Planning the construction of car-sharing parking areas in Milan

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1   Background and problem statement

Milan is located at the center of the so-called Po Valley, one of the most polluted areas in Europe. Recently, the mayor of Milan Giuseppe Sala stated that "around one million vehicles enter the city every day". This fact constitutes a serious environmental problem. Moreover, the traffic in the city is often very intense, also causing problems to the circulation of ambulances and firemen vehicles. Car sharing can be seen as a possible solution. In Milan this service started a few years ago and has multiple advantages. The most obvious one being the reduction of the number of vehicles in the city. In addition, many cars have electric engines and might limit air pollution. This project simulates the study of car-sharing parking areas in the city, trying to rationalize their position and suggest how to build eventual new areas.

This task will be accomplished comparing the position of the existing parking areas with the venues nearby. The identification of popular places close to these areas will be used to make hypotheses concerning the typical car sharing users, and several areas will be grouped according to the type of venues they are close to. Finally, the position of the parking areas will be compared to the position of the subway stations. This comparison will point out the necessity to strongly increase the number of parking areas in certain zones of the city.

2   Data acquisition and preparation

To perform this study a lot of data is needed, the first being the position of the parking areas in the city. This data is freely available at the Milan Comune website through this link. The table also comprehends the number of parking places for each area, allowing a deeper study. Another useful information contained in the data set is the zone of Milan the different parking areas belong to.

To visualize the number of parking places of each area it is also necessary to have the geojson data of the nine zones of Milan. This file is available at this Github repository. The last data source required is the table containing the positions of all the subway stations in Milan. This data is provided by datiopen.it at this link. This data set contains the position of all the Italian stations. However, it is possible to filter the results directly from their website to gather only the data concerning the city of Milan.

To explore the venues near the parking areas, the Foursquare data set will be used. This data will be employed to understand and group different parking areas according to the venues the are close to. The number of venues retrieved for each parking area will be restricted to 10, so that a free foursquare account will be sufficient for data acquisition.

Data preparation is straightforward. All the data sets are available as csv tables in a plug-and-play fashion. The only operation required is the so-called one hot encoding to prepare the data for clustering.

3 Data exploration

The total number of parking areas is 113 and the total number of parking places is 444. Comparing this number with the total number of vehicles entering the city each day (around one million, *vide supra*) it is clear that the number of parking places is absolutely insufficient to reduce the traffic in the metropolitan area. In Fig. 1 the parking areas are shown as red circles on top of the Milan map.
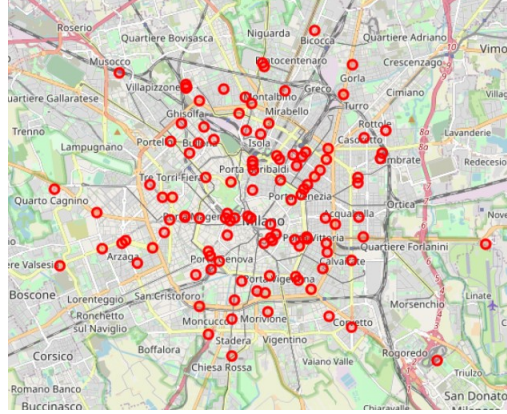

Figure 1: **Car-sharing parking areas in Milan.** The areas are represented as red circles.

It is clear that the city center has the highest number of parking areas. To quantify the number of parking places present in each of the 9 zones of Milan, the parking places are grouped by the zone and summed up. The results are reported in Table 1:

Table 1: **Number of parking places of each zone**. Zone 1 corresponds to the city center.

Zone	Number of parking places
1	117
2	26
3	57
4	33
5	30
6	44
7	31
8	26
9	80

From the table can be seen that more than a fourth of the total parking places are

located in the city center (zone 1). In zone 2 and zone 8 the number of parking places is very low, less than 30. The following map clarifies which zones of the city have a lower number of parking places.
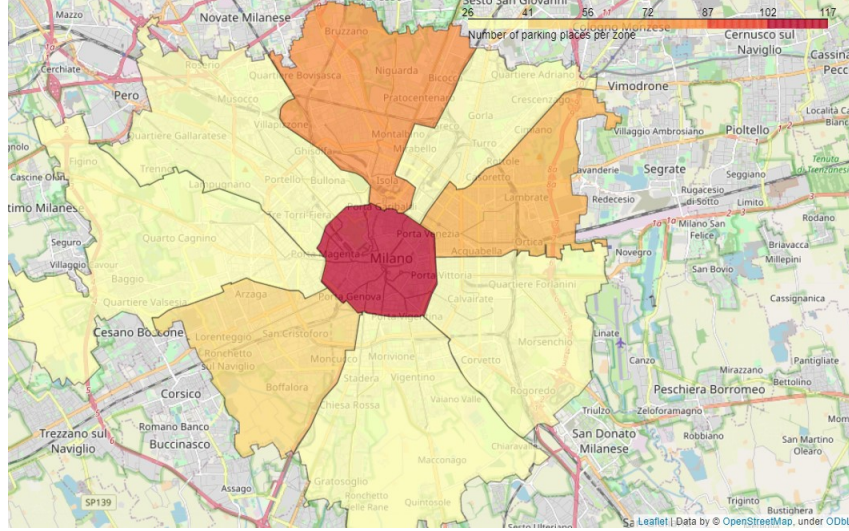

Figure 2: **Choropleth map of the parking areas in Milan.** The city of Milan is divided into 9 zones. The parking areas are mainly located in the city center.

Finally, the foursquare application has been employed to find venues neighboring different parking areas, looking for popular spots. These venues are useful to categorize different parking areas. The neighborhoods of a particular car park are linked to the types of clients that a car park might have, and the lacking of certain types of spots might help one to plan the construction of new parking areas near these venues, in an effort to gather new users of the car-sharing service.

4   Clustering

The k-means clustering algorithm has been applied to the data set consisting of the 10 most common venues in the proximity of the parking areas. The data has been divided into 5 clusters. These clusters are very easy to interpret and label according to the common features. For clustering, the scikit-learn Python library has been used. The Euclidean distance has been employed to calculate the distances between the different points of the data set. Once the labels of each parking area are determined, it is possible to visualize the relationship between the members of the same clusters, and to speculate about possible users of the parking areas.

5   Results and discussion

The elements of the clusters obtained are reported in Appendix for ease of reading. The following table summarizes the results:

Table 2: **Results of the clusters analysis.** The first column reports the number associated to each cluster. The second and the third columns report the label of the clusters and the number of elements, respectively.

Cluster	Label	Number of elements
1	Pizza places	15
2	Free time	43
3	Tram stations	4
4	Restaurants	13
5	Tourism	38

To check if there is a geographical correspondence to the clustering, the parking areas have been plotted on top of the Milan map using different colors for different cluster labels.
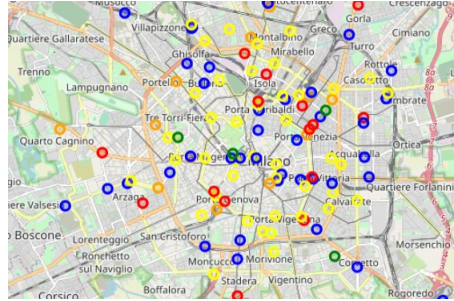

Figure 3: **Labeled car-sharing parking areas in Milan.** Red: cluser 1; yellow: cluster 2; green: cluster 3; blue: cluster 4; orange: cluster 5.

As one can see there are no relations between the cluster labels and the actual location of the parking areas.

Let us now analyze the clusters. Almost all the parking areas grouped in cluster 1 have as most venue pizza places, so this cluster has been labeled "Pizza places". In cluster two the most common venues are cafes, dessert shops, stores and gyms. These are places where people generally go during their spare time, so the cluster has been labeled "Free time". The parking areas assigned to cluster 3 are close to tram stations, so the cluster has been labeled "tram stations". The parking areas in cluster have mainly restaurants in the neighbors, so this cluster is named "Restaurants". Finally,

The parking areas assigned to cluster 5 are near to plazas, art galleries, monuments, and hotels. This places are popular among tourists and so this cluster is named "tourism".

Clusters 2 and 4 are the largest ones, so most of the parking areas are located near restaurants and places for free-time activities. This is expected because car-sharing users usually need the cars for occasional activities. The number of tourists is rapidly increasing in Milan and having parking areas close to monuments and hotels might be helpful to them. Increasing the number of car-sharing parking areas in tourist places could help to further increase the number of tourists. The elements of the clusters are reported in the appendix.

The most interesting part of this analysis is not what was found nearby the parking areas, but what was not. Milan has a well-developed public transportation system consisting of buses, trams, subway and train stations. Being able to reach a car-sharing area from public transportation stations is of great importance, because it allows to link the public transportation system with car sharing. However, only 4 parking areas have been assigned to cluster 3. Furthermore, subway (metro) stations are almost absent as common venues. For a city having more than 100 stations (see below), this fact suggests that new parking areas should be better positioned across the city. Another venue that is clearly missing is university. 39 university centers are located in Milan and the 10% of the Italian university students actually study in Milan. Car-sharing systems might be popular among students, but parking areas are probably located too far from where they study.

Taking the absence of stations as a case of study, it is possible to plot the position of all the train stations on top of the choropleth map of Fig. 2.
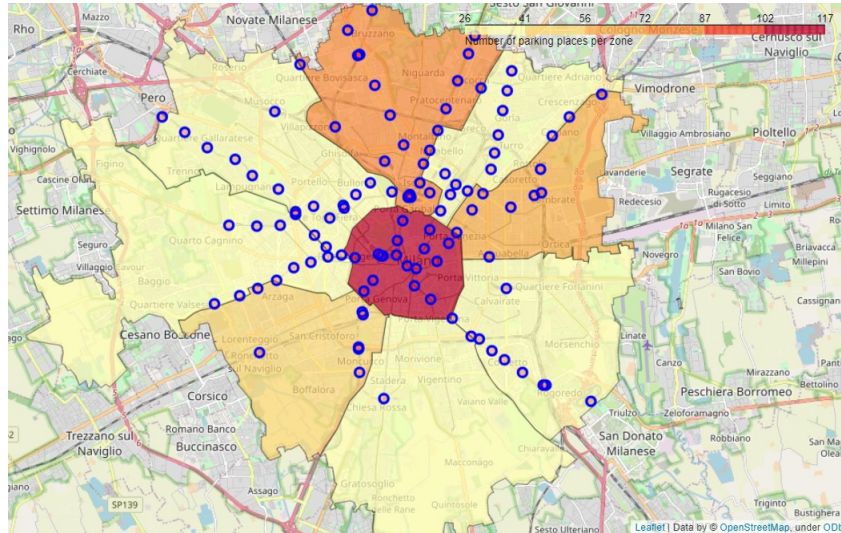

Figure 4: **Subway stations vs car-sharing areas.** The Milan subway stations plotted on top of the choropleth map of Fig. 2. The stations are represented as blue circles.

It can be observed that many stations are located in areas with a low number of

parking places. This simple plot explains why train stations do not appear as common venues. A similar study should be repeated for other crucial infrastructures like hospitals and schools. New parking areas should be built near these structure to increase the usage of car-sharing systems.

6   Conclusions and future perspectives

In this brief study the position of car-sharing parking areas in Milan has been analyzed. The low number of parking places strongly suggests to drastically increase the number of parking places. In some parts of the city the number of parking places in very low, so new parks should be built in these areas. In addition, new parking areas should be built in strategical positions like near the subway stations, in an effort to try lo better link the public transportation system with the car-sharing one.

Possible developments include the quantitative analysis of the distances between parking areas and public infrastructures to better plan where to build new car-sharing parking areas.

Hope you guys enjoyed the reading!

Appendix: Elements of the clusters

In this appendix the elements of the clusters have been reported. Clusters 2 and 4 are quite large so some elements have been dropped (but you can find the entire data set on the notebook).

Table 3: **Cluster 1.** This cluster has been labeled "Pizza places". Columns 1 to 3 report the most common venues.

1$^{\text{st}}$ Most Common	2$^{\text{nd}}$ Most Common	3$^{\text{rd}}$ Most Common
Hotel	Pizza Place	Ice Cream Shop
Pizza Place	Bakery	Café
Pizza Place	Ice Cream Shop	Comic Shop
Pizza Place	Art Museum	Candy Store
Pizza Place	Italian Restaurant	Seafood Restaurant
Pizza Place	Department Store	Bookstore
Pizza Place	Ice Cream Shop	Hotel
Pizza Place	Sporting Goods Shop	Japanese Restaurant
Pizza Place	Italian Restaurant	Chinese Restaurant
Pizza Place	Persian Restaurant	Trattoria/Osteria
Pizza Place	Bed & Breakfast	Gym / Fitness Center
Bus Stop	Pizza Place	Metro Station
Pizza Place	Park	Clothing Store
Pizza Place	Trattoria/Osteria	Candy Store
Pizza Place	Sporting Goods Shop	Clothing Store

Table 4: **Elements of cluster 2.** This is a large cluster so some elements are not shown. This cluster has been labeled "Free time". Columns are labeled in agreement with Table 3.

1st Most Common	2nd Most Common	3rd Most Common
Café	Ice Cream Shop	Hostel
Kitchen Supply Store	Museum	Ice Cream Shop
Ice Cream Shop	Art Gallery	Italian Restaurant
Winery	Sushi Restaurant	Gastropub
Art Gallery	Park	Monument / Landmark
Wine Bar	Pizza Place	Japanese Restaurant
Pizza Place	Italian Restaurant	Museum
Ice Cream Shop	Restaurant	Gym
Dessert Shop	Pizza Place	Hotel
Dessert Shop	Hostel	Italian Restaurant
Soccer Field	Metro Station	Bike Shop
Food Truck	Cocktail Bar	Ramen Restaurant
Tea Room	Café	Dive Bar
Art Gallery	Pizza Place	Wine Shop
Gym	Piadineria	Restaurant
Bistro	Gym / Fitness Center	Salon / Barbershop
Jewelry Store	Flower Shop	Gym / Fitness Center
Pizza Place	Café	Seafood Restaurant
Clothing Store	Coffee Shop	Flower Shop
Café	Italian Restaurant	Asian Restaurant
Ice Cream Shop	Hostel	Restaurant
Restaurant	Historic Site	Plaza
Café	Pizza Place	Chinese Restaurant
Pizza Place	Plaza	Burger Joint

Table 5: **Cluster 3.** This cluster has been labeled "Tram stations". Columns are labeled in agreement with Table 3.

1st Most Common	2nd Most Common	3rd Most Common
Tram Station	Italian Restaurant	Cocktail Bar
Tram Station	Trattoria/Osteria	Supermarket
Tram Station	Cafeteria	Pool
Tram Station	Pizza Place	Restaurant

Table 6: **Elements of cluster 4.** This is a large cluster so some elements are not shown. This cluster has been labeled "Restaurants". Columns are labeled in agreement with Table 3.

1st Most Common	2nd Most Common	3rd Most Common
Italian Restaurant	Bakery	Accessories Store
Italian Restaurant	Design Studio	Church
Seafood Restaurant	Filipino Restaurant	Italian Restaurant
Seafood Restaurant	Italian Restaurant	Japanese Restaurant
Hotel	Restaurant	Monument / Landmark
Cocktail Bar	Hotel	Italian Restaurant
Hotel	Italian Restaurant	Hostel
Italian Restaurant	Pizza Place	Wine Shop
Italian Restaurant	Pizza Place	Art Gallery
Italian Restaurant	Pizza Place	Hotel
Italian Restaurant	Pizza Place	Pub
Italian Restaurant	Camera Store	Eastern European Restaurant
Ice Cream Shop	Italian Restaurant	Spa
Cocktail Bar	Japanese Restaurant	Wine Shop
Italian Restaurant	Tram Station	Pizza Place
Italian Restaurant	Pizza Place	Nightclub
Gym	Bakery	Café
Seafood Restaurant	Italian Restaurant	Hotel
Pizza Place	Italian Restaurant	Café
Plaza	Italian Restaurant	Pizza Place
Italian Restaurant	Health Food Store	Indian Restaurant
Pizza Place	Italian Restaurant	Mediterranean Restaurant
Italian Restaurant	Chinese Restaurant	Bistro

Table 7: **Cluster 5.** This cluster has been labeled "Tourism". Columns are labeled in agreement with Table 3.

1st Most Common	2nd Most Common	3rd Most Common
Plaza	Wine Bar	Electronics Store
Plaza	Art Gallery	Lounge
Lounge	Art Gallery	Korean Restaurant
Plaza	Chocolate Shop	Art Gallery
Chinese Restaurant	Szechuan Restaurant	Hotel
Plaza	Bubble Tea Shop	Fast Food Restaurant
Bakery	Brewery	Arts & Crafts Store
Plaza	Snack Place	Monument / Landmark
Plaza	Bakery	Accessories Store
Coffee Shop	Wine Bar	Electronics Store
Brewery	Coffee Shop	African Restaurant
Plaza	Fast Food Restaurant	Theater
Hotel	Church	Art Gallery