IBM Data Science Professional Certificate Course

# Capstone Project - The Battle of the Neighborhoods

Finding out the best neighborhoods to open up a new restaurant in New York City, NY

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## Introduction

This project is about using the data science skills and techniques that I have learned and developed by taking the IBM Data Science Professional Certificate course. Throughout the project I will be implementing various data science tools and methods and applying them on a real world business problem. This is the capstone project for the IBM Data Science Professional Certificate course, which marks the end of the course and the beginning of my data science path.

## Business Problem

This notebook will try to solve a theoretical business problem using Data Science and Machine Learning, specifically using k-means Clustering. The Business problem is finding the best neighborhoods for existing and new F&B businesses to open up a restaurant in all of New York City's (NYC) 5 boroughs. This notebook will focus on New York City as it is a metropolitan city, where the F&B sector is highly competitive. Many F&B businesses have a very difficult time studying and researching the best location to open up their restaurant. This notebook should give a brief insight on the best neighborhoods to open up a new restaurant in and what type of cuisine would most suit these neighborhoods.

## The Data

The data that will be used in the report will be from the following sources:

1. The list of Boroughs and Neighborhoods from the 'newyork_data.json' file from the IBM server.
2. Geo-coordinates of New York City's Neighborhoods using the Nominatim API from Python's Geopy client.
3. Venues data using the Foursquare API.

**Methodology**

We will begin our analysis by installing/importing the necessary libraries namely:

1. Numpy, which is a library used to handle data in a vectorized manner.
2. Pandas, which is a library used for data manipulation and analysis.
3. Json, which is a library used to handle JSON files.
4. Geopy, which is a library used to convert an address into geo-coordinates.
5. Matplotlib, which is a library used for plotting graphs.
6. Scikit-learn, which is a library used for Machine Learning.
7. Folium, which is a library used for creating maps.

The data will be acquired from a json file and will be cleaned up and rearranged using Python's Pandas library

The Foursquare API, will be used to acquire the top venues of the neighborhoods, and results will be shown in a pandas dataframe and then will be merged with original data and will be cleaned up to be used for machine learning.

The methodology that will be implemented in the analysis will depend on an unsupervised machine learning clustering algorithm, and using the k-means method to create a k number of clusters of NYC's neighborhoods. To find the optimal number of clusters we will begin by using the Elbow Method, and eventually the Silhouette Score for a more accurate choice.

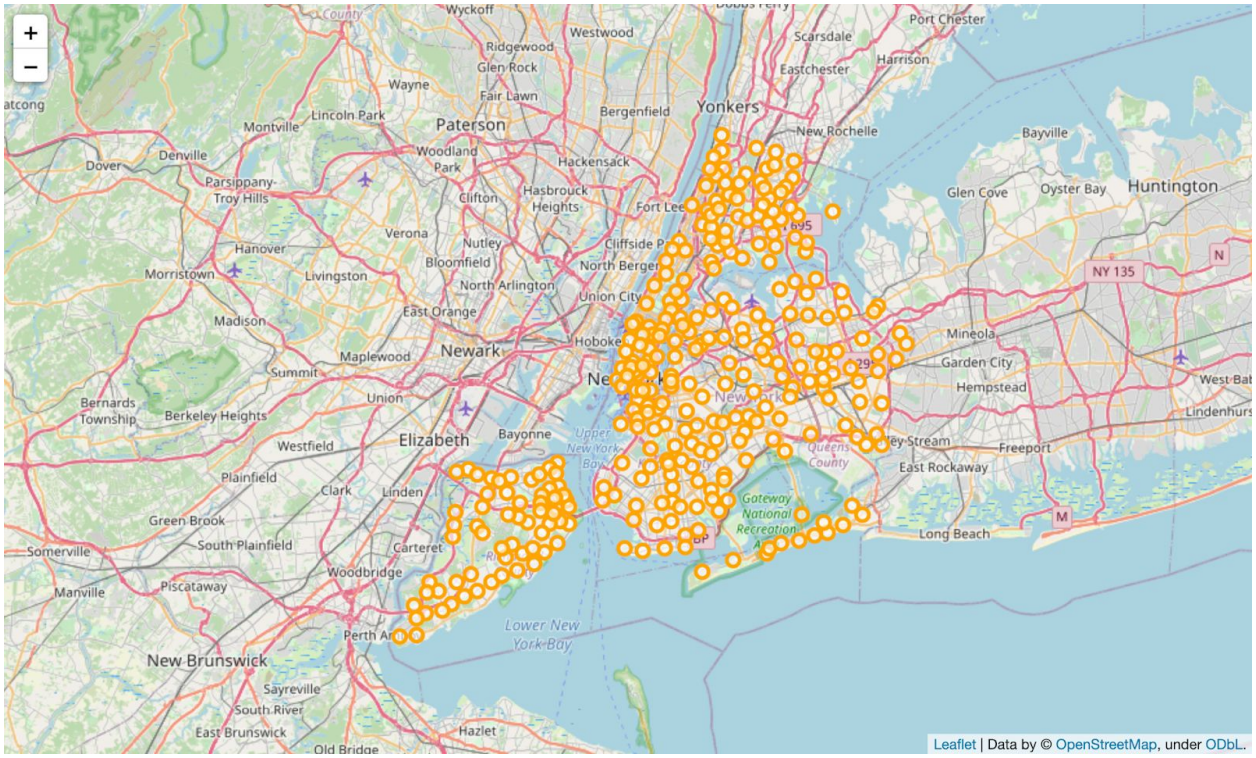
Importing the libraries:

```
import numpy as np # library to handle data in a vectorized manner

import pandas as pd # library for data analsysis
pd.set_option('display.max_columns', None)
pd.set_option('display.max_rows', None)

import json # library to handle JSON files

from geopy.geocoders import Nominatim # convert an address into latitude and longitude values

import requests # library to handle requests
from pandas.io.json import json_normalize # tranform JSON file into a pandas dataframe

# Matplotlib and associated plotting modules
import matplotlib.cm as cm
import matplotlib.colors as colors

# import k-means from clustering stage
from sklearn.cluster import KMeans

!pip install folium
import folium # map rendering library

print('Libraries imported.')
```

The data will be acquired from a json file and will be cleaned up and rearranged using Python's Pandas library with a shape of (5, 306). The top 10 rows are shown below:

| | Borough | Neighborhood | Latitude | Longitude |
|---|---|---|---|---|
| **0** | Bronx | Wakefield | 40.894705 | -73.847201 |
| **1** | Bronx | Co-op City | 40.874294 | -73.829939 |
| **2** | Bronx | Eastchester | 40.887556 | -73.827806 |
| **3** | Bronx | Fieldston | 40.895437 | -73.905643 |
| **4** | Bronx | Riverdale | 40.890834 | -73.912585 |
| **5** | Bronx | Kingsbridge | 40.881687 | -73.902818 |
| **6** | Manhattan | Marble Hill | 40.876551 | -73.910660 |
| **7** | Bronx | Woodlawn | 40.898273 | -73.867315 |
| **8** | Bronx | Norwood | 40.877224 | -73.879391 |
| **9** | Bronx | Williamsbridge | 40.881039 | -73.857446 |

A map of NYC's neighborhoods is created using Folim.




The Foursquare API, will be used to acquire the top venues of the neighborhoods, a function will be defined that will extract the category of each venue retrieved from foursquare, and results will be shown in a pandas dataframe and then will be merged with original data and will be cleaned up to be used for machine learning. The top 5 results for one neighborhood are shown in the dataframe below.

| | Neighborhood | Neighborhood Latitude | Neighborhood Longitude | Venue | Venue Latitude | Venue Longitude | Venue Category |
|---|---|---|---|---|---|---|---|
| 0 | Wakefield | 40.894705 | -73.847201 | Lollipops Gelato | 40.894123 | -73.845892 | Dessert Shop |
| 1 | Wakefield | 40.894705 | -73.847201 | Ripe Kitchen & Bar | 40.898152 | -73.838875 | Caribbean Restaurant |
| 2 | Wakefield | 40.894705 | -73.847201 | Ali's Roti Shop | 40.894036 | -73.856935 | Caribbean Restaurant |
| 3 | Wakefield | 40.894705 | -73.847201 | Jackie's West Indian Bakery | 40.889283 | -73.843310 | Caribbean Restaurant |
| 4 | Wakefield | 40.894705 | -73.847201 | Rite Aid | 40.896649 | -73.844846 | Pharmacy |

One Hot Encoding will be used to analyze the neighborhoods and the data will be grouped and mean of occurrence frequency of each category will be calculated:

| | Neighborhood | Zoo Exhibit | ATM | Accessories Store | Adult Boutique | Adult Education Center | Afghan Restaurant | African Restaurant | Airport Lounge | Airport Service | Airport Terminal | American Restaurant | Amphitheater | Animal Shelter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Allerton | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.016667 | 0.0 | 0.0 |
| 1 | Annadale | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.117647 | 0.0 | 0.0 |
| 2 | Arden Heights | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000000 | 0.0 | 0.0 |
| 3 | Arlington | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.043478 | 0.0 | 0.0 |
| 4 | Arrochar | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.000000 | 0.0 | 0.0 |

Now we find the top 5 most common venues in each neighborhood, a sample of two neighborhoods is shown below:

```
----Erasmus----
                  venue  freq
0  Caribbean Restaurant  0.11
1         Deli / Bodega  0.07
2        Discount Store  0.07
3     Mobile Phone Shop  0.05
4           Pizza Place  0.05


----Far Rockaway----
                  venue  freq
0           Pizza Place  0.09
1    Chinese Restaurant  0.09
2         Deli / Bodega  0.06
3        Sandwich Place  0.06
4  Caribbean Restaurant  0.03
```

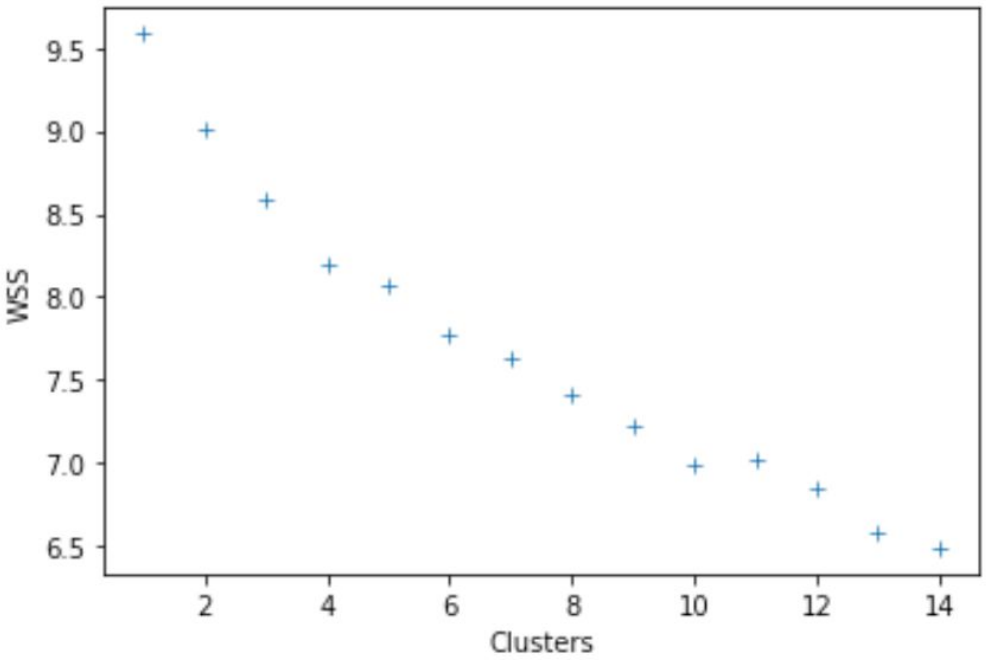
A function that returns the most common venues is defined and will be applied to all neighborhoods to get the top 10 most common venues. The head of the dataframe is shown below:

| | Neighborhood | 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 | 10th Most Common Venue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Allerton | Pizza Place | Donut Shop | Sandwich Place | Deli / Bodega | Caribbean Restaurant | Fast Food Restaurant | Mexican Restaurant | Pharmacy | Fried Chicken Joint | Food |
| 1 | Annadale | American Restaurant | Trail | Home Service | Restaurant | Pizza Place | Diner | Train Station | Park | Pub | Liquor Store |
| 2 | Arden Heights | Park | Italian Restaurant | Dog Run | Sushi Restaurant | Optical Shop | Food | Bus Stop | Spa | Gift Shop | Mexican Restaurant |
| 3 | Arlington | Bus Stop | Deli / Bodega | Hardware Store | Discount Store | American Restaurant | Check Cashing Service | Snack Place | Fast Food Restaurant | Coffee Shop | Donut Shop |
| 4 | Arrochar | Bus Stop | Italian Restaurant | Deli / Bodega | Baseball Field | Beach | Bagel Shop | Mediterranean Restaurant | Middle Eastern Restaurant | Nail Salon | Outdoors & Recreation |

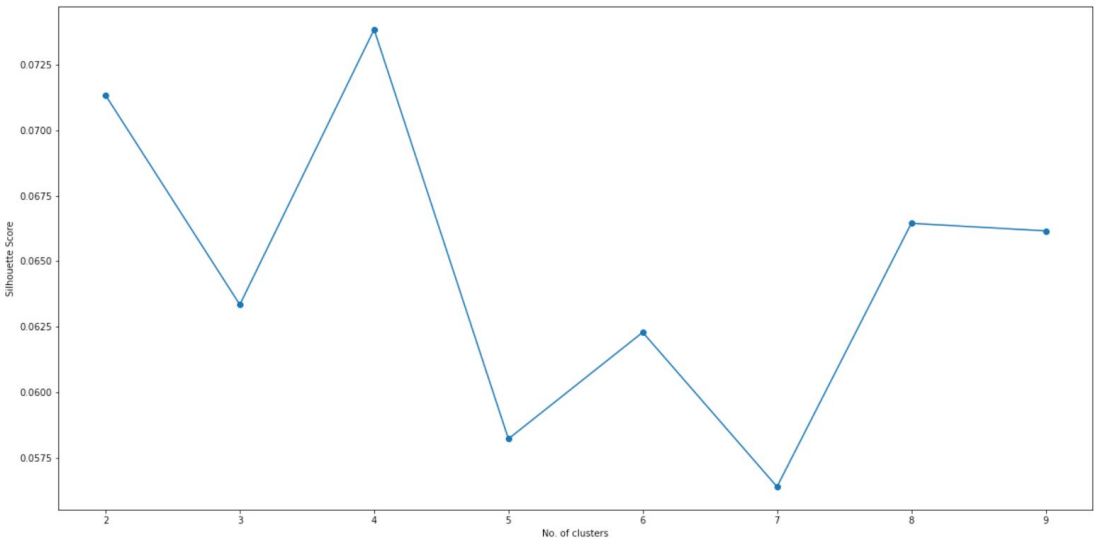
**Machine Learning:**

We will be using a Clustering algorithm using the k-means technique to cluster the most common venues in NYC's neighborhoods. To find the optimal number of clusters we will first use the elbow method and create a graph of it.

The elbow method:



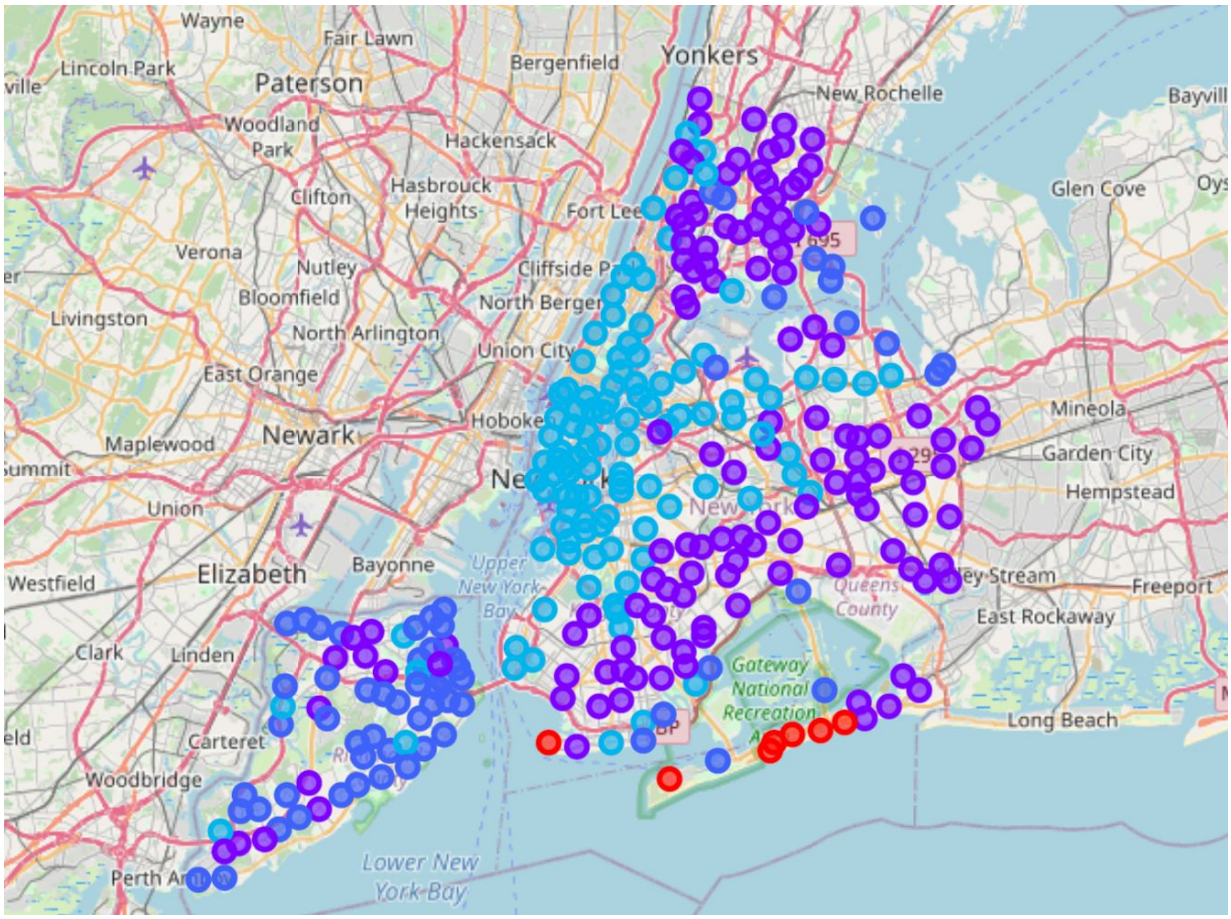
As we can see from the above elbow graph, it is not clear for us which is the best number of clusters, and this could happen with the elbow method. An alternative method would be the Silhouette Scores, which should give a more accurate way to select the number of clusters. The silhouette score gives a score between 0 and 1, the higher the more accurate.




Based on the graph shown above, the optimal number of clusters is 4, and we run the K-means clustering with 4 as the number of clusters. Now, we create a dataframe that contains the cluster labels as well as the top 10 venues for each neighborhood.

| | Borough | Neighborhood | 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 | 9 C |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Bronx | Wakefield | 40.894705 | -73.847201 | 1 | Pharmacy | Caribbean Restaurant | Supermarket | Donut Shop | Fast Food Restaurant | Fried Chicken Joint | Bank | Pizza Place | |
| 1 | Bronx | Co-op City | 40.874294 | -73.829939 | 1 | Pizza Place | Department Store | Mobile Phone Shop | Shopping Mall | Shoe Store | Pharmacy | Clothing Store | Bakery | |
| 2 | Bronx | Eastchester | 40.887556 | -73.827806 | 1 | Caribbean Restaurant | Shopping Mall | Diner | Fast Food Restaurant | Gas Station | Supplement Shop | Grocery Store | Pharmacy | |
| 3 | Bronx | Fieldston | 40.895437 | -73.905643 | 1 | Deli / Bodega | Bus Station | Pizza Place | Bar | Plaza | Sandwich Place | Park | Mexican Restaurant | |
| 4 | Bronx | Riverdale | 40.890834 | -73.912585 | 3 | Bank | Pizza Place | Bar | Park | Diner | Deli / Bodega | Japanese Restaurant | Coffee Shop | |

Map to visualize the clusters is created:




**Results - Clusters Examination:**

Cluster 1:

| | Neighborhood | 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 | 10th Most Common Venue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 85 | Sea Gate | Beach | Supermarket | American Restaurant | Pharmacy | Park | Donut Shop | Chinese Restaurant | Bus Stop | Video Store | Spa |
| 172 | Breezy Point | Surf Spot | American Restaurant | Beach | Monument / Landmark | Park | Trail | Deli / Bodega | Exhibit | Factory | Falafel Restaurant |
| 178 | Rockaway Beach | Beach | Bar | Pharmacy | Boat or Ferry | Latin American Restaurant | Ice Cream Shop | Pizza Place | Eastern European Restaurant | Arepa Restaurant | Supermarket |
| 179 | Neponsit | Beach | Spa | Deli / Bodega | Pub | Mexican Restaurant | Italian Restaurant | Restaurant | Harbor / Marina | Bakery | Boutique |
| 190 | Belle Harbor | Beach | Pub | Donut Shop | Bakery | Mexican Restaurant | Bagel Shop | Chinese Restaurant | Harbor / Marina | Pharmacy | Smoke Shop |
| 191 | Rockaway Park | Beach | Pizza Place | Donut Shop | Liquor Store | Bagel Shop | Bar | Pharmacy | Deli / Bodega | Pub | Supermarket |
| 302 | Hammels | Beach | Surf Spot | Donut Shop | Fast Food Restaurant | Coffee Shop | Pizza Place | Taco Place | Bar | Supermarket | Wine Bar |

Cluster 2: (first 7 rows shown)

| | Neighborhood | 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 | 10th Most Common Venue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Wakefield | Pharmacy | Caribbean Restaurant | Supermarket | Donut Shop | Fast Food Restaurant | Fried Chicken Joint | Bank | Pizza Place | Bakery | Bus Station |
| 1 | Co-op City | Pizza Place | Department Store | Mobile Phone Shop | Shopping Mall | Shoe Store | Pharmacy | Clothing Store | Bakery | Liquor Store | Mattress Store |
| 2 | Eastchester | Caribbean Restaurant | Shopping Mall | Diner | Fast Food Restaurant | Gas Station | Supplement Shop | Grocery Store | Pharmacy | Donut Shop | Discount Store |
| 3 | Fieldston | Deli / Bodega | Bus Station | Pizza Place | Bar | Plaza | Sandwich Place | Park | Mexican Restaurant | Bank | Chinese Restaurant |
| 6 | Marble Hill | Park | Pizza Place | Mexican Restaurant | Café | Donut Shop | Spanish Restaurant | Sandwich Place | Grocery Store | Scenic Lookout | Supermarket |
| 7 | Woodlawn | Pub | Bar | Deli / Bodega | Pizza Place | Bakery | Discount Store | Donut Shop | Bank | Baseball Field | Fast Food Restaurant |

Cluster 3: (first 7 rows shown)

| | Neighborhood | 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 | 10th Most Common Venue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | City Island | Harbor / Marina | Seafood Restaurant | Boat or Ferry | Italian Restaurant | Bar | Thrift / Vintage Store | American Restaurant | Music Venue | French Restaurant | Bank |
| 16 | Fordham | Italian Restaurant | Pizza Place | Spanish Restaurant | Deli / Bodega | Shoe Store | Mobile Phone Shop | Diner | Coffee Shop | Supplement Shop | Dessert Shop |
| 27 | Clason Point | Pool | Boat or Ferry | Event Space | Discount Store | Gym / Fitness Center | Park | Wings Joint | Bus Stop | Farm | Falafel Restaurant |
| 28 | Throgs Neck | Italian Restaurant | Deli / Bodega | Donut Shop | Pizza Place | Harbor / Marina | American Restaurant | Asian Restaurant | Coffee Shop | Trail | Bookstore |
| 34 | Belmont | Italian Restaurant | Pizza Place | Deli / Bodega | Bakery | Shoe Store | Zoo | Dessert Shop | Latin American Restaurant | Café | Garden |
| 37 | Pelham Bay | Italian Restaurant | Deli / Bodega | Fast Food Restaurant | Sandwich Place | Pizza Place | Bank | Bakery | Convenience Store | Donut Shop | Rental Car Location |

Cluster 4: (first 7 rows shown)

| | Neighborhood | 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 | 10th Most Common Venue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Riverdale | Bank | Pizza Place | Bar | Park | Diner | Deli / Bodega | Japanese Restaurant | Coffee Shop | Health & Beauty Service | Bagel Shop |
| 5 | Kingsbridge | Pizza Place | Mexican Restaurant | Sandwich Place | Bar | Diner | Donut Shop | Coffee Shop | Pharmacy | Bank | Park |
| 19 | High Bridge | Lounge | Baseball Stadium | Park | Plaza | Burger Joint | Bar | BBQ Joint | Beer Bar | Caribbean Restaurant | Liquor Store |
| 24 | Hunts Point | Park | Bakery | Market | Paintball Field | Travel & Transport | Gourmet Shop | Farmers Market | Seafood Restaurant | Mexican Restaurant | Home Service |
| 46 | Bay Ridge | Pizza Place | Spa | Italian Restaurant | Coffee Shop | Bagel Shop | Chinese Restaurant | Cosmetics Shop | Greek Restaurant | American Restaurant | Café |
| 48 | Sunset Park | Bakery | Mexican Restaurant | Pizza Place | Chinese Restaurant | Bank | Latin American Restaurant | Ice Cream Shop | Asian Restaurant | Sandwich Place | Dumpling Restaurant |

**Discussion & Recommendations**

After implementing the k-means clustering algorithm, we can see the following for each cluster:

**Cluster 1:**

In the first cluster we can see that there aren't many restaurants in the top spots of common venues in these neighborhoods, and also there isn't a wide variety of cuisine options in the top spots with the most common options being: American restaurants, Donut shops and Pizza places. Furthermore, we can also see that beaches are quite common in these neighborhoods, making it an ideal option for some types of cuisine like seafood, casual dining, and other types of laid back cuisines like lounges.

**Cluster 2:**

In cluster 2 we can see that there are many restaurants in the top 3 spots of most common venues in the neighborhoods, like Carribean restaurants, Donut shops, Chinese restaurants, etc... with Pizza places being quite common. Which can also mean that competition could be high in these neighborhoods. We can also see from the map, that these neighborhoods are mainly in Brooklyn, Queen and The Bronx, and that it is one of the largest clusters where F&B businesses are very common and diverse. Furthermore, we can see that parks occupy a top spot in a couple of neighborhoods, which could give us an idea that these neighborhoods are more family oriented, where Family Diners could do well. The neighborhoods in this cluster could be ideal for fast food outlets, family diners, as well as foreign cuisines given the varse diversity of the neighborhoods.

**Cluster 3:**

In this cluster, we can note that Italian restaurants and pizza places are quite common in these neighborhoods. This could also mean that other types of cuisines could have a good chance there, but this could also mean that the demographic in these neighborhoods prefers these types of cuisines, and that is why we see many of those in these areas. When we look at the map of clusters, we see most of the points are in Staten Island, where the majority of residents are Italian Americans. This cluster could be ideal for a lot of different cuisines and specifically American cuisines given that it has some museums, hotels and other touristy attractions, and also casual or family diners since its neighborhoods have common parks and other family attractions, and finally, it can be ideal for seafood concepts as some of the neighborhoods have Marinas and Harbors as the most common venues.

**Cluster 4:**

If we look at the top most common venues in this cluster, we can find out that it has quite a variety of famous venues from Italian, to Latin American, to American and also Asian cuisines. And looking at the clusters map, we can see that the points of this cluster are mainly in Manhattan, which has a very diverse and competitive market. In this cluster, we can see that coffee shops, bars, cafes and parks are some of the more common venues in the neighborhoods. Making these neighborhoods ideal for such types of cuisines.

**Conclusion**

This concludes my capstone project for the IBM Data Science Professional Certificate course. In my capstone project I tried to answer a hypothetical question and tried to provide answers using

a variety of libraries, methods, and machine learning techniques. All in all, this was an excellent course, which I highly recommend to anyone interested in getting into Data Science.

-The End-