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An isochronic measurement for the analysis of proximity to restaurants and locations of food delivery parking

Ouidad Benhlima,^{1, 2, a)} Fouad Riane,^{1, 2, 3, b)} Jakob Puchinger,^{4, 1, c)} and Hicham BAH^{5, d)}

¹⁾Université Paris-Saclay, CentraleSupélec, Laboratoire Génie Industriel, 91190, Gif-sur-Yvette, France

²⁾Systèmes Complexes et Interactions Ecole Centrale de Casablanca, Morocco

³⁾Faculty of Science and Techniques, Hassan Ier University, Serrat, Morocco

⁴⁾EM Normandie Business School, Métis Lab, 92110, Clichy, France

⁵⁾School of Architecture, Planning and Design, Mohammed VI Polytechnic University, Benguerir, Morocco

^{a)}Corresponding author: ouidad.benhlima@centralesupelec.fr

^{b)}Electronic mail: fouad.riane@centrale-casablanca.ma

^{c)}Electronic mail: jakob.puchinger@centralesupelec.fr

^{d)}Electronic mail: hicham.bahi@um6p.ma

Abstract. The location of a restaurant is critical to its success or failure and the impact it has on the surrounding community. Business owners and customers alike are affected by the geographical spaces selected for restaurants. With the rise of fast-food delivery, people can have their food delivered within a specific time frame. The optimization of the wait time is vital to ensuring the efficiency of operations and customer satisfaction. The first objective of our study is to ascertain the proximity between restaurants and those who live within the study area. The second objective is to then suggest locations where couriers could park to be near the maximum number of restaurants, and thus able to make deliveries in the shortest amount of time possible.

INTRODUCTION

The food delivery industry is expanding rapidly; its value has tripled since 2017 [1], with significant growth during the COVID-19 pandemic. Today, more than ever, people are willing to order fast food online due to lifestyle changes or reduced access to restaurants in neighborhoods or near workplaces. In Morocco, large-scale delivery companies such as Glovo and Jumia food have animated Moroccans to order food from their favorite restaurants. This article discusses the use of spatial data to analyze proximity to restaurants and food delivery parking locations using OpenStreetMap (OSM) and an isochrone-based measure. Couriers in Casablanca generally wait to pick up their first order near one of the city's restaurants; this may be inefficient because it can lead to congestion, especially if they park next to restaurants without private parking. Moreover, the number of couriers could exceed demand at a given time and vice versa. Using OpenStreetMap data and spatial analysis tools, we have been able to identify locations where parking is more suited for food delivery couriers at the beginning of their shift or when they're finished with their current orders.

Isochronic measurement defines accessibility as the number of opportunities one can reach within a given cost (distance or travel time). Isochrones could be referred to as contour measures, cumulative opportunities, or proximity counts [2, 3]. The computation could be performed via the equation 1 [4, 5]

$$Acc_i = \sum_j W_j O_j \quad (1)$$

Where O_j are the opportunities in a zone j , c_{ij} represents the cost to travel from a zone i to a zone j , c_{ij}^* is the threshold value within which one stop counting the opportunities, W_j equals 1 if $c_{ij} \leq c_{ij}^*$ and null otherwise.

The isochrone measure is a widely used tool for analyzing accessibility to different services and opportunities. It is easy to compute and communicate, making it an ideal tool for assessing accessibility. For example, authors in [5] used isochrones to determine the number of employment opportunities within 30 minutes by transit. In [6], the authors used isochrones to analyze the 15-, 10- or 5-minute city concept taking Turin, Italy as a case study. They assessed the services that were available and correspondent served population, following the same concept evaluation, the authors of [7] ascertained the performance of an existing neighborhood in Parma from the 15-minute city concept. During the COVID-19 pandemic, isochrones were used to evaluate the accessibility benefits of the new Bus rapid transit (BRT) system in Winnipeg, Canada [8]. Moreover, authors of [9] used isochrones to assess the urban expansion and differential accessibility by private and public transportation in the Greater Kumasi city-region, Ghana. In the first

part of this article, we used isochrones to assess proximity to restaurants in Casablanca, Bouskoura and, Dar Bouazza areas. In the second part of this paper, we discuss how buffers and k-means clustering methods can be used to optimize parking areas for food delivery couriers, we then show some preliminary results.

METHODOLOGY

The following sections describe our methodology by first giving an overview of Pandana and OSMnx. An analysis is then provided of proximity of restaurants in Casablanca and suitable locations of parking for delivery couriers. Pandana is a python library that enables fast network and accessibility analysis [10]. OSMnx [11] is a Python package that makes it easy to download and clean OSM data. The software allows the user to save networks in different formats, including Esri and SVG. It also calculates many network statistics and enables network analysis.

Proximity counts analysis to restaurants

This study is conducted in the context of the Moroccan metropolitan areas of Casablanca, Bouskoura, and Dar Bouazza. The area features a dynamic economy, with a high concentration of workplaces and is home to a large youth population [12]. The OSM restaurant tag reveals that there are 340 restaurants plotted on the figure (1)

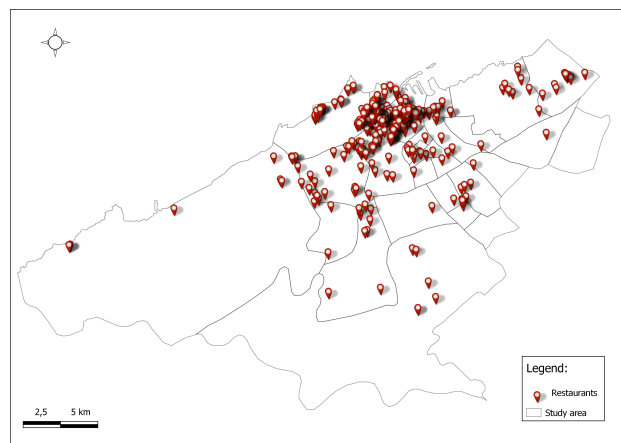


FIGURE 1: restaurant locations

We load network data of our study area from the OpenStreetMap (OSM); It's a graph with 64,671 nodes and 97,166 edges. We then loaded the locations of restaurants listed on the OSM and added them to the network. Isochrone calculations were performed using the count aggregation function in pandana.

Figures (2a,2b,2c,2d) show the number of restaurants within 500, 1000, and 1500 meters from each node, respectively. This information indicates how easily people can access restaurants: Spatial accessibility is high in the Casablanca city center; in several locations, people need to walk 1500 m to access the first restaurant. However, in certain areas, people would need to trek 2000 m to access restaurants, while in other areas, people might need to walk even farther.

Optimization of the spatial locations of food delivery parking spaces

We used two methods to determine the best food delivery parking locations. The first one (figure 3) is based on the spatial distribution of restaurants; there are areas where restaurants are densely located and, thus, where couriers would be interested in parking. We assume that couriers would be available to pick up orders if they are located within a 400-meter buffer zone from restaurants (figure 3a), which is about 5 minutes walking distance from parking. We plotted an area of 400 m around each restaurant, we then calculated the number of overlapping buffers. Delivery

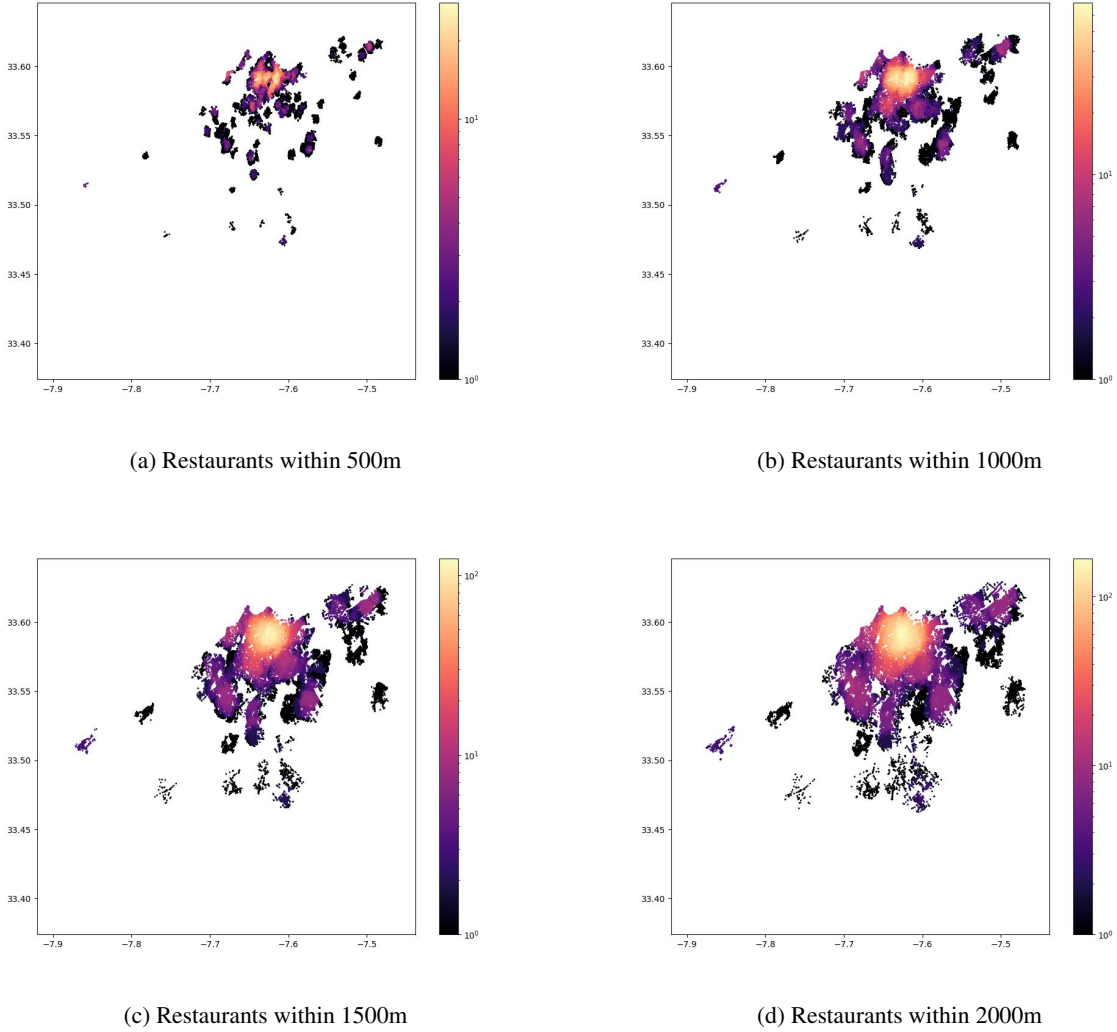


FIGURE 2: Isochrone maps for restaurants in the study area

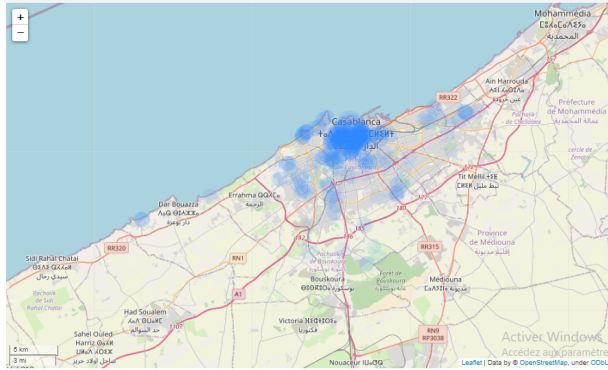
couriers should be positioned next to one of the area's centroids where the maximum buffers are overlapping to be available to the most significant number of restaurants in the area (figure 3b).

The second method we used is the k-means clustering algorithm. It is an unsupervised machine learning technique that divides a set of data into non-overlapping groups. The K-means algorithm seeks to find centroids of the clusters in which the within-cluster variation is minimized, thus minimizing the inertia, also known as the sum of-squares criterion or the objective function (equation 2) [13].

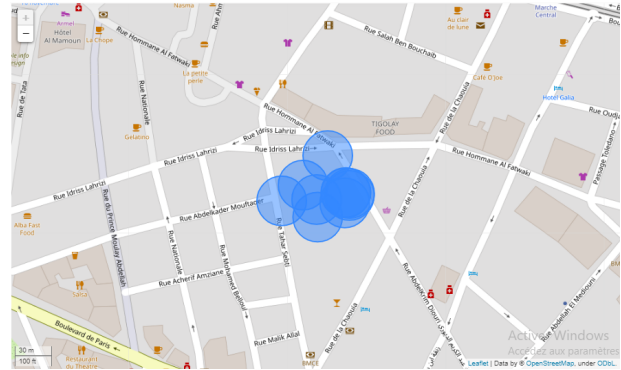
We plot the elbow graph to find the number of clusters in the data. It is a point of inflection at which adding additional clusters does not significantly improve the fit of the model. As shown in the figure 4b, the inertia variance decreases after five sets. Therefore, we chose to divide restaurant locations into five clusters (figure 4c).

$$\sum_{j=1}^k \sum_{i=1}^n \|x_i^{(j)} - c_j\|^2 \quad (2)$$

Where k is the number of clusters, n is the number of element, x_i is the element i, c_j is the centroid of the cluster j and, $\|x_i^{(j)} - c_j\|$ is the distance function

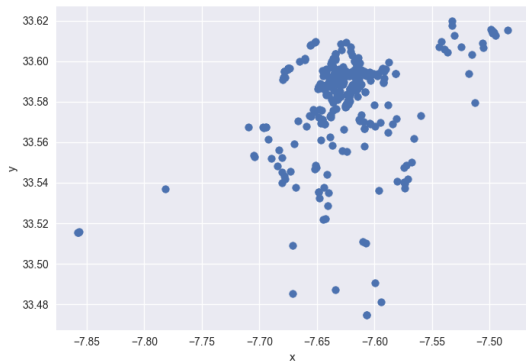


(a) 400m buffers around restaurants

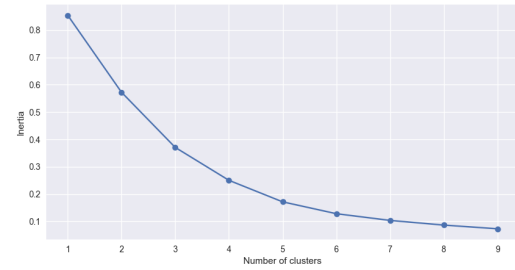


(b) 10 top locations for food delivery parking

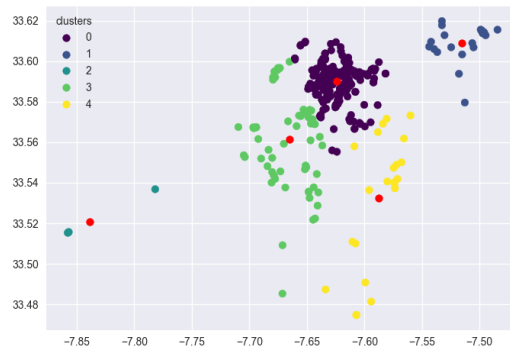
FIGURE 3: Parking locations for food delivery couriers according to the first method



(a) Restaurants



(b) Inertia in function of the number of clusters

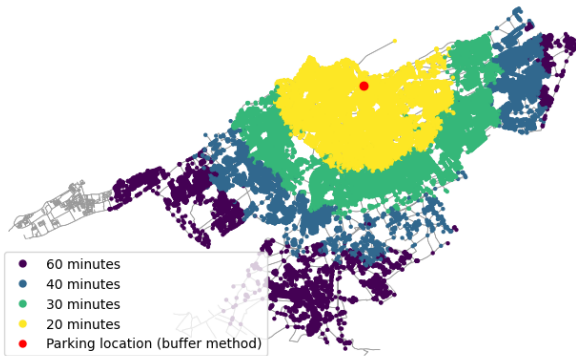


(c) clusters and their centroids

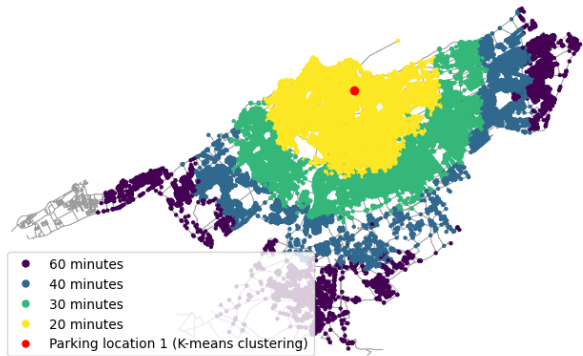
FIGURE 4: Parking locations for food delivery couriers according to the second method

According to the elbow plot, the restaurants in our study area could be grouped into five clusters. We suggest locating parking in the centroid of each one of the clusters for the k-means clustering method and the center of the area with the highest number of restaurants overlapping in the first method. We then plotted the travel time necessary for couriers on motorcycles departing from each parking location to reach all the network nodes; using OSMnx, to

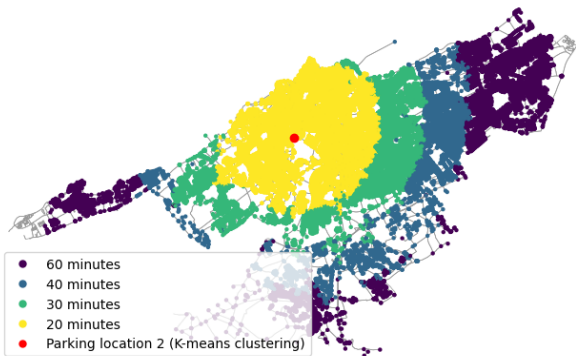
deduce the position of areas that could be reached at 20 minutes, 30 minutes, and 40 minutes from respective parking locations.



(a) Parking location according to buffer overlapping method



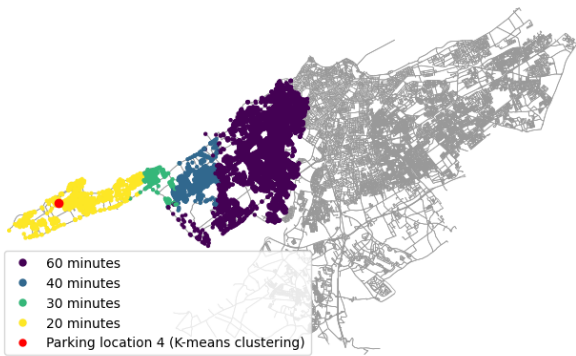
(b) Parking location 1 according to k-means clustering method



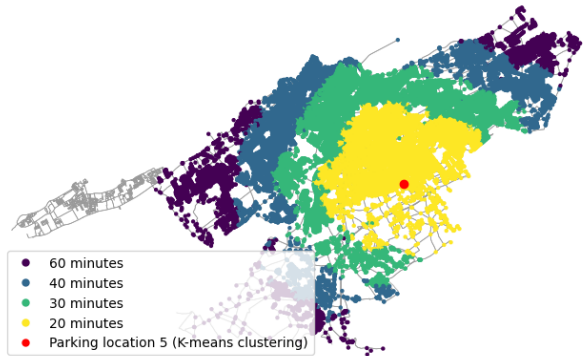
(c) Parking location 2 according to k-means clustering method



(d) Parking location 3 according to k-means clustering method



(e) Parking location 4 according to k-means clustering method



(f) Parking location 5 according to k-means clustering method

FIGURE 5: Locations of parking for food delivery couriers

DISCUSSION AND CONCLUSION

Results are presented in figures (5a, 5b, 5c, 5d, 5e, 5f). They indicate that there are potential areas of service for restaurants belonging to each respective parking lot. Consider a situation in which a food delivery company wants to

deliver orders within 20 minutes after the courier picks up the order. In that case, they should only target areas within 20 minutes from each parking and therefore show restaurant offers only to people living or working within 20 minutes from the parking locations.

The study's results were based only on the spatial distribution of restaurants and did not consider the popularity of each restaurant nor where the majority of orders came from. The time it took to travel was based on the road network and the estimated speed of delivery motorcycles, which was estimated at 20 km/hr. Thus, traffic conditions were not taken into account.

Future research needs to consider parking locations based on the spatial distribution of restaurants, the popularity of restaurants, and the patterns of delivery addresses.

In subsequent works, we aim to predict the travel time required to deliver commands based on the historic delivery time stored by delivery companies and recommend a route for couriers.

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