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Location Suitable for the Implementation of Carsharing in the City of São Paulo

Mariana de Oliveira Lage[a*], Claudia A. Soares Machado[b], Cristiano Martins Monteiro[c], Fernando Tobal Berssaneti[d], José Alberto Quintanilha[a]

[a]*Institute of Energy and Environment, University of São Paulo, São Paulo, Brazil*
[b]*Department of Transportation Engineering, Polytechnic School, University of São Paulo, São Paulo, Brazil*
[c]*Departament of Computer Science, Federal University of Minas Gerais, Belo Horizonte, Brazil*
[d]*Department of Production Engineering, Polytechnic School, University of São Paulo, São Paulo, Brazil*

Abstract

This study aimed to analyze the relationship between carsharing and urban mobility in the context of smart cities. These themes converge with the current trend of the city and the introduction of new technologies to make life easier for citizens. The smart cities offer strategic principles aligning to the three main dimensions integration of infrastructures and technology-mediated services, social learning for strengthening human infrastructure, and governance for institutional improvement and citizen engagement. A growing number of cities are implementing carsharing programs to increase this transportation model, and São Paulo (Brazil) is one of these cities around de world. That model provides the general public with affordable access to public car, and can promote the integration of public transport systems and carsharing programs to improve mobility, traffic and environment related problems. One of the key factors for the success of such programs is the location of car stations in relation to potential transport demand. This study proposes a GIS-based method to calculate the spatial distribution of the potential demand for trips, locate stations using location-allocation models, and determine the best location to settle car-sharing stations. The results obtained shows which are the best places for the implementation of carsharing and its possible partnerships with several types of commercial establishments in the city of São Paulo.

Keywords: Smart City, Carsharing location, Location-allocation, Models GIS, São Paulo.

1. Introduction

The definitions of smart city are diverse. As the concept is being known commonly but used all over the world with different names and in different circumstances, there are a range of conceptual variants generated by replacing smart with other alternative adjectives. In [1] recognized smart city as an “urban labeling” phenomenon, particularly in terms of what the label ideologically exposes as well as hides.

*Corresponding author.
E-mail address: mariana_lage@usp.br

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Governments and public agencies at all levels are embracing the notion of smartness to distinguish their new policies, strategies, and programs for targeting sustainable development, sound economic growth, and better quality of life for their citizens [2].

Smart buildings, smart homes, and larger smart ensembles like airports, hospitals or university campuses are equipped with embedded devices as well as connected sensors, actuators and with a multitude of mobile terminals [3]. Smart ecosystem is a conceptual extension of smart space from the individual context to the larger community and the entire city [4].

The smartness in smart technologies also merits attention. The technologies had permeated into the commercial application of intelligent-acting products and services, artificial intelligence, and thinking machines [5]. Smartness in the technology context implies the automatic computing principle like self-configuration, self-healing, self-protection, and self-optimization [6].

In recent years, urban transport planners have focused much of their attention on policies promoting the use an alternative car use. With the rapid development of motorization and urbanization, urban mobility and accessibility are declining in the whole world, especially in the growing cities of emerging countries [7].

This situation causes various transport issues relating to urban mobility, such as traffic congestion, insufficient transport facilities, mode shift from public to private transport and etc. [8], [9], [10], [7]. Moreover, the increasing use of private transport brings negative externalities, including traffic accidents, traffic congestion and air pollution [5].

The concept of sustainable transport started to attract wide attention. Sustainable transport refers to any types of transport modes with fuel-efficient, space-saving and healthy lifestyle, and calls for a balance between the transportation and resource needed by present and future generations [12].

The concept of sharing is developing rapidly and becoming increasingly common all over the world. It helps to reduce the number of private vehicles per family and helps to consolidate this new mentality, in which users renounce ownership of a vehicle and use shared transportation services at their convenience. Recent research shows that the global market for shared means of transport is expected to grow from US$ 1.1 billion in 2015 to US$ 6.5 billion by 2024 [13].

Carsharing is a mode of shared transport, where a service is offered in which several people share the access and use of a set of vehicles. This is a relatively new mode of urban transport, which gives users access to a fleet of shared vehicles for short periods of rental, thus providing the benefits of using private vehicles, while avoiding charges [14], [15], [16].

In recent years, the growth of vehicle sharing services as a new sustainable means of transportation has led to the shift from private mobility based on the ownership of the good (vehicle) to the use of the service. The basic idea of carsharing is quite simple: to share the use of a fleet of vehicles between members / users of the system to make trips according to the individual demand of each one. The fleet (economic asset) belongs to a company that operates the system [17].

There are three carsharing modalities: station-based round-trip, station-based one-way and free-floating one-way. In station-base round-trip modality available vehicles are stationed in pick-up stations, which are parking lots defined by the service provider or local administration and the journey must start and end at the same station. Thus, this operational model does not consider any intermediate stops that the user can plan for personal needs. The set of parking lots (stations) is predefined [17]. Station-based one-way is a similar mode as above, but in the unidirectional case, the station where the trip ends may be different from the station where it started. The set of parking lots (stations) is preset. Finally the Free-floating one-way model is the latest on the market, vehicles are freely parked in public spaces within the operating area (ie the area serviced by the sharing company), and the journey can start and end at anywhere in this area [17], [13], [18].

This article seeks to identify and select preferred areas in the city of São Paulo to implement a prototype of a carsharing system. The method was calculated the spatial distribution of the potential demand for trips in São Paulo (Brazil), and applied location-allocation models in order to determine the best place to settle car-sharing stations with GIS-based. The results obtained shows which are the best places for the implementation of carsharing and its possible partnerships with several types of commercial establishments. These locations are important because they present an optimization of the stations for the implementation of carsharing, being possible to maximize the profit and maximize the clients served. The next section presents the location-allocation model.

2. Location-Allocation Models

Location-allocation models were developed as a way of simultaneously addressing both location and allocation decisions in the planning process, which means that, determining the locations of facilities and determining who is served by which facility [19]. Based on the literature survey, classical location models mainly contain p-median problem (PMP), the location set covering problem (LSCP), and the maximal covering location problem (MCLP) [20]. Moreover, the distance-constrained p-median problem (DCPMP), and spatial interaction location-allocation model (SILA) were also introduced to deal with location-allocation problems [20]. As an example, the traditional spider plot of a p-median problem solution is illustrated in Figure 1.

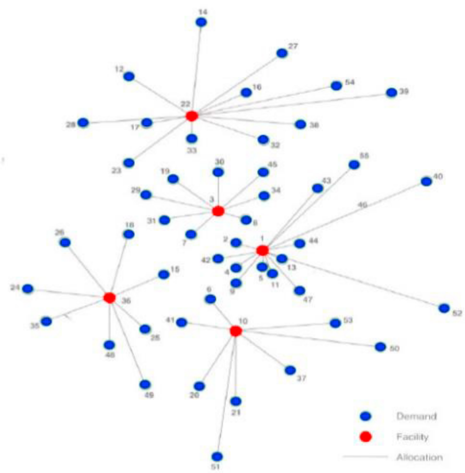

Figure 1: Spider plot of a p-median problem solution.
Source: (FARHAN *et al*., 2006)

New methods have also been developed to improve these classical location models in recent years. For example, with respect to bicycle sharing in [21] presented a GIS-based, grid-cell model for prioritizing and locating cycling facilities and proposed that the grid-cell model can also be used in locating other cycling facilities such as bike parking or public bike station.

3. Data and Method

This study considered the following public and free databases, which are available in tabular and vector formats: origin/destination survey of São Paulo City [22], commercial establishment [23], land use map [23], road network [24], São Paulo City districts [25], and transport infrastructure [23].

The methodology was divided into three stages. The first stage consisted of identifying the types of economic activities in the area under study, surveying and locating the number of commercial establishments such as "hotels", "shopping malls", "parking garages" and "colleges". The parking garages and hotels were filtered from the number of employees, so we selected only those with 10 to 50 employees or more.

The second stage was the data load of the road network of the city of São Paulo. With the road network installed it was possible to apply the Location-allocation model. The last step was the application of the model, with the road network present within the study area, the types of establishments selected and the units of a car shop. The model was applied using the ArcGis 10.2 software.

The area of study delimited were the large corporate centers of the city of São Paulo. It was calculated a buffer covering the area that can be reached by walking 10 minutes from the main routes of the corporate sector in São Paulo (Figure 2).

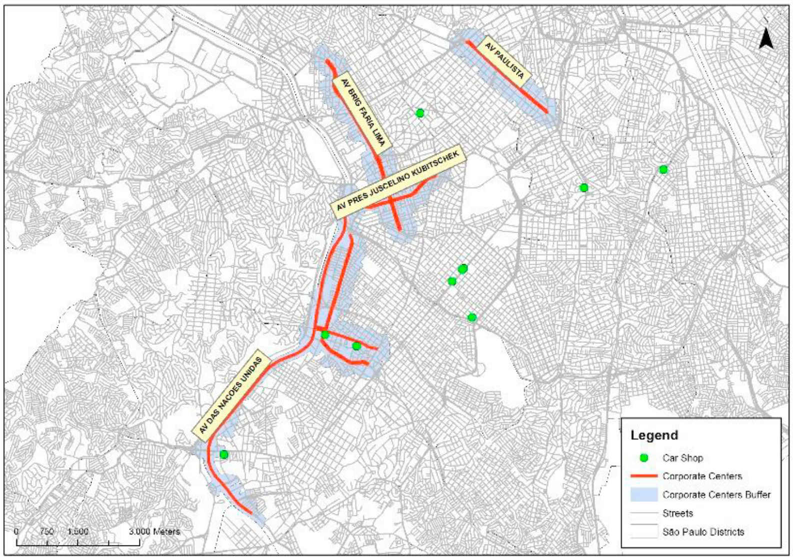

Figure 2: Study area

4. Results

Table 1 shows the quantity of each type of commercial establishment available in the study area. The location-allocation model was choose the best type of partner for each type of establishment in the region through the road network of the municipality of São Paulo and the location of the car shops.

Table 1: Quantity of each type of commercial establishment available in the study area.

Types of economic activities	Quantity
Hotels	33
Shopping Malls	8
Parking Garages	36
Colleges	39

Figure 3 presents the chosen commercial establishments, i.e., the commercial units that the location-allocation model chose as the best type of partnership, with great chances to receive a point of carsharing. The chosen ones for the partnerships have coherence, are places of high purchasing standard, with high traffic of people and with a good infrastructure for the application of a car-sharing station in the city of São Paulo.

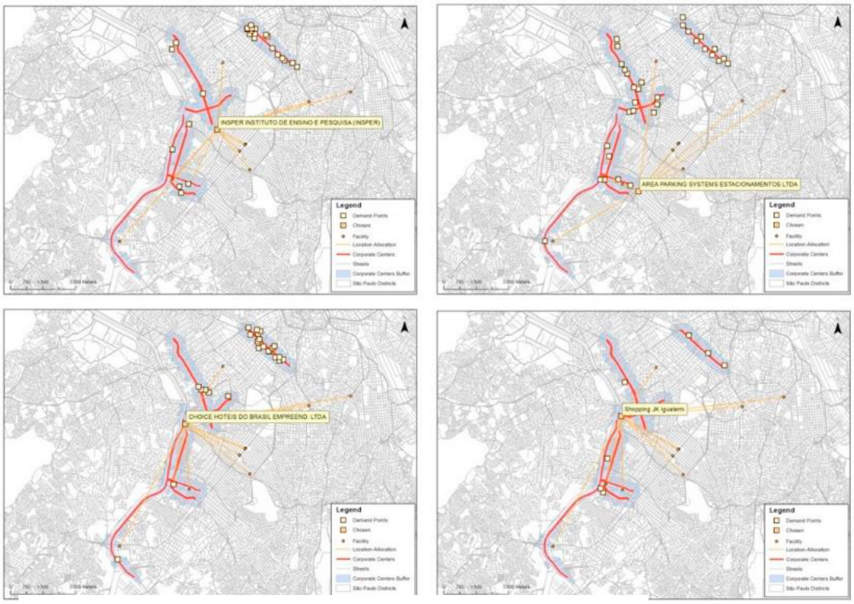

Figure 3: Commercial establishments chosen by the location-allocation model in the area of influence of the corporate sector.

5. Conclusions

Carsharing services facilitate access to vehicles and discourage the purchase of such goods, in cases where the car is used in a short-term on an as-needed basis. This type of service can produce positive changes to the city, because sharing cars helps reduce the number of vehicles purchased and outstanding, reducing congestion and improving air quality, which today represents an important improvement factor for urban centers.

The location-allocation model helps in choosing where to put your business and which likely partners. In a city like São Paulo, with several options of commercial establishments of the same type of activity, the model helps to solve these questions and also the logistics issues that the carsharing demands, such as parking spaces available, the nearest location to pick up the car, to use carsharing, and where the carsharing users are concentrated.

By the spatial data analysis of available public and free databases, the method yields the districts in the city of São Paulo (Brazil) more favorable for the implementation of a prototype of a carsharing system. The result found was expected, so it is possible to apply this model to other areas of the city of São Paulo, as well as to other types of commercial establishments.

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