V. Pacheco de Freitas

27 June 2021

Capstone Project - The Battle of the Neighborhoods

Vegetarian Restaurant in Krakow

1. Introduction

Recent results show that over 3 million Poles no longer eat meat and 8.4% of Polish adults had followed a vegetarian diet or had eaten only fish but no other meat for a period of time [1]. The same report indicates that even people who eat meat want to make an effort to limit their consumption.

Warsaw, capital of the country was also ranked the 6th most vegan friendly city on the planet [2]. Thinking of this, our stakeholder wants to expand this trend to Krakow, and open a vegetarian restaurant in the city, which is one of the largest cities in Poland.

The advantages of Krakow include the fact that the city attracts tourists with its beauty, unique historic complex and cultural events.

When choosing a place to open a new venue, we should take into considerations a few key aspects, like demographics of people interested in this type of restaurante, their income, where they usually live across the city and also real state prices for our business. We also need to know the density of other restaurantes and other restaurantes similar to ours.

Considering that the analysis in the scope of our initial research relies on free available information and constraints imposed by the Foursquare API, used to track the nearby venues for the district in the city, we will limit our analysis to a few key points:

- Population in each district
- Number of restaurants per district and
- Number of vegetarian restaurants already in the area.

2. Data

For this preliminary analysis we will consider the list of 18 districts in the Krakow area and their coordinates, available in [3]; the population and population density in each district [4]; the number of restaurantes within a certain radius from each district and the number of

vegetarian restaurants in each district. This will be limited to the free information from Foursquare API.

In the following sections we will use the Foursquare API to search the venues in each district and to sort the total number of restaurants and total number of vegetarian or vegan restaurants in each district. Using this in comparison to the population in each district, we apply an unsupervised learning technic (KMeans) to cluster the districts with regards to our feature selection in order to help us to assess the best neighborhood for the new restaurant.

2.1. Initial set of data

Krakow has 4 distinct areas with a total of 18 districts. Our first step is to get the population, area (in km^2) and density of population (number of people per km^2). This data was available in [4].
We also have available in Wikipedia [3] the latitude and longitude for each district, which we can use to produce Table 1.

We show in Figure 1 the location of the districts with the radius of each circle being proportional to the population density in each of them.

Figure 1: Map of Krakow with population density in each district highlighted.

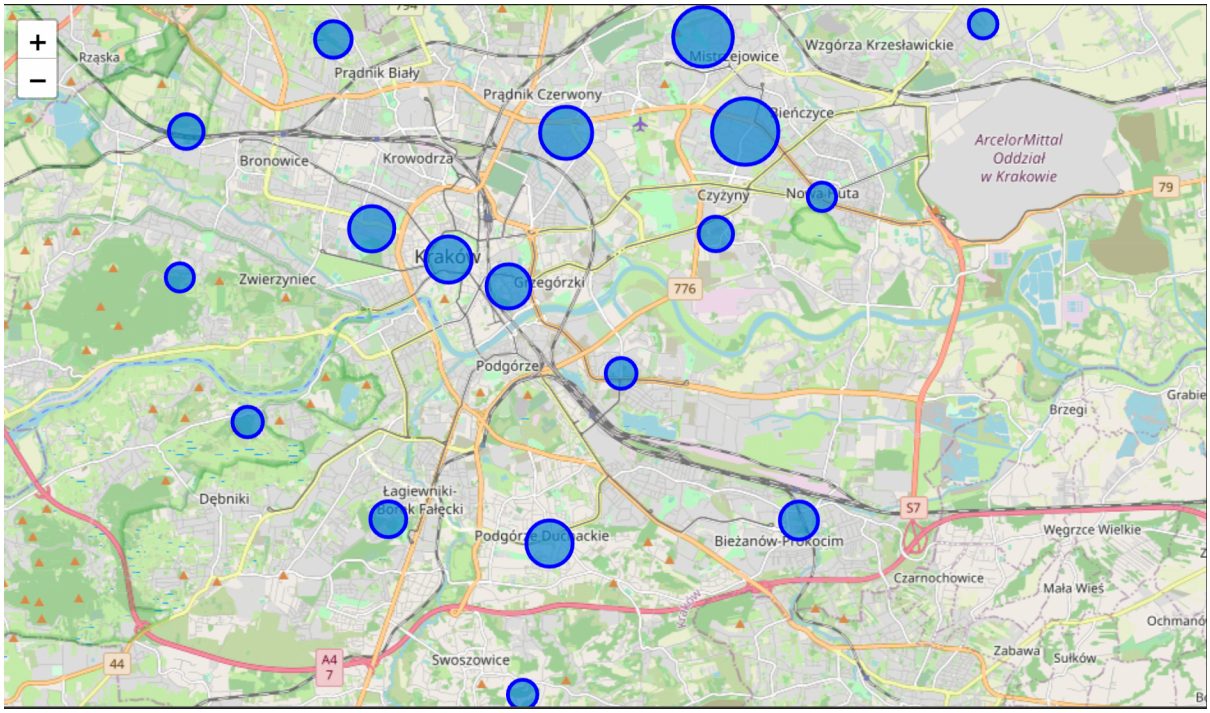


Table 1: Krakow districts, population, area (km^2), density of population (people per km^2) and coordinates.

Region	District	Population	Area	Density of population	Latitude	Longitude
Śródmieście	Stare Miasto	31 359	5 568	5 632	50.061389	19.937222
Śródmieście	Grzegórzki	29 474	5 845	5 042	50.056611	19.953278
Śródmieście	Prądnik Czerwony	46 627	6 438	7 243	50.083231	19.968844
Krowodrza	Prądnik Biały	70 647	23 419	3 017	50.099239	19.906303
Krowodrza	Krowodrza	30 223	5 619	5 379	50.066667	19.916667
Krowodrza	Bronowice	23 678	9 560	2 477	50.083333	19.866667
Krowodrza	Zwierzyniec	20 392	28 731	710	50.05825	19.864922
Podgórze	Dębnik	61 637	46 189	1 334	50.033333	19.883333
Podgórze	Łagiewniki-Borek Fałęcki	15 259	5 415	2 818	50.016472	19.921083
Podgórze	Swoszowice	27 493	25 604	1 074	49.986378	19.956869
Podgórze	Podgórze Duchackie	53 747	9 540	5 634	50.012278	19.964069
Podgórze	Bieżanów-Prokocim	62 830	18 474	3 401	50.016328	20.031161
Podgórze	Podgórze	36 885	25 667	1 437	50.041667	19.983333
Nowa Huta	Czyżyny	29 635	12 257	2 418	50.065723	20.00879
Nowa Huta	Mistrzejowice	52 011	5 590	9 304	50.099575	20.005478
Nowa Huta	Bieńczyce	41 112	3 699	11 114	50.083333	20.016667
Nowa Huta	Wzgórza Krzesławickie	20 205	23 815	848	50.101944	20.080497
Nowa Huta	Nowa Huta	51 234	65 410	783	50.072222	20.0375

2.2. Using Foursquare API

Having the latitude and longitude of each district we can use the Foursquare API (https://developer.foursquare.com/) to find the nearby venues in each region.

Doing some preliminary exploratory analysis, we can see the main 3 venues in each district and also notice that we have restaurants among the top 3 in many districts, including in the more densely populated ones. We present this result in Table 2.

In the next section we will merge the results from Table 1 with all the venues listed in the Foursquare API and select the features we want to use in our analysis. One important note here is that we have a limitation in the number of venues we can get for free with Foursquare, but for the current scope of our assessment (limit = 500) this is enough.

Table 2: Districts and top 3 venues based on Foursquare API data.

District	**Stare Miasto**	**Grzegórzki**	**Prądnik Czerwony**
1	Café	Bar	Food & Drink Shop
2	Hotel	Hotel	Bus Station
3	Italian Restaurant	Food Truck	Pizza Place
District	**Prądnik Biały**	**Krowodrza**	**Bronowice**
1	Coffe Shop	Café	Flower Shop
2	Grocery Store	Park	Train Station
3	Italian Restaurant	Bistro	Flea Market
District	**Zwierzyniec**	**Dębnik**	**Łagiewniki-Borek Fałęcki**
1	Zoo	Scenic Lookout	Shopping Mall
2	Grocery Store	Restaurant	Bus Station
3	Restaurant	Pizza Place	Gym
District	**Swoszowice**	**Podgórze Duchackie**	**Bieżanów-Prokocim**
1	Shoe Store	Supermarket	Convenience Store
2	Memorial Site	Convenience Store	Gym/Fitness Center
3	Liquor Store	Gas Station	Platform
District	**Podgórze**	**Czyżyny**	**Mistrzejowice**
1	Tram Station	Bus Stop	Tram Station
2	Bus Station	Supermarket	Park
3	Supermarket	Department Store	Sushi Restaurant
District	**Bieńczyce**	**Wzgórza Krzesławickie**	**Nowa Huta**
1	Supermarket	Construction & Landscaping	Park
2	Fast Food Restaurant	Diner	Bus Station
3	Tram Station	Pet Store	Café

2.3. Data cleaning and feature selection

Now we can select the venues that are interesting to our analysis. We start by sorting the number of places tagged with "Vegetarian/Vegan", which will give us the number of vegetarian places in each district. We also select the venues with tags "Restaurant, Diner, Pizza Place" to account for all restaurants in each neighbourhood.

After some data cleaning we have the final table we will use. Values are presented in Table 3.

Table 3. Number of restaurants and of vegetarian restaurants in each district.

District	Latitude	Longitude	Area	Density of population	Total Restaurants	Total Vegetarian
Stare Miasto	50.061389	19.937222	5 568	5 632	28.0	3.0
Grzegórzki	50.056611	19.953278	5 845	5 042	28.0	2.0
Prądnik Czerwony	50.083231	19.968844	6 438	7 243	5.0	0.0
Prądnik Biały	50.099239	19.906303	23 419	3 017	5.0	0.0
Krowodrza	50.066667	19.916667	5 619	5 379	22.0	1.0
Bronowice	50.083333	19.866667	9 560	2 477	0.0	0.0
Zwierzyniec	50.05825	19.864922	28 731	710	2.0	0.0
Dębnik	50.033333	19.883333	46 189	1 334	3.0	0.0
Łagiewniki-Borek Fałęcki	50.016472	19.921083	5 415	2 818	3.0	0.0
Swoszowice	49.986378	19.956869	25 604	1 074	1.0	0.0
Podgórze Duchackie	50.012278	19.964069	9 540	5 634	1.0	0.0
Bieżanów-Prokocim	50.016328	20.031161	18 474	3 401	1.0	0.0
Podgórze	50.041667	19.983333	25 667	1 437	3.0	0.0
Czyżyny	50.065723	20.00879	12 257	2 418	5.0	0.0
Mistrzejowice	50.099575	20.005478	5 590	9 304	2.0	0.0
Bieńczyce	50.083333	20.016667	3 699	11 114	6.0	0.0
Wzgórza Krzesławickie	50.101944	20.080497	23 815	848	1.0	0.0
Nowa Huta	50.072222	20.0375	65 410	783	4.0	0.0

We will use the density of population, density of restaurants (Total Restaurants/Area) and density of vegetarian restaurants (Total Vegetarian/Area) as our features to use the clustering method KMeans in order to define a set number of clusters that will help us to assess the best place to open the new restaurant.

3. Methodology

After computing the number of restaurants and the number of vegetarian restaurants, we can compute the density of restaurants and density of vegetarian restaurants, which number of restaurants/area.

This will reduce our dataset to density of population, density of restaurants and density of vegetarian restaurants.

After normalising this data we want to use the unsupervised learning method KMeans to cluster our data based on these characteristics. A cluster refers to a collection of data points aggregated together because of certain similarities.

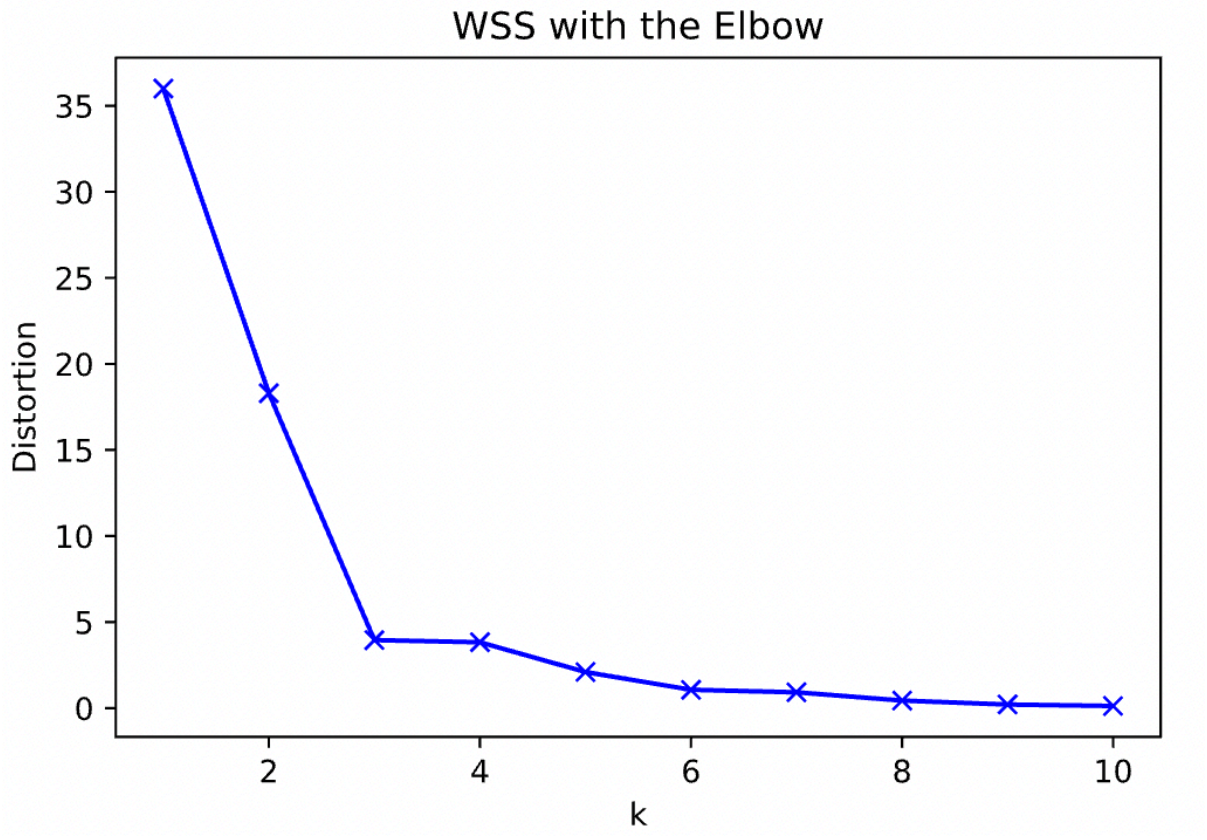
In order to do that, we define a target number k, which is the number of centroids we need in the dataset, which represents the center of each cluster. Every data point is then allocated to each of the clusters reducing the in-cluster sum of squares.

Before selecting the number of k, we can use two techniques to choose and validate the optimal k [5].

3.1. Elbow method:

Calculate the Within-Cluster-Sum of Squared Errors (WSS) for different values of k and choose the k for which WSS starts to diminish. We show the results in Figure 2.

Figure 2: Optimal k with Elbow method.



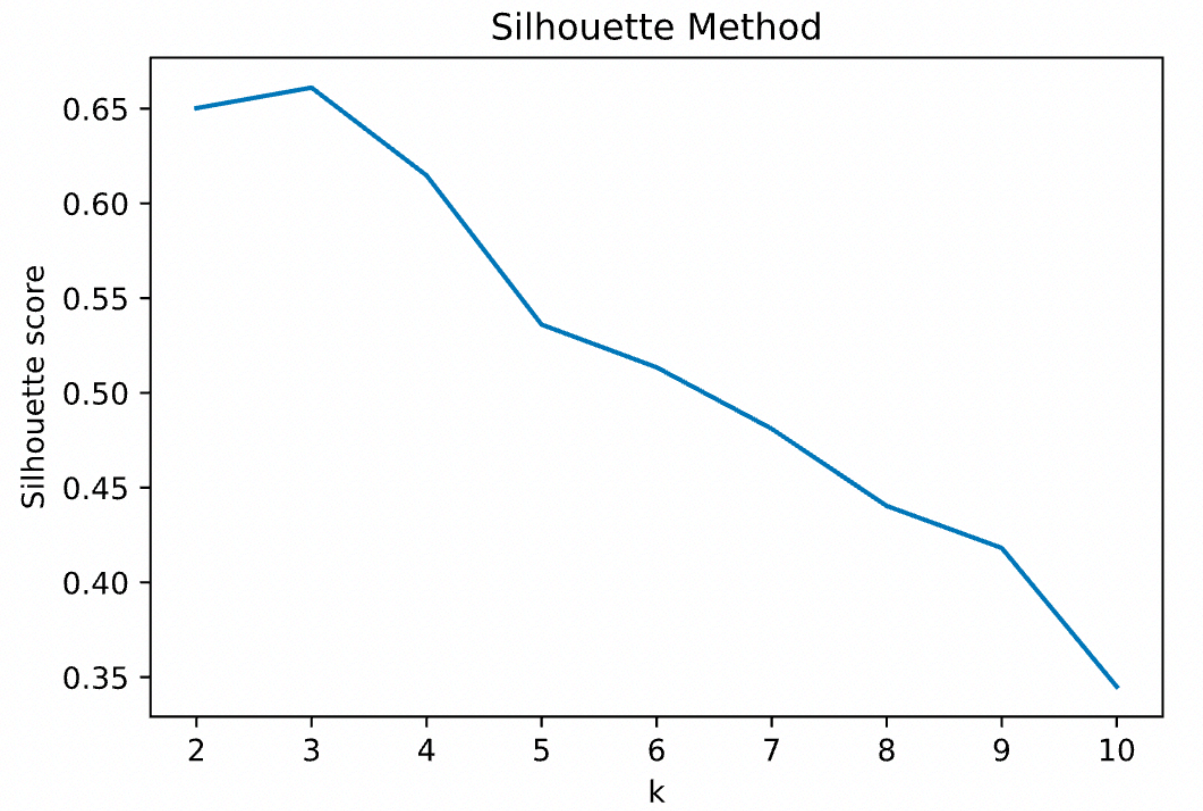
We see that the elbow is forming around k=3. In order to validate this selection, we can use another method, called Silhouette method to see if this is actually the optimal k.

3.2. Silhouette Method:

The Silhouette value is between 1 and -1. A high value indicates that the point is placed in the correct cluster. If many points have a negative Silhouette, it may indicate that we have created too many or too few clusters.

This method reaches its global maximum at the optimal k. We see in Figure 3 that we have his maximum at k=3, confirming our selection with the Elbow method.

Figure 3: Silhouette Method for k selection.

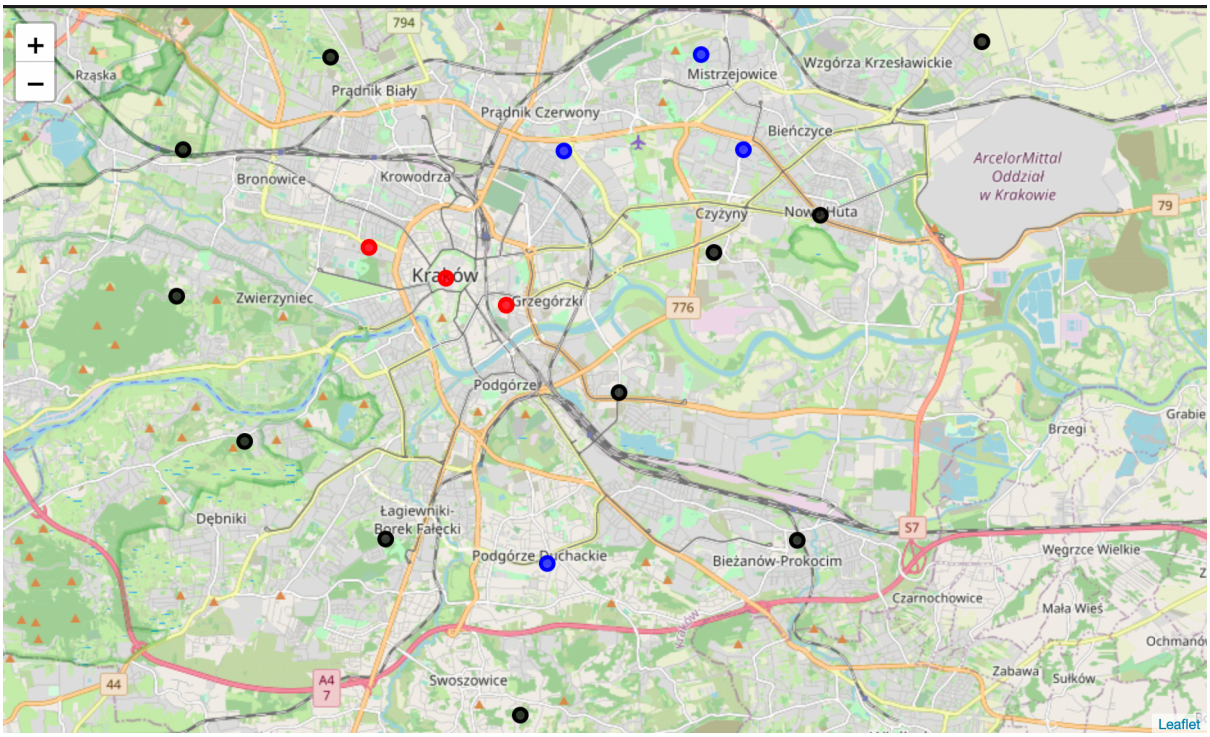


3.3. Clusters with k=3

We can now run the KMeans method with k=3 using our data set.

In Figure 3 we show the results with the colours indicating the cluster for each district. In the next section we will explore the results in more detail.

Figure 3: Clusters using k =3.



4. Results

Now let's look in Figure 4 and 5 at the clusters with radius being proportional to the density of vegetarian restaurants and total restaurants, respectively.

Figure 4: Clusters highlighting density of vegetarian restaurants.

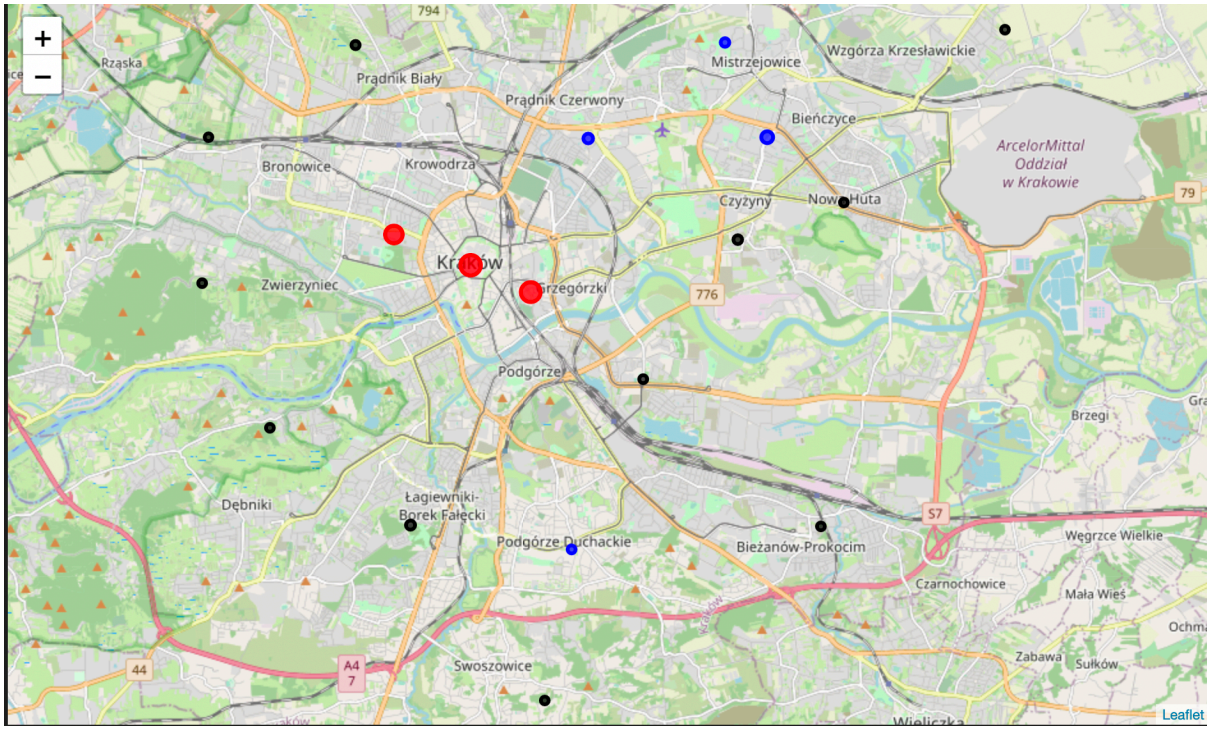
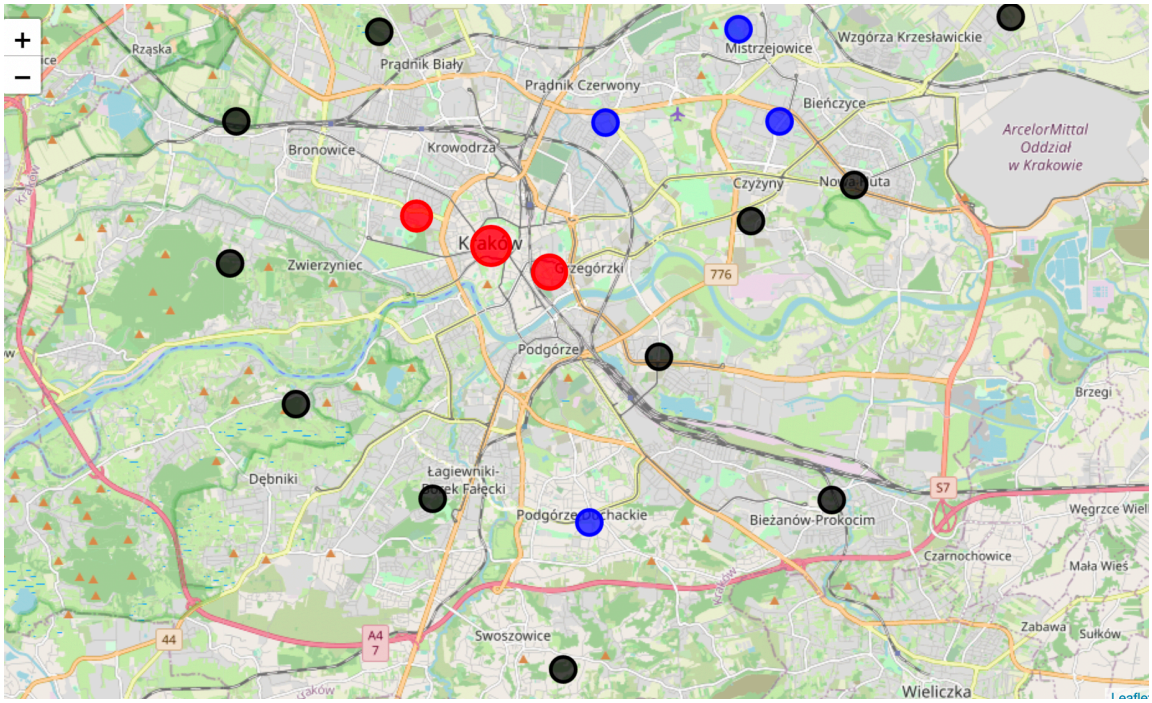


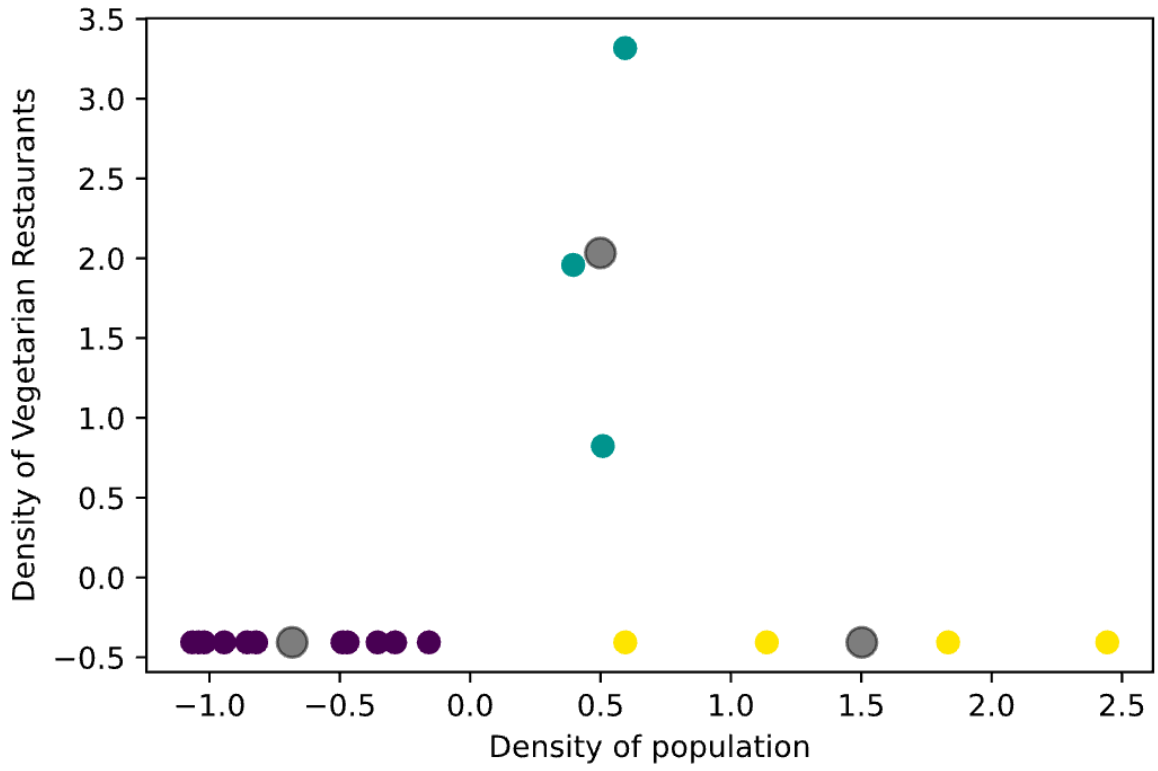
Figure 5: Clusters highlighting density of restaurants.



When exploring the clusters, we see that the vegetarian restaurants are in cluster 2, in red. They are located in the regions with high restaurant density.

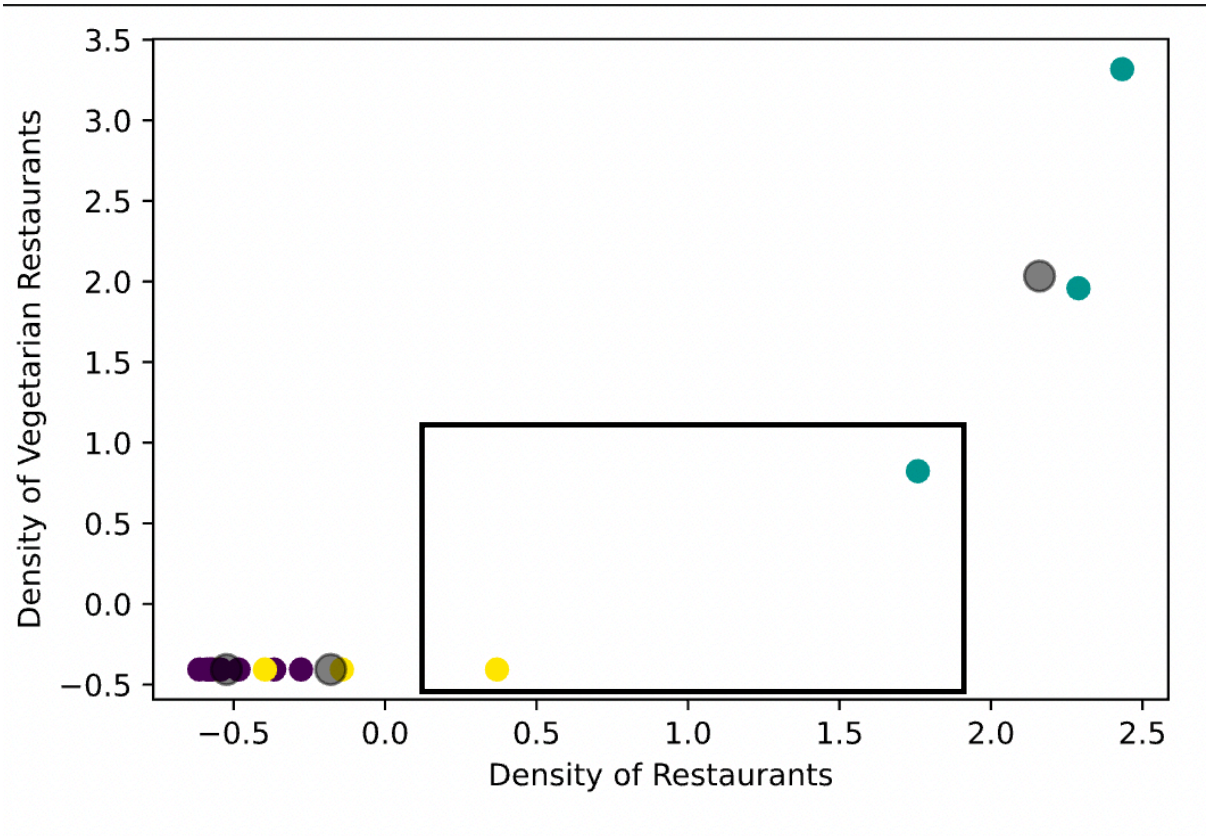
Now we can look at the scatter plot of our feature values in order to make a final decision.

Figure 6: Scatter plot of Density of Vegetarian restaurants and population.



The grey circles mark the centroid of each cluster. We see from Figure 6 that Cluster 2 is in a moderate populated region and from Figure 7 the same region has the highest restaurant density. Notice that we are using the normalised values from the KMeans step, hence the values are not in the original scale.

Figure 7: Density of Vegetarian restaurants and all Restaurants.



We can discard Cluster 1, since it is less populated than the rest. Based on the population density, Cluster 2 seems desirable. However we want to avoid competition and the two highest values would be problematic in terms of presence of restaurants and specially vegetarian restaurants, therefore we can eliminate Stare Miasto and Grzegórzki from our list.

In Figure 7 we highlight the two possible places. In yellow we have Podgórze Duchackie from Cluster 3 and in green, Krowodrza, from Cluster 2, with moderate population density and restaurant density.

5. Discussion

Some things we need to consider is that looking only at the densities we could be overlooking regions without urban areas, such as forests and parks. We could also perform additional analysis, like other venues around the selected region and distance from public transportation or parking places. Also, we could expand the limited list from Foursquare, which does not show all venues. However, this is a preliminary analysis for our stakeholder and we could see a number of features with the data already available.

Considering that among the two selected regions, Krowodrza is closest to the city center, museums and also to many schools and universities, we can see the potential of opening our new restaurant in this region. And this will be our preferred district.

6. Conclusions

We did some preliminary data analysis to identify the most optimal place for a vegetarian restaurant in Krakow by analysing some features of each district, such as density population, restaurant density and density of already existing vegetarian restaurants. We have used a clustering method to help with the selection of the optimal areas and the most attractive one was Krowodrza.

References:

[1] https://notesfrompoland.com/2020/01/14/almost-40-of-poles-claim-to-be-cutting-back-on-meat-and-8-4-have-quit-completely/

[2] https://www.happycow.net/vegtopics/travel/top-vegan-friendly-cities

[3]https://en.wikipedia.org/wiki/Districts_of_Krak%C3%B3w

[4] https://www.bip.krakow.pl/zalaczniki/dokumenty/n/253681/karta

[5]https://medium.com/analytics-vidhya/how-to-determine-the-optimal-k-for-k-means-708505d204eb