula, to the distance calculation between the park and all pharmacies in Queens and the park and all existing adult day care centers in Queens. We'll focus on parks satisfying above two conditions (at least one pharmacy within 2 km of the park and no existing adult day care center within 1 km of the park). For each respective park satisfying these conditions we will count the number of pharmacies within 2 km of the park.

And finally third, for these parks in Queens we'll produce a heat map based on the count of respective pharmacies to graphically display promising locations. These park locations will be presented to stakeholders as a starting point for stakeholders final 'street level' exploration to determine the optimal adult day care center location.

4. Analysis

4.1 Basic explanatory analysis

Basic explanatory data analysis shows that we have good data. None of our datasets:

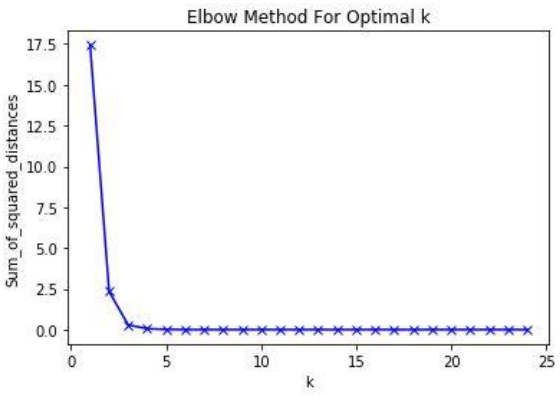
1. queens_neighborhoods (neighborhoods data for Queens)
2. queens_pharmacies_and_parks (parks and pharmacies venues data in Queens)
3. queens_adult_care_services_data (adult day care service data in Queens)

has any null or NaN value. There are 81 neighborhoods in Queens, 78 pharmacies and parks, and quite a lot of adult day care service centers (121). Summary Statistics of

numeric columns show data consistency for all 3 datasets. For all 3 datasets mean values of Latitude and Longitude are almost equal to the geographical coordinates of Queens: 40.6524927, -73.7914214158161. Top 3 venues in Queens are Pizza Place, Deli/Bodega, and Chinese Restaurant.

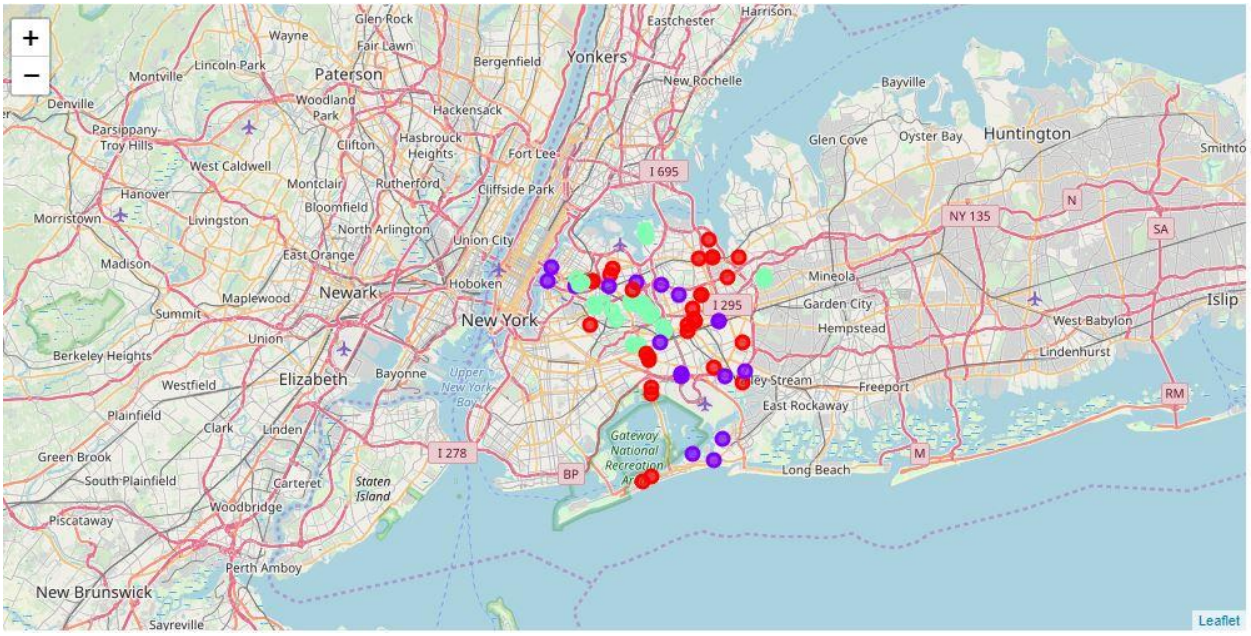
4.2 K-means Clustering

Having established that we have good data, in order to cluster pharmacies and parks in Queens using k-means clustering method, we need to do one hot encoding of the "Venue Category" categorical variable for the queens_pharmacies_and_parks dataset. This variable has only 2 values: Park or Pharmacy. One hot encoding is a process by which categorical variables are converted into a form that could be provided to Machine learning algorithms to do a better job in prediction. By applying the "elbow' method to determine k for k-means clustering we find that the optimal k for the queens_pharmacies_and_parks dataset is 3 as can be seen from the below plot:



In the plot above the elbow is at k=3 indicating that the optimal k for the queens_pharmacies_and_parks_grouped dataset is 3

We generate 3 clusters: one with parks only (violet color), one with pharmacies only (red color), and one with pharmacies and parks mixed together (green color) as can be seen from the below folium map:



4.3 Analysis of the queens_adult_care_services_data

The analysis shows that some of the neighborhood names (NTA column) are slightly different in this dataset as compared to the queens_pharmacies_and_parks dataset, for example **Elmhurst-Maspeth** in the queens_adult_care_services_data vs. **Elmhurst** in the queens_pharmacies_and_parks dataset. We decided to split the NTA column on "-" and take the first part of the split as the neighborhood name.

With this data transformation in place we joined the queens_adult_care_services_data with the queens_pharmacies_and_parks data enriched with respective cluster labels using the neighborhood name as the inner join column in order to see the distribution of respective adult day care service centers across clusters.15 neighborhoods were not joined


Now check which neighborhoods from queens_adult_care_serv_neigh_list are not in the queens_pharmacies_and_parks_neigh_list

```
queens_adult_care_serv_neigh_list = sorted(queens_adult_care_services_massaged["neighborhood"].unique().tolist())
s = set(queens_pharmacies_and_parks_neigh_list)
queens_adult_care_serv_neigh_not_in_ph_and_park_list = [x for x in queens_adult_care_serv_neigh_list if x not in s]
print("Not in queens_pharmacies_and_parks_neigh_list:", queens_adult_care_serv_neigh_not_in_ph_and_park_list)
```

```
Not in queens_pharmacies_and_parks_neigh_list: ['Bellerose', 'Breezy Point', 'Briarwood', 'East Elmhurst', 'East Flushing', 'Far Rockaway', 'Flushing', 'Ft. Totten', 'Hammels', 'Jamaica', 'Jamaica Estates', 'Hunray Hill', 'North Corona', 'Queens Village', 'St. Albans']
```

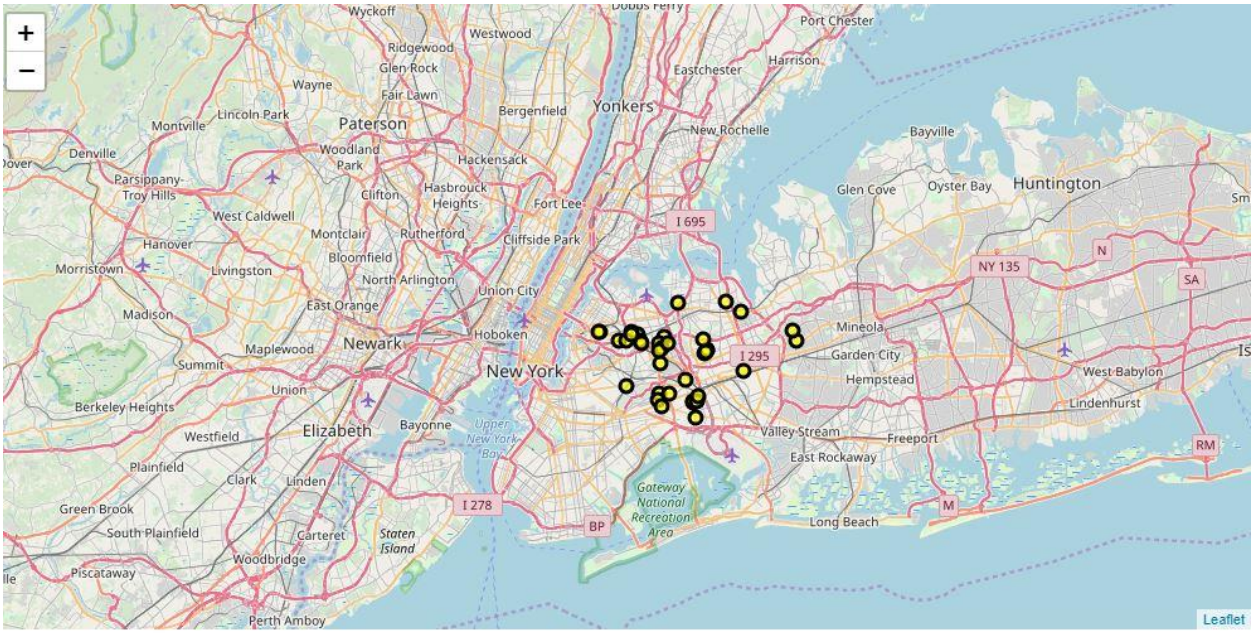
Majority of the adult day care service centers is located in the Parks cluster (1) and Pharmacies and Parks cluster (2)

```
In [62]: pd.DataFrame(adult_care_serv_in_pharm_and_parks['Cluster Labels']).apply(pd.value_counts)
```

Out[62]:

	Cluster Labels
1	22
2	12
0	3

Below is the distribution of these centers across clusters on a folium map:



4.4 Distance calculation using Haversine formula and final data frame

For each park we did calculate the distance between the park and all pharmacies in Queens and the park and all existing adult day care centers in Queens distributed across clusters and limited the output to pharmacies within 2 km from the park and to adult care services within 1 km from the park. After this step we created the final data frame that contains for each park respective counts of pharmacies within 2 km from the park and counts of adult day care centers within 1 km from the park along with respective cluster labels.

Below is the snapshot of the final data frame:

```
In [111]: queens_final_parks_pharm_adult_serv_info = queens_parks[['Neighborhood', 'Venue', 'Venue Latitude', 'Venue Longitude', 'Venue Category', 'Cluster Labels']]
queens_final_parks_pharm_adult_serv_info.rename(columns={'Venue Latitude':'Park Latitude', 'Venue Longitude':'Park Longitude'}, inplace=True)
queens_final_parks_pharm_adult_serv_info1=pd.merge(queens_final_parks_pharm_adult_serv_info, pacsd_1km_or_less_stats, how='left', left_on=['Park Latitude','Park Longitude'], right_on=['Park Latitude', 'Park Longitude'])
queens_final_parks_pharm_adult_serv_info1.rename(columns={'Cnt':'AdultService Count'}, inplace=True)
queens_final_parks_pharm_adult_serv_info2=pd.merge(queens_final_parks_pharm_adult_serv_info1, pphsd_2km_or_less_stats, how='left', left_on=['Park Latitude','Park Longitude'], right_on=['Park Latitude', 'Park Longitude'])
queens_final_parks_pharm_adult_serv_info2.rename(columns={'Cnt':'Pharmacy Count'}, inplace=True)
values = {'AdultService Count': 0, 'Pharmacy Count': 0}
queens_final_parks_pharm_adult_serv_info2.fillna(value=values, inplace=True)
queens_final_parks_pharm_adult_serv_info=queens_final_parks_pharm_adult_serv_info2.astype({"AdultService Count": int, "Pharmacy Count": int})
queens_final_parks_pharm_adult_serv_info
```

Out[111]:

	Neighborhood	Venue	Park Latitude	Park Longitude	Venue Category	Cluster Labels	AdultService Count	Pharmacy Count
0	Elmhurst	Broadway Park	40.740795	-73.885517	Park	1	6	5
1	Corona	William F. Moore Park ('Spaghetti Park')	40.743666	-73.855443	Park	1	3	3
2	Forest Hills	Yellowstone Park	40.726251	-73.847759	Park	2	0	6
3	Forest Hills	MacDonald Park	40.722239	-73.847141	Park	2	0	5
4	Kew Gardens	Eight Oaks Triangle	40.707226	-73.827127	Park	2	1	2
5	Kew Gardens	LIRR Metropolitan Yard	40.703840	-73.824317	Park	2	1	1
6	Richmond Hill	Lt. Frank McConnell Park	40.694270	-73.829010	Park	1	2	4
7	Sunnyside	Thomas P. Noonan, Jr. Playground	40.741053	-73.922213	Park	1	2	5
8	Maspeth	Whitefish Triangle Park	40.726517	-73.901752	Park	2	0	3
9	Rego Park	Fleetwood Triangle	40.726679	-73.862636	Park	2	3	5
10	Woodhaven	Equity Park	40.691645	-73.853378	Park	2	4	5
11	South Ozone Park	Back Streets Park (Officer Edward Byrn Park)	40.667846	-73.806453	Park	1	0	0
12	South Ozone Park	Pals Oval Park	40.668634	-73.805878	Park	1	0	0
13	South Ozone Park	Back Street Park	40.666542	-73.806407	Park	1	0	0
14	College Point	Popepnhausen Park	40.781653	-73.844672	Park	2	0	2
15	College Point	Poppenhuesen Triangle Park	40.788130	-73.845970	Park	2	0	2
16	Glen Oaks	Glen Oaks Oval	40.749273	-73.714957	Park	2	1	2
17	Hollis	Kings Park	40.712344	-73.764469	Park	1	1	0
18	Hollis	Jamaica Park	40.712351	-73.764478	Park	1	1	0
19	Springfield Gardens	Springfield Park	40.665932	-73.758064	Park	1	0	2
20	Edgemere	Bayswater Park	40.596248	-73.770970	Park	1	0	0
21	Queensboro Hill	Mateos Park	40.742153	-73.827568	Park	1	0	0
22	Laurelton	Laurelton Park	40.670598	-73.735900	Park	1	0	1
23	Somerville	community playground	40.601131	-73.794403	Park	1	0	0
24	Forest Hills Gardens	Hawthorne Park	40.716422	-73.840083	Park	2	0	5
25	Pomonok	Blue park	40.733952	-73.808854	Park	1	5	1
26	Hunters Point	Hunter's Point Community Park	40.745033	-73.953225	Park	1	0	0
27	Sunnyside Gardens	Torsney Playground	40.747019	-73.921128	Park	2	2	5
28	Middle Village	Juniper Valley Park	40.720281	-73.881258	Park	2	0	3
29	Bayswater	Inwood Park	40.614236	-73.761475	Park	1	0	0
30	Queensbridge	Queensbridge Park	40.756701	-73.948653	Park	1	0	0

4.5 "Solution" parks

The solution of our problem are parks with Adult Service Count = 0 and Pharmacy Count > 0. There are 9 parks satisfying these 2 conditions:

```
In [112]: queens_final_parks_pharm_adult_serv_candidates = queens_final_parks_pharm_adult_serv_info[(queens_final_parks_pharm_adult_serv_info["AdultService Count"]==0) & (queens_final_parks_pharm_adult_serv_info["Pharmacy Count"] > 0)]
queens_final_parks_pharm_adult_serv_candidates_potential = queens_final_parks_pharm_adult_serv_candidates.sort_values(by=["Cluster Labels", "Pharmacy Count"], ascending=False)
queens_final_parks_pharm_adult_serv_candidates_potential.reset_index(drop=True, inplace=True)
queens_final_parks_pharm_adult_serv_candidates_potential
```

Out[112]:

	Neighborhood	Venue	Park Latitude	Park Longitude	Venue Category	Cluster Labels	AdultService Count	Pharmacy Count
0	Forest Hills	Yellowstone Park	40.726251	-73.847759	Park	2	0	6
1	Forest Hills	MacDonald Park	40.722239	-73.847141	Park	2	0	5
2	Forest Hills Gardens	Hawthorne Park	40.716422	-73.840083	Park	2	0	5
3	Maspeth	Whitefish Triangle Park	40.726517	-73.901752	Park	2	0	3
4	Middle Village	Juniper Valley Park	40.720281	-73.881258	Park	2	0	3
5	College Point	Popepnhausen Park	40.781653	-73.844672	Park	2	0	2
6	College Point	Poppenhuesen Triangle Park	40.788130	-73.845970	Park	2	0	2
7	Springfield Gardens	Springfield Park	40.665932	-73.758064	Park	1	0	2
8	Laurelton	Laurelton Park	40.670598	-73.735900	Park	1	0	1

It is interesting to see now the distances of the pharmacies to respective "solution" parks

Out[114]:

	Neighborhood	Park	Pharmacy Latitude	Pharmacy Longitude	Venue	Distance
11	Forest Hills Gardens	Hawthorne Park	40.718438	-73.838177	Rite Aid	275.817504
12	Forest Hills Gardens	Hawthorne Park	40.721396	-73.843421	CVS pharmacy	620.683159
13	Forest Hills Gardens	Hawthorne Park	40.724004	-73.847911	Walgreens	1070.793864
14	Forest Hills Gardens	Hawthorne Park	40.726791	-73.853772	CVS pharmacy	1631.436981
15	Forest Hills Gardens	Hawthorne Park	40.703557	-73.824861	CVS pharmacy	1922.180490
19	Middle Village	Juniper Valley Park	40.712905	-73.878023	AJ's Village Chemist	864.574704
20	Middle Village	Juniper Valley Park	40.727184	-73.892861	CVS pharmacy	1243.460892
21	Middle Village	Juniper Valley Park	40.722987	-73.900637	Eagle pharmacy	1661.073463
28	Laurelton	Laurelton Park	40.660851	-73.739247	Walgreens	1120.385569
6	Forest Hills	MacDonald Park	40.724004	-73.847911	Walgreens	206.755769
7	Forest Hills	MacDonald Park	40.721396	-73.843421	CVS pharmacy	327.295251
8	Forest Hills	MacDonald Park	40.726791	-73.853772	CVS pharmacy	754.126679
9	Forest Hills	MacDonald Park	40.718438	-73.838177	Rite Aid	865.907530
10	Forest Hills	MacDonald Park	40.730898	-73.860729	CVS pharmacy	1496.432745
22	College Point	Popepnhausen Park	40.783961	-73.846040	Rite Aid	281.357993
23	College Point	Popepnhausen Park	40.785310	-73.845660	Walgreens	415.166141
24	College Point	Poppenhuesen Triangle Park	40.785310	-73.845660	Walgreens	314.674123
25	College Point	Poppenhuesen Triangle Park	40.783961	-73.846040	Rite Aid	463.686857
26	Springfield Gardens	Springfield Park	40.673555	-73.770720	Variety Drugs	1363.404179
27	Springfield Gardens	Springfield Park	40.660851	-73.739247	Walgreens	1685.246699
16	Maspeth	Whitefish Triangle Park	40.722987	-73.900637	Eagle pharmacy	403.731647
17	Maspeth	Whitefish Triangle Park	40.727184	-73.892861	CVS pharmacy	753.037221
18	Maspeth	Whitefish Triangle Park	40.708905	-73.905848	Rite Aid	1989.080718
0	Forest Hills	Yellowstone Park	40.724004	-73.847911	Walgreens	250.195391
1	Forest Hills	Yellowstone Park	40.726791	-73.853772	CVS pharmacy	510.425139
2	Forest Hills	Yellowstone Park	40.721396	-73.843421	CVS pharmacy	652.088138
3	Forest Hills	Yellowstone Park	40.718438	-73.838177	Rite Aid	1186.376035
4	Forest Hills	Yellowstone Park	40.730898	-73.860729	CVS pharmacy	1209.297584
5	Forest Hills	Yellowstone Park	40.737679	-73.859863	Rite Aid	1629.929919

and also the distance to the nearest adult day care center for each "solution" park

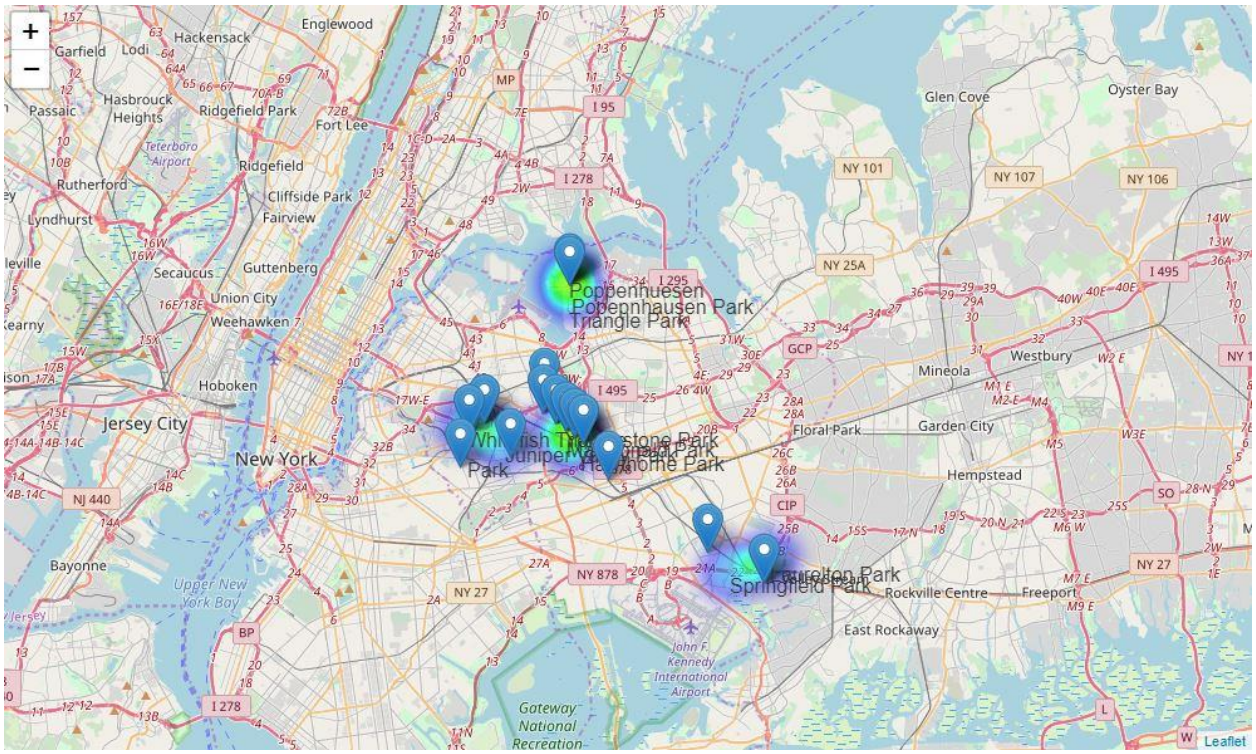
Out[115]:

Neighborhood	Park	Distance
College Point	Popepnhausen Park	1450.871273
	Poppenhuesen Triangle Park	2172.749876
Forest Hills	MacDonald Park	1039.123592
	Yellowstone Park	1001.678970
Forest Hills Gardens	Hawthorne Park	1366.428196
Laurelton	Laurelton Park	5424.023681
Maspeth	Whitefish Triangle Park	1291.385571
Middle Village	Juniper Valley Park	1798.627996
Springfield Gardens	Springfield Park	5289.929131

We see that our "solution" parks satisfy 2 conditions of the problem:

1. No existing adult day care center within 1 km of the park latitude and longitude coordinates.
2. At least one pharmacy within 2 km of the park latitude and longitude coordinates.

Here is the heat map based on the count of respective pharmacies to graphically display promising locations. Popups mark pharmacies locations.



It is important to note here even if we use directly the queens_adult_care_services_data without performing a join to find out to which cluster respective adult day care center belongs the solution is still the same. See the notebook for details. In other words our solution is not sensitive to splitting the NTA column on "-".

5. Results and Discussion

Our problem was to identify parks in Queens satisfying the following 2 conditions:

1. No existing adult day care center within 1 km of the park latitude and longitude coordinates.
2. At least one pharmacy within 2 km of the park latitude and longitude coordinates.

We found 9 parks that satisfied these 2 conditions displayed in the 4.5 section.

The analysis shows that it is possible to solve our problem using the Foursquare location data in combination with the Queens neighborhoods and adult day care centers data. Of course, this list of 9 parks is a very first step in the process of finding an optimal location for an adult day care center in the Queens Borough of New York City whose main focus would be on recreational activities and social stimulation for the elderly population who would otherwise stay at home alone. These park locations will be presented to

stakeholders as a starting point for stakeholders final 'street level' exploration to determine the optimal adult day care center location.

Final decision on optimal adult day care center location will be made by the stakeholders who would also need to take into consideration additional factors since starting an adult day care facility does have some unique start-up considerations. For example, there are federal and state requirements, medical and insurance requirements as well as zoning laws. Entrepreneurs who are considering starting an adult day care facility should consider applying for a nonprofit tax status since many of the senior programs and grants available are offered only to non-for-profit organizations. Since most seniors are on some type of an assistance program, getting an IRS tax status as a nonprofit may be beneficial. Also many states require that adult day care facilities provide meals. Two state requirements that most states require are CPR and first aid certifications. It is also important to define which medical services the day care will provide, because state certifications and licensing requirements vary. Adult day care facilities also need fire insurance and should consider theft insurance. Most importantly, some states have facility standards and requirements for adult day cares and this must be addressed prior to choosing a location. In addition, the stakeholders need to check real estate availability information and prices around the parks, depending on what they plan to do, rent or buy a place. If starting an adult day care in a house, the stakeholders need to check if zoning laws will allow such a business in the area. So it's interplay of all these factors that would influence the final decision on the optimal adult day care center location.

7 out of 9 parks belong to Pharmacies and Parks cluster which confirms our intuition that an optimal location for an adult day care center would be probably around a park that belongs to a cluster where parks and pharmacies are mixed together. We see that the k-means clustering can provide a quick way to identify most of the potential candidate parks. We are confident that k=3 used for the k-means clustering is an optimal one since the plot for the "elbow" method looks really like an arm. The stakeholders who already have an established business and want to expand will most likely be interested in locations around big parks, like Juniper Valley Park or Springfield park. Small parks like Popepnhausen Park or Yellowstone Park might be of interest to entrepreneurs who want to start adult day care business.

6. Conclusion

The purpose of this project was to find an optimal location for an adult day care center in the Queens Borough of New York City whose main focus would be on recreational activities and social stimulation for the elderly population who would otherwise stay at home alone. The optimal location had to satisfy 2 conditions:

1. No existing adult day care center within 1 km of the park latitude and longitude coordinates.
2. At least one pharmacy within 2 km of the park latitude and longitude coordinates.

We did show that it's possible to identify such locations using the Foursquare location data in combination with the Queens neighborhoods and adult day care centers data.

The k-means clustering can provide a quick way to identify most of the potential candidate parks.

These park locations will be presented to stakeholders as a starting point for stakeholders final 'street level' exploration to determine the optimal adult day care center location. Final decision on optimal adult day care center location will be made by the stakeholders who would also need to take into consideration additional factors such as federal and state requirements, medical and insurance requirements, zoning laws and real estate availability information and prices around the parks. Distance limits of the adult day care centers and pharmacies used in this project for the optimal location are not set in stone and can be customized based on the stakeholders interest.

Future directions include researching how to incorporate real estate availability information and prices data around the parks to produce more focused locations.

References

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2. https://bizfluent.com/about-5479617-requirements-adult-day-care-business.html
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