1. Introduction

Denver is the capital and the most populous municipality of the US state of Colorado. With an estimated population of about 800,000, Denver is one of the most populous and fastest growing cities in the United States. Today, Denver is an important commercial, industrial and transportation hub. Its economy is lifted by the telecommunications and biomedical technology industries, as well as mining, construction, real estate and tourism. Denver is home to a US Mint and numerous federal agencies, including the Environmental Protection Agency and the National Oceanic and Atmospheric Administration.

2. Business Problem

The objective of this capstone project is to analyze and explore the locations and identify the most convenient and economical neighborhood to live in the city of Denver. Using the data science methodology and unsupervised machine learning techniques like clustering, this aims to explore the best neighborhoods in the city.

3. Target Audience

This project is particularly useful to anyone who is moving to or living in Denver and searching the most convenient and economical neighborhoods to live in.

4. Data

To solve the problem, we need the data consisting of

1. List of Neighborhoods of Denver,

2. Average rental price in Denver CO by neighborhood
3. Latitude and Longitude of these Neighborhoods
4. Related Venue Area Related. This will help us to explore the neighbors that are suitable for the purpose.

5. Extracting the data

1. Fortunately, the Denver-neighborhoods data is readily available on the statistical_neighborhoods.csv file in the Denver Mile High City website. The url of the website is https://www.denvergov.org/opendata/dataset/city-and-county-of-denver-statistical-neighborhoods.
2. The web scrapping techniques is used to extract the average house rental price in the 74 neighborhoods from the website https://www.rentcafe.com/average-rent-market-trends/us/co/denver/
3. We use the Geocoder package for obtaining the Latitudes and Longitudes of these neighborhoods.
4. Finally, we get the venue data related to these neighborhoods using the Foursquare API.

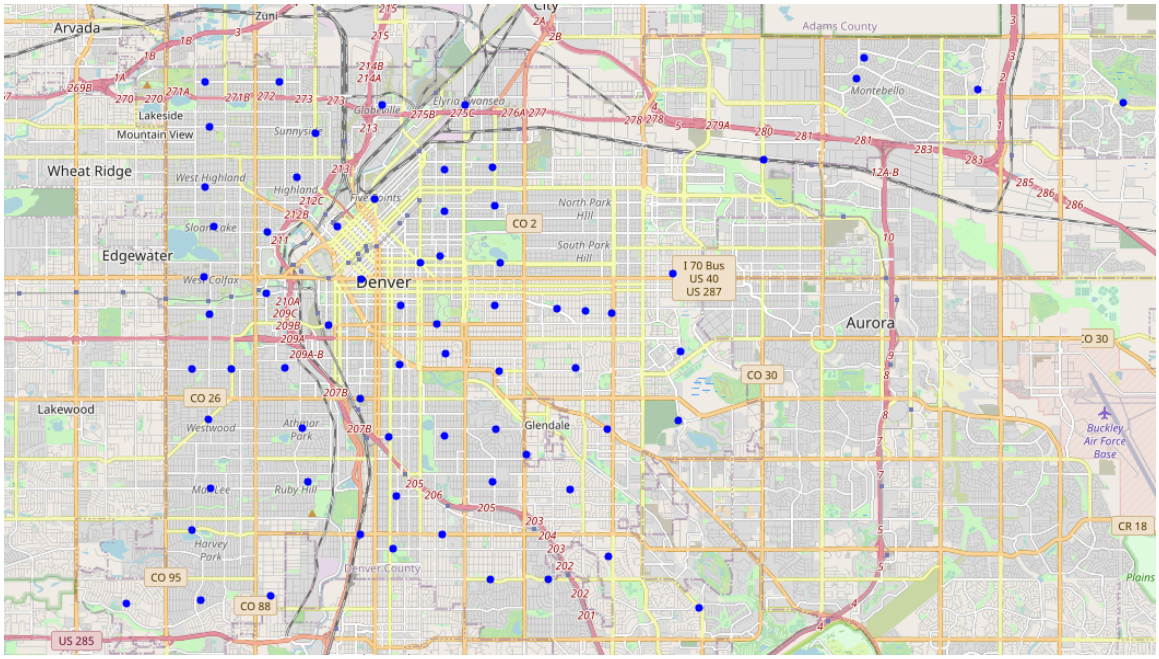


Fig 1: *Neighborhoods in Denver*

6. Analyzing the data

For analyzing the data, we followed the following steps.

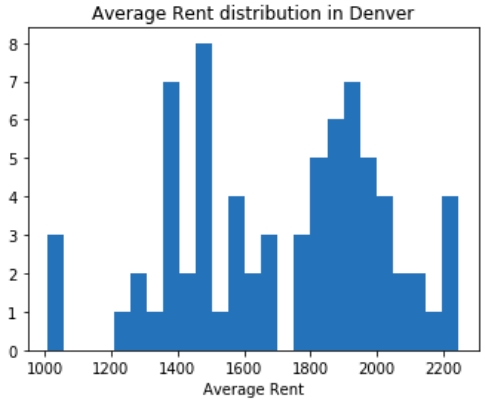
1. Defined the Foursquare credentials and versions to create and get request URL. Then we proceeded to explore the number of popular venues in each neighborhood.
2. Performed one hot encoding for the venues and added the neighborhood columns back to the data frame.
3. Computed the mean frequency of occurrence of each category and grouped the rows by neighborhoods.
4. Created the new data frame showing the top ten venues for each neighborhood.

7. Analyze neighborhoods vs no. Of popular venues

We combined the popular venues data of the neighborhoods with the average rental price and get the summary of datasets shown in Table 1.

Table1: Summary of Popular venues vs Average Rent in the neighborhood

	Venues	Average Rent
Count	73	73
Mean	14.75	1515.63
Std	18.65	308.31
Min	01	1010
25%	04	1469
50%	06	1796
75%	20	1947
Max	98	2245



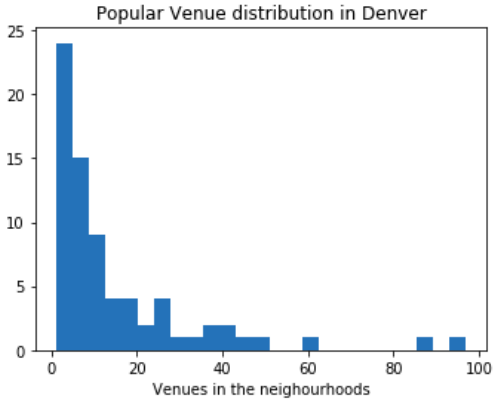


Fig 2: *Distribution of Average Rent and No. of Popular Venues in Denver*

The average rent price in the Denver does not have a normal distribution. Of course, there are many factors that affect the rent price. The distribution of the average rental price shows that there are three cheapest and four costliest neighborhoods where the average rent prices are less than $1200 and more than $2200 respectively. Also, the distribution of the number of popular venues indicates that there are more neighborhoods with less number of venues and vice versa. We shall later try to explore these neighborhoods.

Table2: The five cheapest and the costliest Neighborhoods

Neighborhood	Venue	Av. Rent ($)	Neighborhood	Venue	Av. Rent ($)
Westwood	2	1010	Congress Park	12	2245
Barnum	7	1010	LoDo	97	2231
Mar Lee	5	1010	Cherry Creek	86	2223
Chaffee Park	2	1218	Belcaro	04	2205
Regis	4	1277	Highland	36	2156

Table3: The five Nbds having the least and most number of popular venues

Neighborhood	Venue	Av. Rent ($)	Neighborhood	Venue	Av. Rent ($)
LoDo	97	2231	Willshire	01	1902
Cherry Creek	86	2223	Belcaro	01	2205
Five Points	67	2114	Windsor	02	1563
Park Hill	47	1684	Hampden	02	1321
RiNo Denver	46	1859	Hampden South	02	1590

The Westwood, Barnum and Mar Lee are the cheapest Neighborhoods in the Denver. The rental prices in these areas are $1010. The Congress Park, LoDo and the Cherry Creeks are the most expensive neighborhoods where the average rent exceeds $2200 per month. The LoDo, Cherry Creek and Five Points are the neighborhoods offering the greatest number of venues ($\geq$63 venues). The Chaffee Park neighborhood offers the least number of venues (1 venue). Now, let us see if there exists any relationships between the number of venues and average rental price. Let us consider the line and scatter plots of these variables.

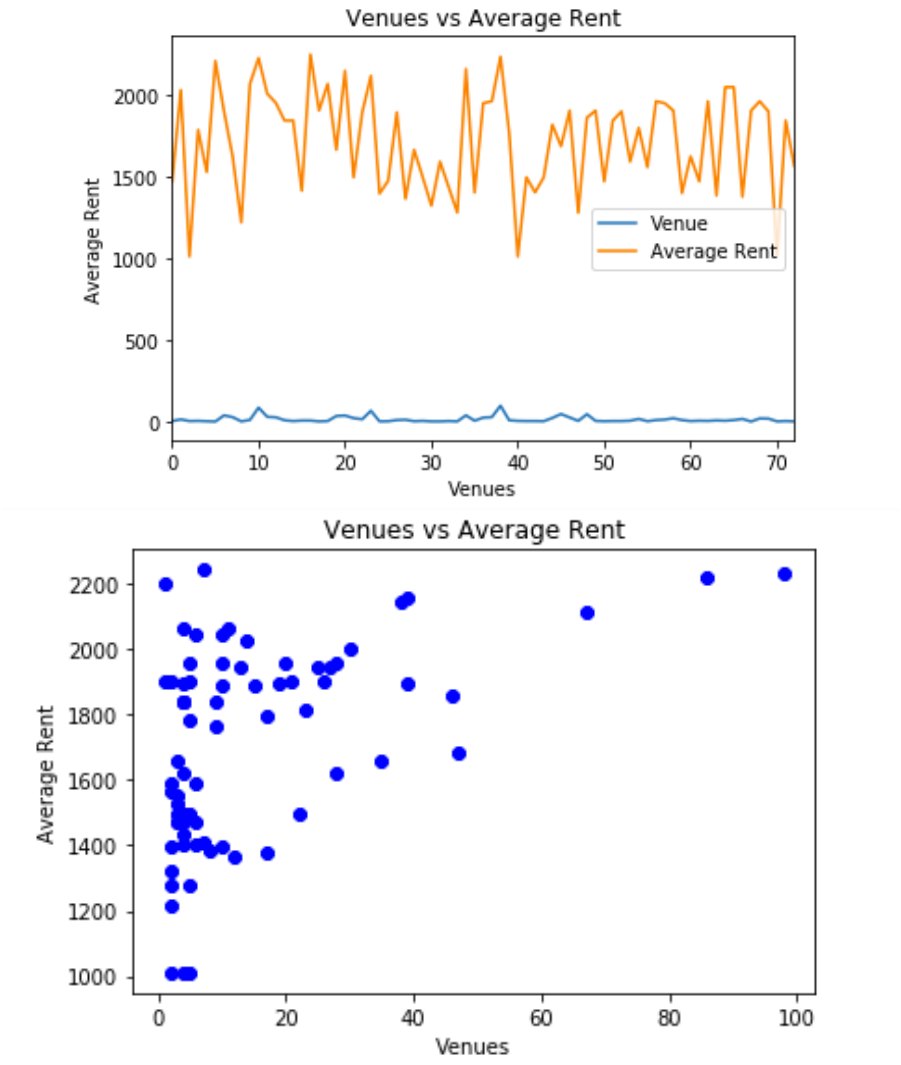


Fig3: Line and Scatter Plots, Venues vs Average Rent

The scatterplot shows that there may exist a correlation between the number of venues and average rent price. As we observe that there are plenty of neighborhoods offering equal number of popular venues, yet their rental price extending from minimum to maximum, we convinced ourselves that there does not exist a relation between these two.

These two plots also suggested that there is a neighborhood offering about 50 venues with rental price reasonably cheap (about $1600). In order to explore this neighborhood, we observe the neighborhoods offering more than 45 popular venues and see that there indeed exists the Park Hill Denver offering 47 venues with average rental price $1684.

Table 4: Neighborhoods offering more than 45 venues

Neighborhood	Venue	Av. Rent ($)
LoDo	98	2231
Cherry Creek	86	2223
Five Points	67	2114
Park Hill	47	1684
RiNo Denver	46	1859

Table 5: Summary of Park Hill

Nbhd	Venues	Rent	Popular Venues
Park Hill	47	$1684	Pizza Place American Restaurant Brewery Convenience Store Marijuana Dispensary

8. Cluster Neighborhoods

We now use the unsupervised clustering algorithm to group the similar neighborhoods containing popular venues in the Denver city. The elbow method suggests that the number of clusters is $k = 4$ for the optimal clustering. There are respectively 61, 8, 2 and 2 neighborhoods in cluster1, 2 3 and 4, respectively with the average rent $1732, $1593, $2053 and $1374 respectively. The details of the information is provided in figure 2, 3 4 and 5 respectively.

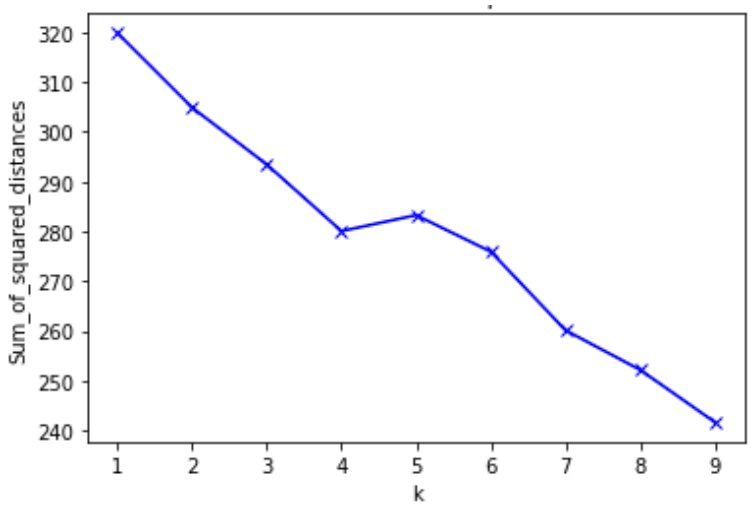


Fig 4: *Elbow method for optimal k*

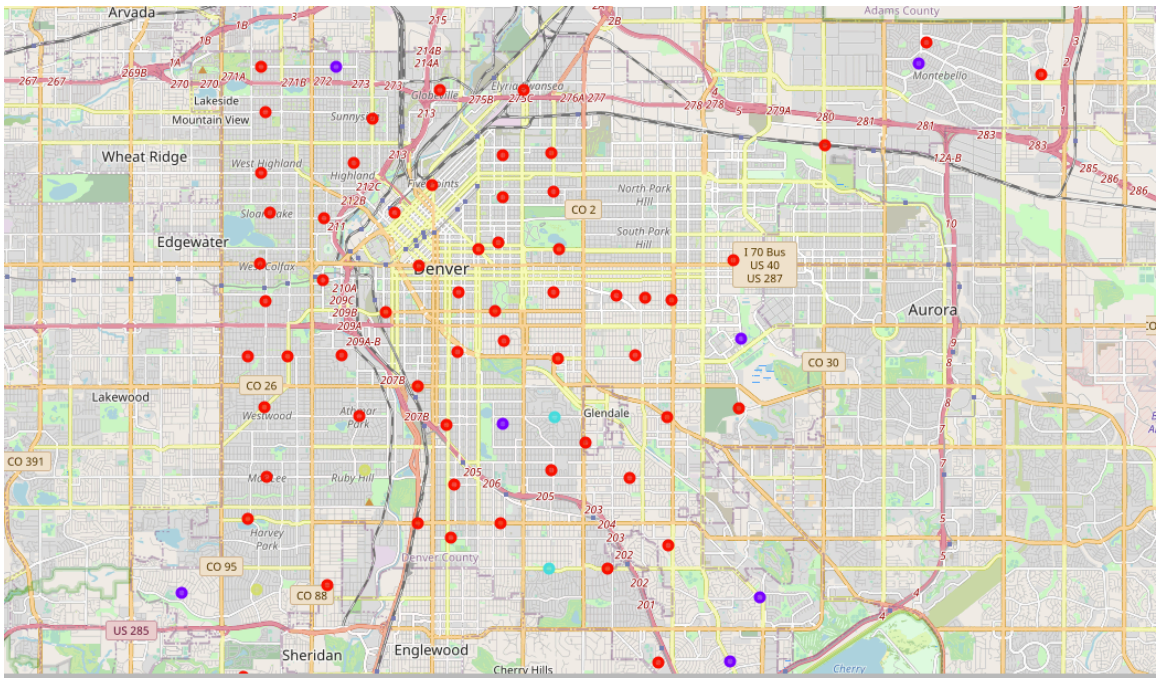


Fig 5: Clustering of neighborhoods in Denver

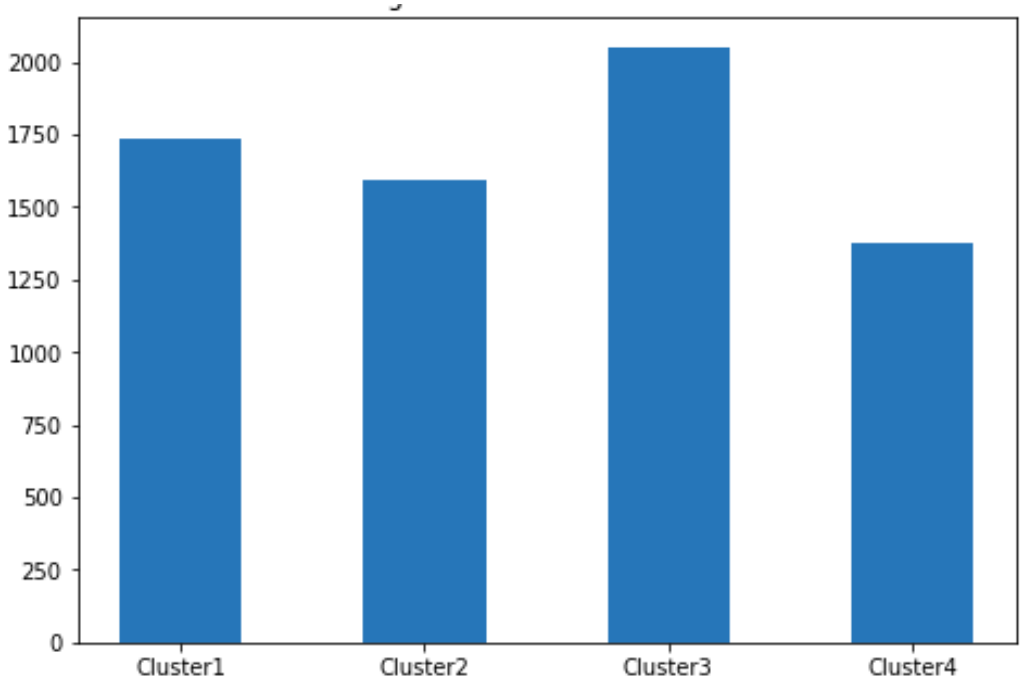
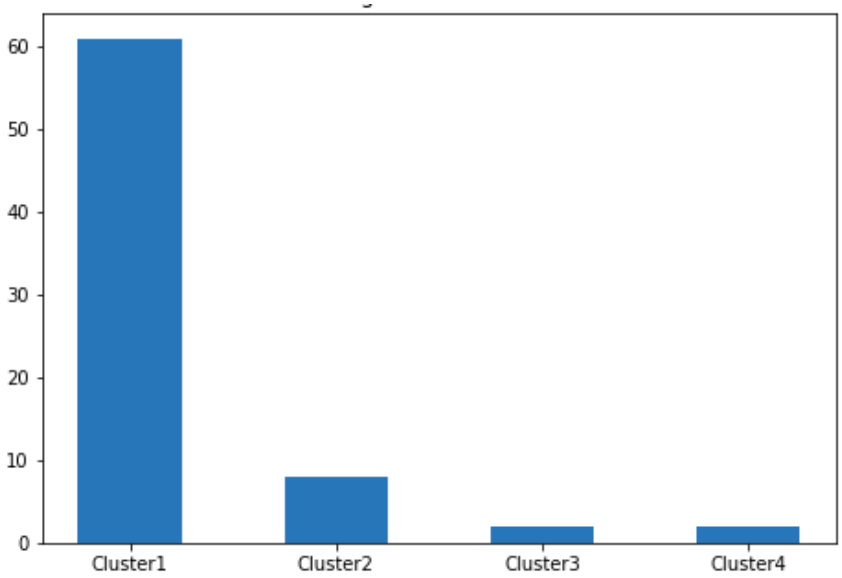


Fig 5: Average Rent in each clusters



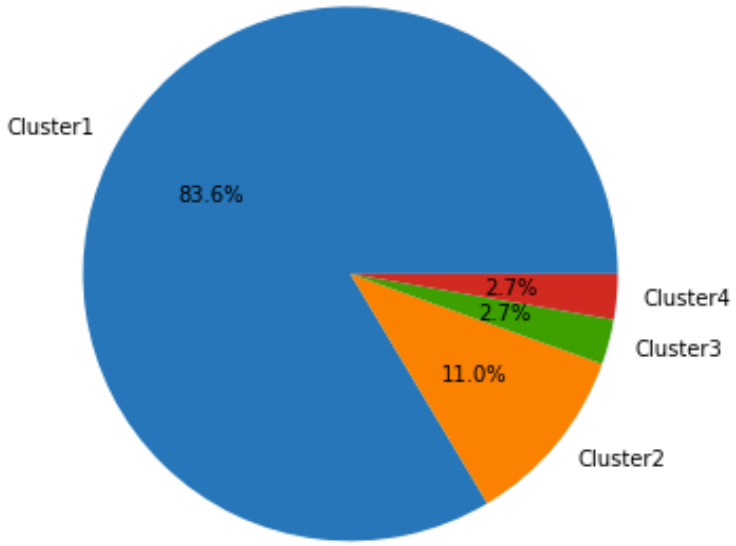


Fig 6: Number of Neighborhoods in each cluster.

9. Analysis of each cluster:

9.1 Cluster1: The first cluster consists of 61 neighborhoods including most of Denver city as shown.

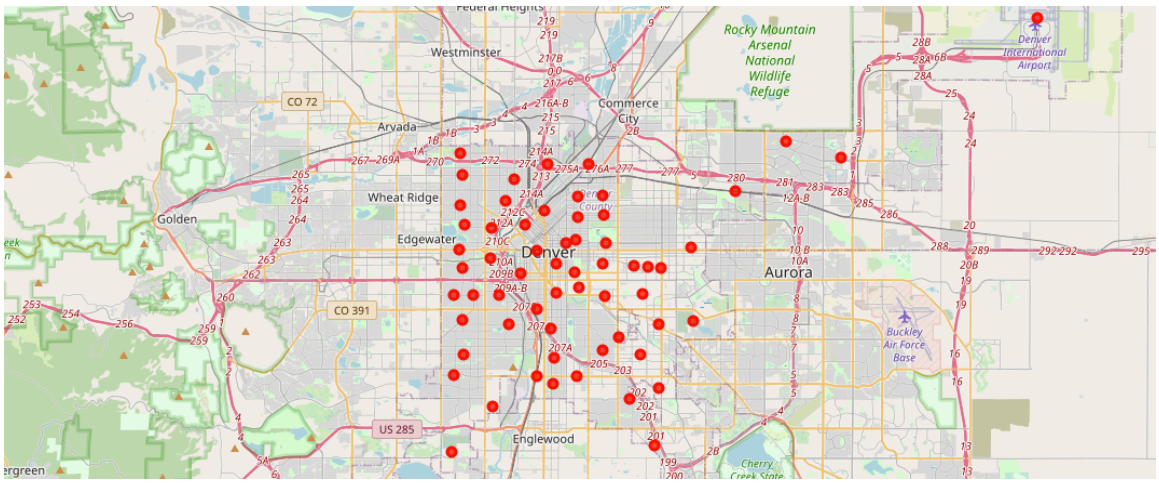


Fig 7: *The Cluster1 of Denver*

9.1.1: Summary of Cluster1:

Average Rent		**Neighborhood**	**Popular Venues**
Min	$1010	Mar Lee, Barnum, and Westwook	1. Pizza Place 2. Stores 3. Coffee Shop 4. Resturant and Bars 5. Food Trucks
Max	$2245	Congress Park	
Average	$1731	---	

9.2 Cluster2: The second cluster consists of 8 suburbs of Denver city as shown in the figure.

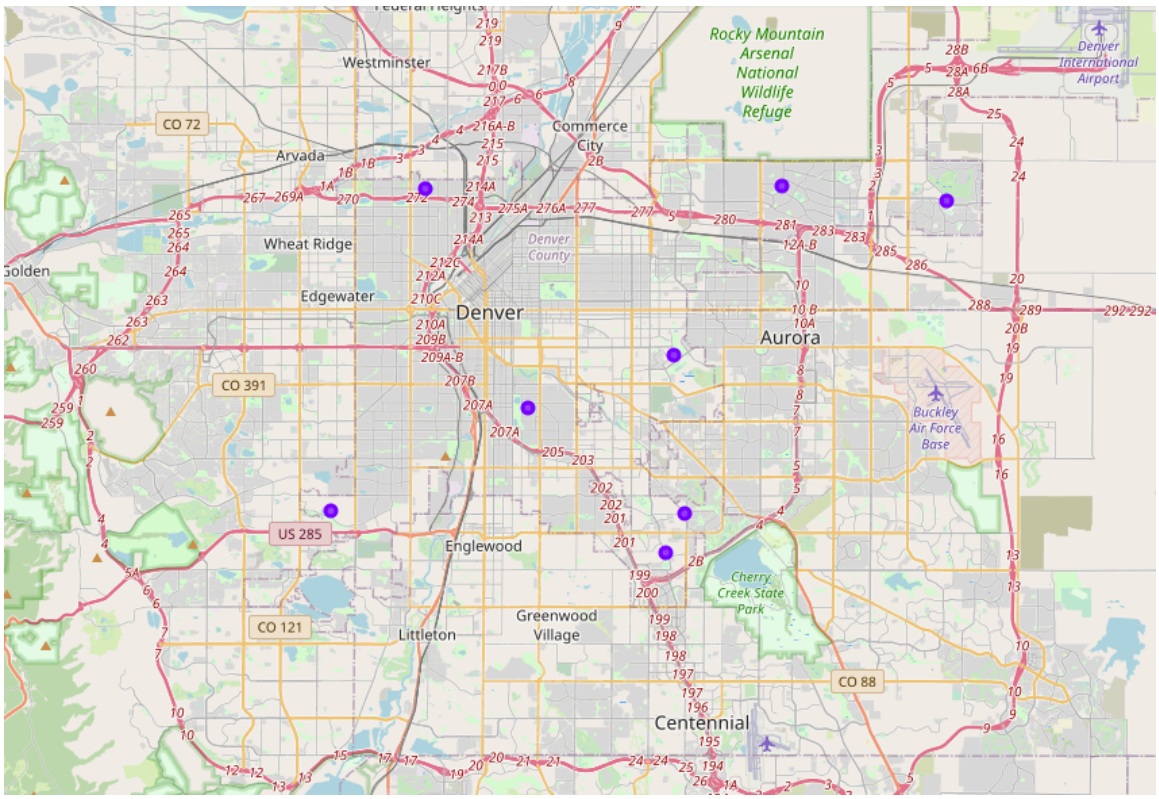


Fig 8: *The Cluster2 containing suburbs of Denver*

9.2.2: Summary of Cluster2:

Average Rent		Neighborhood	Popular Venues
Min	$1218	Chaffe Park	1. Park 2. Construction and Landscaping 3. Farm, Farmers Market 4. Exhibit 5. Women's Store
Max	$2045	Washington Park	
Average	$1593	---	

9.3 Cluster3 and Cluster4: These are the remaining clusters consisting of two neighborhoods each. They have popular venues similar to cluster2 and their summary is as shown.

9.3.1: Summary of Cluster3:

Average Rent		**Neighborhood**	**Popular Venues**
Min	$1902	Wellshire Denver	1. Art Gallery 2. Women's Store 3. Farmers Market 4. Farm 5. Exhibit and Event Space
Max	$2205	Belcaro	
Average	$2053	---	

9.3.2: Summary of Cluster4:

Average Rent		**Neighborhood**	**Popular Venues**
Min	$1279	Harvey Park South	1. Trail 2. Construction and Landscaping 3. Women's Store 4. Event Space 5. Ethiopians Restaurants
Max	$1469	Ruby Hill	
Average	$1374	---	

10. Recommendation:

1. A person who enjoys foods and loves visiting restaurants and stores should be willing to stay in the Cluster 1 where the average rent is estimated to be $1731 per month.
2. Cluster2 is the suburbs of the Denver and is suitable for persons to loves visiting parks and farms. As it is also popular for landscaping and constructions, this looks like a developing region with the average is $1593 per month.

11. Limitations and Future Scope

The entire study is made for the purpose of completing the Applied Data Science Capstone project. The factors affecting the average rental price in any city varies and requires a more concrete and careful study, which has not been taken into consideration. Incorporating those things in future studies could be an excellent starting point for further exploration. Thus, the recommendations and finding provided may not be used for professional purpose.

Regards: Madhav Wagley