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Using Data from Foursquare Web Service to Represent the Commercial Activity of a City

Taras Agryzkov, Almudena Nolasco-Cirugeda, José L. Oliver, Leticia Serrano-Estrada, Leandro Tortosa, José F. Vicent

Abstract—This paper aims to represent the commercial activity of a city taking as source data the social network Foursquare. The city of Murcia is selected as case study, and the location-based social network Foursquare is the main source of information. After carrying out a reorganisation of the user-generated data extracted from Foursquare, it is possible to graphically display on a map the various city spaces and venues especially those related to commercial, food and entertainment sector businesses. The obtained visualisation provides information about activity patterns in the city of Murcia according to the people‘s interests and preferences and, moreover, interesting facts about certain characteristics of the town itself.

Keywords—Social networks, Foursquare, spatial analysis, data visualization, geocomputation.

I. Introduction

IN recent years, there has been a growing interest in making today's and future cities smarter, sustainable and resilient. In practice, this could not be possible without a reliable understanding of how cities work. "Cities have always organised flows of people and resources through street networks, however social infrastructure is nowadays not only limited to the built environment, but it includes network computing. The latter tends to augment rather than replace the former; architecture has acquired a digital layer" (see [17], page 47). In this regard, social networks play a crucial role as Social Network Sites and services generate an extraordinary amount of data every day.

Boyd and Ellison [3] defined the Social Network Sites as "web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system". If properly used, the data originated out of these complex and dynamic networks, could yield new knowledge in various fields [12] such as the scientific (see, for example, [5], [20], [23], [24], [28]) and the marketing sectors [14], [22].

Particularly, social networks such as Facebook, Foursquare and Twitter have been considered as the newest new data sources [1], [7] as a consequence of the relatively new phenomenon associated to the digital world: "a growing shift in internet browsing from PCs to mobile devices -tablets and smartphones-" [16]. This phenomenon has brought a new dimension to the social media data as mobile devices allow sharing location via GPS. Thus, as an activity that happens in the real world is shared online, its location -latitude and longitude values- gets shared as well as part of the physical place's digital overlay [14].

A set of methods used for the study of social patterns and organisation of the city include social network analysis that specifically allows research on the relational aspects of such structures [29]. The use of these methods depends on the availability of relational rather than attribute data. One of the difficulties that arise is how this social network's relational data can be collected, sorted, stored and prepared in order to conduct an analysis [11]. One can assume that the major difference between conventional and network data is that conventional data focuses on actors and attributes while network data focuses on actors and relations (nodes and ties). As a consequence of this, network analysis focuses on the relations among actors instead of just individual actors and their attributes. See, for example, Fig. 6 and 7 for a detailed graphic support of the basic concepts and methods used within the network analysis context. See [4] for a reference in the analysis and visualization of social networks, in general.

The study of the urban public space has been carried out in the direction of a greater understanding of its potentialities as structural element of cities. This fact has led authors such as Jacobs [9] and Borja [2] to consider the public space as the city itself, understood as a physical network where collective expression and social and cultural diversity takes place. As such, these studies have evolved into the idea that the public space plays an important role in social and economic issues of a city. In this regard, the city is, from a commercial point of view, where consumption happens; it constitutes a space for consumption in which we express ourselves as citizens of a consumer society [18]. Furthermore, the built environment is "the ultimate expression of consumption activities" ([10], page 7), since the relationship between the act of consuming and urban life has largely contributed to social and spatial division of city structure ([10], page 201).

Another consideration to be taken into account has to do with the tasks within individuals' daily schedule. Such activities include a simple supermarket purchase, a breakfast at a corner coffee or any other city-break with a recreational purpose. All these habits, routines and sporadic actions, stimulated by the service sector and trademarks, lead to synergies among people and city spaces fostering a sense of belonging to the public realm ([10], page 83). Additionally,

L. Tortosa and J.F. Vicent are with the Department of Computer Science and Artificial Intelligence, University of Alicante, Spain, e-mail: tortosa@ua.es, jvicent@ua.es

A. Nolasco-Cirugeda and L. Serrano-Estrada are with the Department of Edificación y Urbanismo, University of Alicante, Spain, e-mail: almudena.nolasco@ua.es, leticia.serrano@ua.es

J.L.Oliver is with the Department of Graphical Expression and Cartography, University of Alicante, Spain, e-mail: joseluis.oliver@ua.es

T. Agryzkov is with University of Alicante.

the service sector at large contributes to the vitality of the public space which, at the same time, articulates the different activities and establishes linkages between individuals and the city spaces [13]. Bearing in mind that the liveability of a city largely depends on how varied, complex and inviting is its public place and that ”the presence of people in itself signals which places are worthwhile” ([8], page 63), it is then possible to assume that the location of commercial establishments and recreational venues has a lot to do with where successful public spaces are in a city. At the same time, these spaces, which are likely to have a certain degree of popularity, often act as symbols that reflect the city’s image and identity [15].

The main objective that we consider in this paper is the visualization of the commercial activity of a city using as data source the information that provides us a social network. Both, a social network and a city are selected in order to undertake this objective. On the one hand, data in this work is drawn from Foursquare [6], a location-based social network that has emerged as one of the dominant social utilities [22]. On the other hand, Murcia is used as case study as it is Spain’s fourth city in amount of activity on Foursquare according to www.puromarketing.com/16/15391/comousan-espanoles-four square.html). As Foursquare data provides information about the number of individuals that have gone to various city spaces -such as commercial establishments, it is then possible quantify, analyse and visualise the activity patterns in Murcia according to the people’s interests and preferences.

The resulting visualization might be particularly useful in assessing the different activities happening in a city under different perspectives, for example, the study of how urban public spaces are used [25], or the analysis of the urban complexity in an urban environment [19], to name a few.

II. The Social Network Foursquare

With the vast penetration of GPS equipped mobile devices and the rapid increase in the broadband Internet access, individuals have gained access to ”applications designed to make connections -to people, to brands and services, to information, to places, and to the world around them” ([22], page 4). As a consequence, there has been a substantial progress with regard to the type and amount of user-generated content within Social Network Sites. This progress certainly had something to do with the introduction of the Web 2.0 concept [21], transforming the way geographic information is collected, stored and distributed through the web [23]. From there on, Location Based Social Networks [23], or called Location Based Engagement Platforms [22], began to emerge.

Foursquare (foursquare.com) is, as categorised by Sui and Goodchild [26], a social check-in site that enables users to share their whereabouts with their friends [22] and, in most cases, with any on line user. The ”basis of the platform consists of user-generated venues for business and points of interests” [22] from where Foursquare users can check-in. Currently, the number of registered individuals and businesses that are part of the Foursquare community surpasses the 50 million and 1.9 million businesses respectively (Foursquare, 2014). Moreover, the enormous amount of the geographic information generated overtime on Foursquare is accessible to the public through Application Programming Interfaces (API) [23].

Taking all these considerations into account, Foursquare is considered to be an advantageous source of information for four main reasons. First, as a user check-in through a mobile device (IAB Spain Research and ELOGIA, 2013) and can only do so while physically being in the venue, the check-in is considered as primary source information. Second, Foursquare tracks the number of visiting users to a venue or site, thus is then possible to know which city spaces attract more people. Third, ”Information -such as the number of check-ins at a certain venue, the number of individual visitors, likes and tips- further indicate the popularity of that specific place and can be employed to improve user’s experience of the city” [23]. Lastly, Foursquare data is downloadable using its public streaming API.

III. The City of Murcia. Organising Data from Foursquare

As previously mentioned, the city of Murcia is used as a case study for this work. The selected area of study covers the corresponding consolidated urban fabric of the historic centre and its intermediate extensions. This selection defines an area of 40 hectares and is justified by a dense concentration of commercial venues and facilities. This fact implies a closeness between the commercial activities and therefore guarantees good connectivity between the points (called nodes). Fig. 1 shows the selected area for the study proposed for this paper.

Once defined the scope of analysis the next task is to identify strategic points (the nodes of the graph). In this context, each identified node represents an urban public space composed of a street intersection, a place of interest or an urban space located next to a building with commercial, restoration, recreational, etc., premises. With this in mind, 1196 nodes were identified in total. The number of links (hereafter referred to as edges) that define the connectivity of the urban activity in the selected area is 1869. Fig. 2 shows the graph that represents the city of Murcia with the 1196 nodes and 1869 edges.

According to the data downloaded for the purpose of this study, Foursquare categorises each venue into five pre-defined categories:

- Outdoors & Recreation,
- Shops,
- Food,
- Arts & Entertainment,
- Nightlife.

It must be pointed out that, in a previous study [27], Foursquare was found to have up to eight pre-defined venue categories which are: *Arts & Entertainment*, *Colleges & Universities*, *Food*, *Great Outdoors*, *Nightlife Spots*, *Travel Spots*, *Shops*, *Home*, *Work and Others*.

In turn, each category is divided into a number of subcategories. The subcategories that show the foursquare data are summed up:

- Outdoors & Recreation: Plaza, park, outdoors, neighborhood.

Fig. 1: The area of the city of Murcia studied in this work.

Fig. 2: Graph representing the city of Murcia.

- Shops: Mall, department store, grocery, supermarket, farmers market, clothing, plaza.
- Food: Tapas, pizza place, spanish restaurant, plaza, gastropub, vegetarian restaurant, donut shop, cafe, sandwich, seafood restaurant, american restaurant, fast food, chinese restaurant, ice cream, frozen yogurt, bakery.
- Nightlife: brewery, beer garden, bar, pub, lounge, cocktail bar, nightclub.
- Arts & Entertainment: theater, movie theater, historic site, multiplex, concert hall, stadium, art museum, music venue, performing arts, science museum, rock club.

As it is apparent from the different subcategories that fall into relevant categories, there is little organisation in the data supplied by the Web service, due to the fact that the users set out the categories themselves. This set of subcategories is highly subjective since the venue classification depends solely on the user criteria. Moreover, the classification of a particular venue in a subcategory or another can be difficult to determine. For example, there are many establishments that can fall under the category of coffee even when these offer other products such as fast food, for example. This makes the task of categorising a rather difficult one.

In order to simplify the subcategories within each of the categories, we conducted a new organisation of the subcategories as follows:

- Outdoors & Recreation: plaza, parks-gardens, outdoors-recreation.
- Shops: malls, supermarkets, stores.
- Food: spanish food, international food, cafe-bars, ice cream-frozen yogurt, others.
- Nightlife: bars-music.
- Arts & Entertainment: theater, movie theater, museums, art gallery, entertainment.

In Table I we collect the data obtained from Foursquare for the city of Murcia, according to the new simplified classification of subcategories proposed.

In the first column of Table I the stated categories are listed while, in the second column the new classification of subcategories is shown. The summarised Foursquare data with the number of places that have received at least one visitor is shown in a third column.

The total number of venues that have received at least one visit by the users, in each general category, is:

- Outdoors & Recreation: 168.
- Shops: 525.
- Food: 974.
- Nightlife: 204.
- Arts & Entertainment: 84.

In total, if you add up all the places that have received at least one visit in all categories, we have a total of $1,955$ sites visited by users.

It must be pointed out that the data shown in Table I correspond to the entire city of Murcia while only a portion (downtown area and surroundings) concerns this study. Therefore, it stands to reason that many of these data are geolocated beyond our area of analysis. Moreover, a fundamental problem to represent the data is to determine

TABLE I:
GENERAL DATA FROM FOURSQUARE.

Category	Subcategory	Number places
Outdoors	Plaza	51
	Parks-gardens	36
	Outdoors-recreation	81
Shops	Malls	13
	Supermarkets	49
	Stores	463
Food	Spanish food	349
	International food	263
	Cafe-bars	229
	Ice cream-frozen yogurt	19
	Others	114
Arts & Entertainment	Theater	4
	Movie-theater	11
	Museums	9
	Art galleries	9
	Entertainment	51
Nightlife	Bars-music	204

TABLE II:
DATA FROM FOURSQUARE IN THE URBAN AREA STUDIED.

Category	Subcategory	Number places
Outdoors	Plaza	37
	Parks-gardens	16
	Outdoors-recreation	36
Shops	Malls	6
	Supermarkets	24
	Stores	319
Food	Spanish food	224
	International food	150
	Cafe-bars	137
	Ice cream-frozen yogurt	12
	Others	73
Arts & Entertainment	Theater	3
	Movie-theater	4
	Museums	8
	Art galleries	6
	Entertainment	20
Nightlife	Bars-music	141

which of these venues are found in our study area, in order to establish the exact number of places that are located in the area under study. For this purpose it was necessary to perform a study of all geolocation data, counting those found within the study area. The summary of this study of geocomputation is shown in Table II.

Now, the total number of places that have received at least one visit by Foursquare users, according to the different categories, and taking into account only the venues located within the area shown in the map of Fig. 1, is:

- Outdoors & Recreation: 89.
- Shops: 349.
- Food: 596.
- Nightlife: 141.

- Arts & Entertainment: 41.

If we now add all the places visited in the area under study, we have a total of 1216 venues that have received at least one visit through the social network. It is noteworthy that, speaking in broad terms and considering all the categories, the 62% of the data obtained from the web service Foursquare are located within our study area. We must not forget that our main objective is to focus on the representation of the commercial activity of the city from this set of data.

If we detail by categories the number of venues that are located within our study area, we obtain the following results:

- 53% of the venues in the category Outdors & Recreation are located within our study area.
- 66.5% of the venues in the category Shops are located within our study area.
- 61% of the venues obtained from the web service Foursquare in the category Food are located within our study area.
- 69% of the venues in the category Nightlife are located within our study area.
- 49% of the venues in the category Arts & Entertainment are located within our study area.

To carry out the study of the commercial activity, we will arrange the categories and subcategories in a different way. We try to simplify the number of categories and subcategories for the purpose of the study is most efficient. The set of commercial venues will be divided into three basic types according to different sectors related to commercial activities. Thus, we distinguish the following types:

- TYPE I: It represents the food and recreation sector.
- TYPE II: It represents the small-shop sector.
- TYPE III: It represents the large shop sector (basically malls and supermarkets).

Foursquare sets forth five categories, three of which relate to the types of commercial activity proposed and described above. Thus, the Foursquare categories that are considered of interest for this study are: shops food and nightlife.

IV. Some Remarks about the Data

Foursquare provides the possibility of describing the influence of city places according to their significance in society and people's preferences rather than merely indicating the location and quantity of activities.

Therefore, it can be said that Foursquare data offers important information for urban research given that it portrays issues related to the reality of the built environment and how the city works. In this regard, it should be noted that graphically representing Foursquare data not only allows to visualize the most highly rated spaces and activities in cities but also, to study urban complexity and its influence on the use of urban public spaces.

We want to highlight some points related to the data offered by the Foursquare Web service.

- If we consider the overall set of data on the city and surrounding area, the number of venues that have received at least one visit is 1995. Of these, 1216 are located in the urban area under study. This means that 61% of the venues are located in the city centre. This gives us an idea of the importance of the urban centre in this city. The large number of visits means that a great amount of commercial, leisure and entertainment activities happen in this area of the city.
- In our aim to measure the commercial activity taking place in the centre of the city, based on the commercial sectors of restaurants and shops, we wonder whether the data obtained from the social network can be useful or not to carry out the graphical representation. It may be the case that the tastes or preferences of the users are not related to what we want to evaluate. The answer to this question is evident in the data displayed in Tables I and II. Out of 1216 places visited, a total of 1081 (the sum of shops, food and nightlife) corresponds to the business we want to represent. This value represents 90% of the total data. This data allows us to draw several conclusions. First, the data provided by the social network Foursquare are appropriate to visualize the commercial activity. Second, the data show very clearly some essential features of the city, particularly highlighting their predominantly commercial and service nature.
- Out of 1216 venues visited by users of the social network, nearly 600 are restaurants, accounting for almost 50% of the visits. This allows us to conclude, first, that it is a city with a high gastronomic offer. Second, we can say that the population uses and shares the wide gastronomic offer, which means that going out to lunch or to dinner takes part of the daily routine of people. This translates into an essential feature of the city: the historic centre is characterised by its open and lively nature.

V. A Graphical Representation

As discussed in Section 3, the data obtained from the Web service Foursquare are geolocated in a big area of the city of Murcia, some of them far from our study area, as can be appreciated in Fig. 3.

In order to geolocate the different venues on the city map, we have chosen a set of colours, so that the green colour marks represent the venues related to the stores sector, the blue colour marks represent the venues related to the large shops sector; finally, the red colour marks are related to the food and recreation sector.

From the set of data extracted from Foursquare regarding the categories related to commercial activity, a process of assigning the obtained information to the elements of the graph representing the city has been undertaken. This is a fundamental part in the study. Our goal is not only to locate the allocations and related commercial activity, but to visualise in a clear display the intensity of the commercial activity establishments.

Commercial venues appear in the figure as shaded squares (in black color) with the letter D inside. The first example, in Fig. 4(a), follows a fairly flexible rule. We know that all the venues or places that Foursquare provides us (in this case, commercial venues) are geographically located at some edges

Fig. 3: Data provided by Foursquare for the whole city of Murcia.

of the network. We identify the nodes that comprise the edge and assign them the information to each of the nodes. Thus, as it is remarked in Fig. 4(a) each node collects the corresponding square venues.

However, on the right-hand side of the picture used as example, Fig. 4(b), the issue from a geometrical point of view appears to be more complex. Now, if we consider a particular venue, we must determine the polygon in which this venue is located. Then, this venue is associated with the vertices of the polygon whose edges enclose such an allocation. This process must be performed for all the commercial venues in the network studied.

In this paper, in order to reduce the degree of subjectivity and possible errors when allocating all the venues or facilities, it is used the process described in Fig. 4(b). Consequently, the task of mapping the information to the nodes of the network has two main parts: first, it is necessary the location of the city block that contains the commercial facility. Secondly, we proceed with the allocation to its geometrical vertices, taking these vertices as if they were network nodes.

Therefore, after performing the process of mapping the information to the network, we have a quantification of the commercial activity of the city. Each node of the urban network has a number of commercial venues (venues for Foursquare) that allow us to establish a certain classification of the nodes themselves. Those network nodes that have much commercial activity around them, are going to have a very high number of venues allocated. Moreover, the network nodes where there is no commercial activity on its proximity will not have information allocated, thus, allocations to it will be very

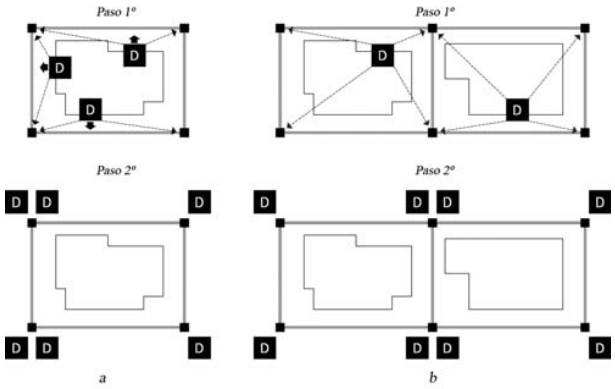

Fig. 4: A procedure followed to assign information to the nodes of the network.

few in number.

These quantitative differences in the nodes that constitute the network can be displayed graphically in many different ways. The way we choose for displaying the data consists of a chromatic scale of values called *Hot-Cold* scale, based on the RGB model (Red, Green, Blue). This colour domain comprises the following values: Blue[0,0,255], Cyan[0,255,255], Green[0,255,0], Yellow[255,255,0], Red[255,0,0].

Consequently, we have two distinct scales: first, the scale of the domain of values that provides quantification of information and, on the other hand, the scale that provides us with the graphic scale. It is necessary to enhance a linear interpolation to set the colour that is assigned to each of the nodes, according to the amount of information associated with it. Once we have this colour range in the nodes, a graphical representation of the edges follows the same format representation. Fig. 5 shows an example of the graphical output that follows the specific values of the nodes of the example.

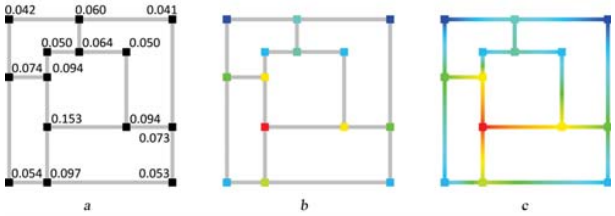

Fig. 5: Transformation of the numeric values of the nodes to a chromatic scale.

With the chromatic scale, we can represent the commercial activities of the city for both, general and specific sectors.

In Fig. 6 we represented the commercial activity of the city of Murcia from the Foursquare visits, taking into account only the data related to the sector of malls and supermarkets. Note the special geometry obtained in this picture, in which several isolated areas relative to each other appear. The commercial activity related to supermarkets and department stores are like ”islands” within the city map.

Fig. 7 shows the commercial activity related to the sector of small trade (small shops and stores). Similarly, Fig. 8 shows

Fig. 6: Data visualisation for Malls and supermarket sector.

Fig. 7: Data visualisation for small shops sector.

a visual representation of the places visited by Foursquare users, that correspond to the food and leisure sectors. It must be noted that despite of what with the representation of malls and supermarkets, this graph is much smoother than in the previous case.

Fig. 9 shows a visual summary of all this commercial activity in the city, taken overall. Mayor commercial arteries can be clearly identified in the urban network representing the city, a major axis running from north to south where some of the most important shops in town are located. This main artery is clearly shown in the above figures, which gives an idea of the importance of the number and diversity of commercial venues present therein.

VI. Conclusion

We used data from the social network Foursquare to represent the commercial activity of the city of Murcia, Spain. A reorganisation of categories and subcategories of the different places that have been visited by the users of the network was carried out. Then, we conclude that almost 90%

Fig. 8: Data visualisation for food and leisure sector.

Fig. 9: Data visualisation for general commercial activity.

percent of the places visited are associated with commercial activity related to stores and food sectors. This result validates the study in the sense that the data used are consistent with the activity that we wanted to visualize. In order to visualize the data, a chromatic scale was used to determine the intensity of the activity on the nodes and edges of the graph representing the urban fabric. As a result, various city maps were obtained showing the intensity of the commercial activities according to those under consideration.

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