When Internet Became Geography

Spatial patterns on urban open spaces through the analysis of user-generated data in Barcelona

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***Abstract* - The main objective that motivates the paper concerns the study on user-generated data (UGD) for exploring new methodologies that could support and improve the understanding of spatial patterns for urban planning and design of open spaces in urban areas. This paper aims at taking a step forward from current literature, providing on the one hand a method for social science analysis and, on the other hand, expecting to motivate the possible outcomes of user-generated data coming from two ICT platforms into policy driving strategies in order to improve quality of life. In order to do so, this paper examines UGD coming from social network platforms and apps to provide a visual and scientific exploration of the resulting spatial pattern, specifically of locals, visitors and tourists which have used two urban open spaces (UOS) in Barcelona, Enric Granados Street and Forum. In addition, for the purpose of analysis, the spatial patterns have been discriminated by language to study the further insides of how diverse groups of population construct different spatial patterns given by their preferences in visiting a city.**

Keywords - Big Data, Mapping, Twitter, Urban Open Spaces

I. INTRODUCTION

Recent development in Information and Communication Technologies (ICT) brought important changes in the daily life of people. The possibility to communicate worldwide through common smartphones opened new perspectives to individuals, who very quickly responded with a massive use of social network platforms and applications. Since smartphones include Global Positioning System (GPS), if activated, data outgoing from each device can be geo-referenced. Thus, the large amount of data coming from smartphone can be geo-located with a time reference. The consequence is the constant production of "Big Data" [1, 2] which can be overlaid on maps and analyzed not only by mathematical or semantic techniques, but also by means of spatial analysis methods. Substantial works on the nature of geography and its methodology have discussed the spatial pattern formed by many purposes of analysis, since the classical works of Hartshorne [3], Harvey [4], Friedman and Alonso [5], Berry [6], and Haggett [7] among many important others till nowadays. Their relevant research on the organization and placement of people and activities in the human world, the regularity of distribution brought significant and worthy results which made huge advancements in Geographical Thought. In 2016, the massive generation of georeferenced data and abundance implementation of Geographical ICT tools brought a new paradigm in the study and analysis of spatial patterns in Human Geography. Problems nowadays seem to be more related to find appropriate models and methodologies to draw a good statistical sample from the population, to depurate the data, to discriminate the data size and to analyze consistently the results to cope with substantial results for the postulated research objectives.

The goal of this paper is to deepen the study on user-generated data (UGD) for exploring new methodologies that could support and improve the understanding of spatial patterns for urban planning and design of open spaces in urban areas. This paper aims at taking a step forward form current literature, providing on the one hand a method for social science analysis and, on the other hand, expecting to motivate the possible outcomes of user-generated data coming from two ICT platforms into policy driving strategies in order to improve quality of life. In order to do so, this paper examines a visual and scientific exploration of the spatial pattern of UGD, specifically of locals, visitors and tourists which have used two urban open spaces (UOS) in Barcelona. In addition, for the purpose of analysis, the spatial patterns have been discriminated by language to study the further insides of how diverse groups of population construct different pattern given by their preferences in visiting a city.

To understand different group behaviors in choosing and visiting urban spaces, this study analyzes UGD of visitors to two charismatic and opposed urban open spaces in Barcelona, the street named Enric Granados (Carrer Enric Granados) and the Forum (Fòrum de les Cultures). The former is a residential lively, dense street with services and amenities located centrally in the Barcelona's Cerda Enlargement [8]; the latter is mainly a reunion of buildings and cement plazas built for the 2004 Forum of Cultures exhibition. For the most part, locals and neighbors use Enric Granados Street, while Forum's facilities are used for large meetings, conventions and festivals, while other times it is an empty space. Both spaces are marginally used for tourist or visitors.

Tourist and visitors use touristic guides in deciding to visit a city. When they arrive to a place there is a compulsive intent

to watch what has been prepared to see in the city, which is a fabricated product to be consumed by a stratified demand. Different groups of people prefer very specific itineraries to visit. Tastes are very much diverse depending on nationalities, cultures, and backgrounds. Tourist attractions, transport hubs, monuments and shopping malls are mostly where people concentrate. Higher the density of people, higher is the possibility that people makes use of a communication tool, as web social networks, for sharing its activity, opinion or position. The study raises a number of different questions from which we try to focus on two of them: Could we use these spatial insights to learn more about demand and planning of the city? Do different groups of population draw different spatial patterns in the city? And can we use it to design a better sustainable city?

Methodologically, UGD obtained from two different platforms has been used for this paper. The first platform is Twitter, the web social network currently used by 284 million of monthly active users [9]. Twitter provides large amounts of data georeferenced. Although only a part of the entire urban population use the Twitter application, Twitter data can be used to understand where people in the city are and why there might be some activity/clustering in given places. Furthermore, information can be obtained also from the content of messages sent. The second platform is WAY Cyberparks, a recent application developed by DeustoTech Mobility within the COST Action TU1306 – CYBERPARKS [10, 11, 12]. This GPS-based platform focuses on the use of ICT for understanding and collecting data on the use of urban open spaces in order to improve the quality of UOS and include them in a sustainable-chain-development planning goals.

To analyze this UGD, an experimental study has been organized in different steps that coincide with this paper sections. Section 2 analyzes the state of the art regarding uses and applications of "User-Generated Content" (UGC) within spatial studies and how it is used by different institutions and policy makers. Section 3 describes the methodology, while Section 4 is about its testing to the two case studies in Barcelona. The final step, in Section 5 provided the conclusions derived from the direct experiment. Finally, the paper offers some insides of expected future developments for the integration of new methodologies within spatial planning processes.

II. Background and Related Work

The availability of big and open data is nowadays offering new opportunities for re-thinking the human behavior and impact on Earth. Since these data is often geo-referenced, their overlaying on maps provides information on particular organization and structure of spatial systems. Therefore, many disciplines can benefit from their use such as urban planning, urban design, transport planning, social sciences or human geography.

Although a large number of applications and experiments constellates the landscape of research, the academic research has barely yet found a specific own identity within these huge opportunities. Meanwhile, geographers do not have the knowledge of computer scientists or mathematicians, nor architects know how to handle this intangible material. However, relevant academic work is coming out as well as public and private bodies have begun to use big data for their own development. A concise overview on the state of the art on the use of geolocated user-generated contents in spatial planning is meant to show analysis, applications and uses.

A. Seeking Spatial Patterns on Smart Cities

Cities have the pressure of millions of inhabitants to increase their quality of life. Through the introduction of ICT to urban spaces in everyday life, cities try to cope with population needs with strategies based on an integrative framework, including management, technology, governance, policy; a reunion of factors which some call smart city [13]. The concept of "smart city" has not a clear consensus and nor a consistent understanding among academia and practitioners, but in this paper this concept will be used to refer to a city with massive implications of ICT affecting citizens and processes. What is clear about most of today cities is that based on sensors, tools and applications for collecting data, city information is obtained on the use of the city, and most of its policy relies on the diffuse use of devices for quantifying movements, environment quality and healthiness, and energy consumption. But private enterprises, such as the biggest technological companies like IBM, Cisco or Siemens are very interested on data collection and analysis for their own objectives and strategies.

Local institutional organizations such as local governments or urban planners use big data to organize popular exhibitions with different goals. Some are under the idea of crowdsourcing; in which citizens' digital footprint such as tweets or use of online municipal services help city planners improve city's design and functionality. For instance, the Chicago Architecture Foundation (CAF) partnering with IBM [14, 15, 16] launched "Chicago: City of Big Data", with the goal to open up a dialogue on the connection between big data and human lives and to show how spatial systems are impacted by this information, and also how relevant each individual was to the design of their environment. The exhibition's dashboards were built with IBM's City Forward platform, a free web-based "civic resource that enables people to visualize and interact with city data" [17].The methodological basis selected data sources using two criteria: the data's availability at a large enough scale; and its capability to communicate valuable insights about the city's needs and flows. Then, they used complex geographic information systems (GIS) and web-based tools to compile and visualize the data in effective ways. Data sources consisted of over 18 million Twitter data points data, with only timestamp and location attributes, which turned into dynamic and "interactive models of city's human activity." [17]. On the broad objective of "explor(ing) the emergence of the database as a framework for cultural and political thinking and the effects of datafication of the world.", the Big Bang Data exhibition (organized by Centre de Cultura Contemporània de Barcelona, CCCCB and Fundación Telefónica) [18] took under consideration different topics about city's shape on the basis of different kind of data.

Academic literature on spatial analysis based on Twitter-use patterns has developed at different scales. The spatial pattern of social networks and the threshold of their activities have been analyzed at urban scale, where large-scale data is analyzed across three cities in order to produce an inter-urban analysis. For instance, Bawa-Cavia [19] suggests to aggregate the activity on the network onto a grid of dots which represent the 'walkable' cells, each one 400x400 meters in size, where a resolution of 400m is chosen based on research into threshold walking distances in urban areas [20]. The area of each dot corresponds to the level of activity in that cell. At wide scale, human flows are gathered, extracted and analyzed in geolocated social media data through different instruments. An example is FlowSampler, an interactive interface for visual analysis of urban flows in geolocated social media data. It adopts a graph-based approach to infer movement pathways from spatial point type data and expresses the resulting information through multiple linked multiple visualizations to support data exploration [21]. It uses the time and the coordinates of subsequent tweets from the same user (or group of users) to trace the route whose arcs are plotted on maps. A second step is about text base computation which allows characterizing places in base the "density" of arc traces and the distribution of keywords within the local groups [22].

Big data also helps to study prescription planning. Huge amount of geotagged tweets were obtained in several cities around the world and map them to plan where buses and subways should be, if they conformed to the way people actually move and live [23].

Through the spatial analysis of user generated data, a study found that some cities are far more active early in the morning, while others showed higher activity at night or on weekends [24]. The Center for Advanced Spatial Analysis at University College London (CASA, UCL) monitored several cities' Twitter-use over a one week period to determine patterns in temporal activities and learn about networks within the cities. Another research analyzes user-generated data and publicly available data from social networks - Twitter, Facebook, Flickr and Instagram - to capture information about citizens' feelings, how citizens use their city, where they feel comfortable and what conditions can evolve into problematic situations. Funded by the German Research Foundation, the universities of Heidelberg and Kaiserslautern test these sources to validate their results by checking whether the emotions measured correlate with the subjective assessments in the social media. In search for the appropriate toolset, the "People as Sensors" concept measures emotions and stress levels. According to "Urban Emotions" project, modern city dwellers face a number of stressors, such as "unsafe bike paths, traffic jam stress, frightening underpasses" [25]. Therefore, measurements of citizens' emotional responses to their environment were made with sensors, similar to a wristwatch "that allows us to measure skin conductance, body temperature and variations in heart rate that change, for instance, when someone is startled" [26].

Differently, but tracing emotions, the exploration of how people express excitement online show a regular pattern in which as much higher levels of excitement and more intense the flurry of messages in the collective, the shorter messages become [27, 28]. Striking mathematical regularity shows the experiment, in which emotional bursts become faster and more impulsive online than events offline. Many associated questions and outcomes become unanswered, such as: "Are people doing this independently, or in response to seeing other short messages? Are we following the herd? Could we use these insights to learn more about financial bubbles by measuring more impulsive, less rational responses? And can we design better communication services?" [28].

B. Cautions and considerations on the use of Big Data

There are many positive aspects on big data analysis, but many fears can arise too. The obvious one is the intrusion on private lives. Also, putting data culture at the center of decision-making and on the way of interpreting the world opens up many possibilities and involves numerous risks. The main danger of data-centrism is that it encourages the idea that whatever the problem, the answer lays in data. Preserving values such as subjectivity and ambiguity is especially important for decision-makers at a time when it is easy to believe that all solutions are computable, and that they are hosted on a server and stored in a Data Centre. Otherwise cities that rush into the "Geek City" [29] category risk to define just their targets and not to define the method by which achieving their goals.

The proliferation of the use of big data as support to spatial planning and other social issues bring new discussions on the table, about claims that big data will necessarily answer important or relevant research or policy questions. Although broadband and Internet-connected smartphones has reduced the prominence of the "digital divide," sophisticated analysis is not on the everyone space; and "Data divide" could represent a new source of world inequalities [30]. A good practice to be seen in designing experiments is to pursue experiment-control using standard and big data methods to compare and complement the results. To understand if cell phone traces are sufficient to intuit travel behavior, it might be controlled through surveys or interviews to validate the results. To understand if postings to social networking websites provide insights are not specially biased windshield survey and in-depth interview could help to validate the previous results. Comparison between crowdsourced data and "known" sources could explain the variations and biases discovered [31].

The use of Twitter data is very interesting to make analysis of how people use urban open spaces and what is the geographical pattern of their communications. Nevertheless, a number of issues have to be carefully considered in using this data. First of all, Twitter users are a small part of the entire population, while geo-referenced data are a portion of the total amount of useful Twitter messages. This outlines that only a small part of the entire demographics is represented by the Twitter data. Secondly, Twitter messages contents are about everything, then, in order to be used, they need to be filtered.

Thirdly, it is particularly important to consider that Twitter users are not conscious that their messages are tracked, or more simply, they are not interested on the way their data will be used. Finally, the location of a tweet should be

approximated considering that a tweet takes some time to be written and sent, and beside this, the user can move during sending a tweet. Thus, according to the mode of mobility, in the meantime the user may have traveled a substantial spatial distance.

III. Methodology and Data

Different agents use UGC for different purposes. Academically UGC has been widely discussed by various disciplines. Generally, "User Generated Content comes from regular people who voluntarily contribute data, information, or media that then appears before others in a useful or entertaining way, usually on the Web –for example, restaurant ratings, wikis, and videos." [32].

In this paper, UGC is analyzed to understand how it could improve the design of public spaces, based on users' suggestions, complains, and movement patterns. Two different sets of data coming from Twitter and from CYBERPARKS App helped to build two different purpose sets of contents.

A. Twitter Data and Spatial Pattern in Urban Open Spaces in Barcelona

Twitter, the web social network platform which counts hundreds millions of users worldwide, is used by only 23% of total population in the U.S.A. The particularity of this kind of data is that it is open for freely use and can provide very large amount of records and information, including attributes on time and location of each single tweet. The messages sent by the use of this platform are public and, according to users' settting, geo-referenced. Thus, each message can be downloaded and stored on a personal database through free API available on the Web (Table 1).

TABLE I. Data records about the single Tweet.

ID	Message	User from	User to	Date	Lat	Lon
1	🏄❄ @ Outside - Calvin Harris http://t.co/14oG7mPxwE	albasancho95	fjdh	Wed Jan 07 08:55:20 +0000 2015	41.47267	2.27114
2	Nos aventuramos a las rebajas... Tengo miedo xD	zaidasphyxiated		Wed Jan 07 08:55:18 +0000 2015	41.52691	2.229489
3	#cyberparks #TU1306	e_frola		Fri Jan 09 10:29:08 +0000 2015	41.50982	2.229217
4	…….	…..	…..	…..	…..	…….
n	…….	…..	…..	…..	…..	…….

For each tweet is possible to freely obtain different information: the text of the message, the nick-name of the user who sends the message, the eventual name of the user receiver of the message, the date and hour in which the message was sent, the latitude and longitude from where the tweet was launched.

Furthermore, it is possible to obtain information by single Twitter user. Particularly, characteristics such as user's screen name, user's full name, his/her location, user's self-description, the number of his/her followers, the date in which the user first joined Twitter, the user's time zone, main language, current status with date, the user's numeral ID, the ID of the user's followers, and his/her profile pictures (Fig. 1).

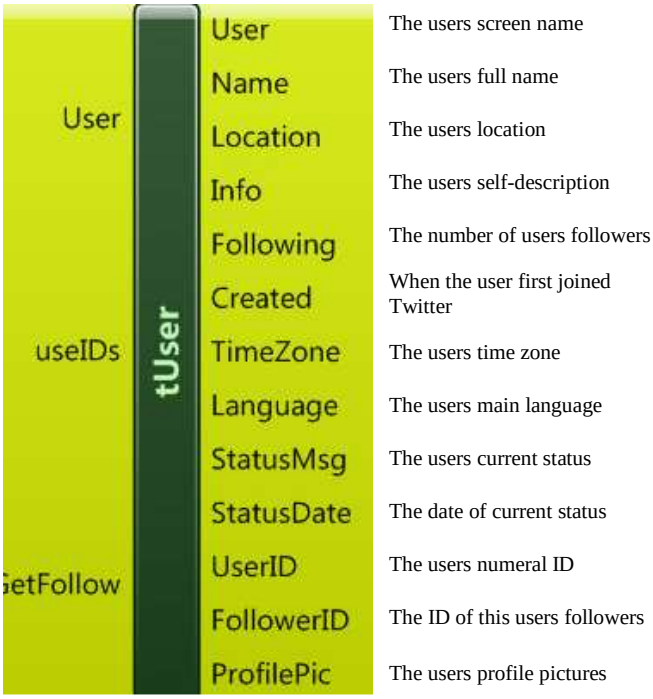

Fig. 1. Collectible data about the single Twitter user. Image source: Authors' own production.

SiTI (Higher Institute on Territorial Systems for Innovation) collected Twitter data in Barcelona during the period January 7-19, 2015, both included, for the entire area of Barcelona. The total amount of records was 126,288 Tweets, of which 103,404 (81.88 %) were georeferenced. Among these, only 4,781 (3.79 %) records were from users who passed across one or both of the two case study areas.

B. CYBERPARKS App – WAY and UGC for UOS Planning Purposes in Barcelona

The CYBERPARKS App - WAY (WAY), developed by DeustoTech Mobility (Developed by with the support of the Spanish Ministry and executed during the COST Action TU1306) [33] is a GPS-based platform that, differently from Twitter data, registers the users' movements twice a second. The result is a point database which allows building up a timeline with the full path travelled by users, with continuity and precision (Fig. 2).

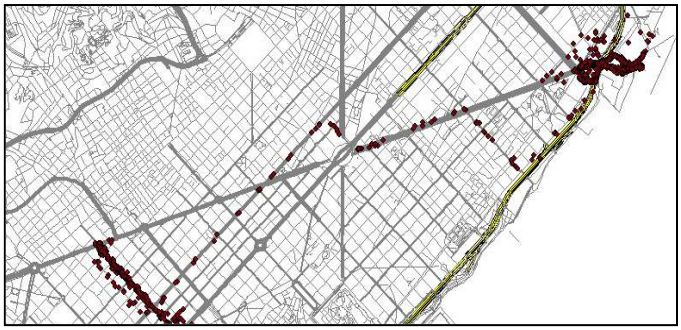

Fig. 2. Data collected by the CYBERPARKS App - WAY. Image source: Authors' own production.

The app is conceived as a Volunteered Geographic Information (VGI) platform where users collaborate for producing information. In particular, it collects data for better understanding the use of public open spaces in order to improve their production and their relevance to sustainable urban development. To achieve this task, it collects also data on the user such as age, sex, education, job, the distance from home and from working place, and the reason of being in a public space, such as walking, running, reading, kids or pets (Fig.3).

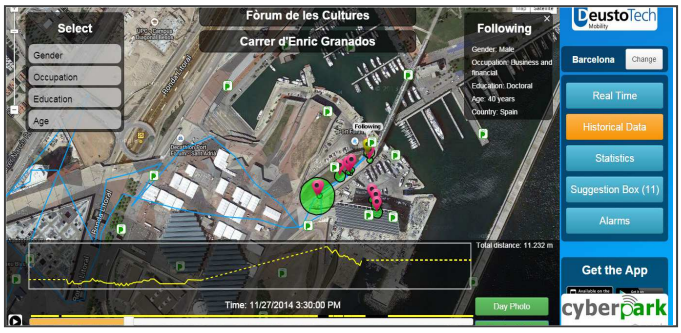

Fig. 3. Visualization of data gathered in one case study area of Barcelona through the CYBERPARKS App - WAY. Source image: Deusto Tech Mobility, 2014.

This data collected has some specific considerations. Data gathered during the pilot test organized in November 27, 2014, with a selected group of users moving in and between the two case study areas in Barcelona. Nevertheless, the main limit of WAY data is given by the fact that who generates the data, namely the user, is conscious that he/she is producing data for some specific analyst task. Therefore, it is necessary to consider that this awareness can alter the veracity of the data.

C. *Building Methodology for Twitter and WAY's Data*

Once data was obtained, the geovisualization of these data provided users' movements and other elements for the understanding and designing of public spaces. Methodologically, data analysis needed subsequent steps as follows:

- To import data from Cyberparks App - WAY in Arcmap: converting the *.json file into a file readable from ESRI ArcMap.
- To elaborate Twitter data in Excel.
- To import Twitter data in ESRI Arc Map.
- To use information about time and coordinates of data from Cyberparks App to trace plausible paths of single users (or group of users).
- To use information about time and coordinates of tweets to trace plausible paths of single users (or group of users) within specific areas.
- To use information about time and coordinates of tweets to trace plausible paths of single users (or group of users) who pass through specific areas.
- To use tweets information about languages, presence of tweets for large periods (to differentiate local users from tourists or visitors), keywords, to identify different kinds of densities within specific areas.

IV. Case Studies

For analysis purposes, we had chosen a very diverse morphological and social UOS in Barcelona Enric Granados Street and Forum (Fig. 4).

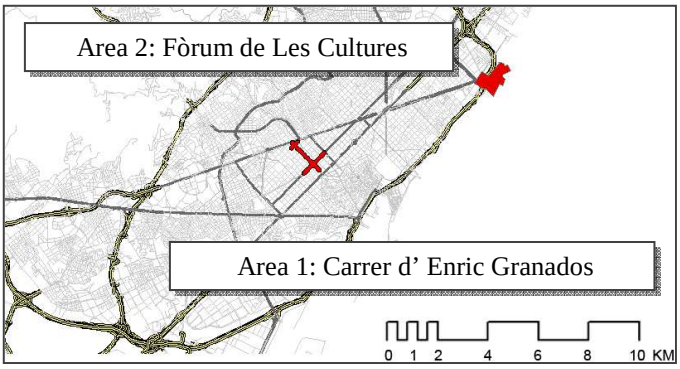

Fig. 4. Location of the two case study areas in Barcelona. Image source: Authors' own production.

A. *Enric Granados Street*

Enric Granados Street is within the consolidated historical city, which connects Diagonal Avenue with a foundational building of the University of Barcelona on the Gran Via de les Corts Catalanes. Differently from Rambla de Catalunya and Passeig de Gracia, which are parallel to it, Enric Granados Street is not highly touristic, but hosts several leisure activities mostly for neighbors and local people (Fig. 5 and 6).

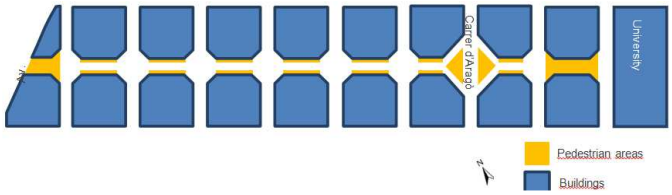

Fig. 5. Scheme resuming the design of Enric Granados Street

Fig. 6. Enric Granados Street. Map source: Google Inc. Image source: Autors' own production.

Enric Granados is part of the regular orthogonal subdivision of the city pattern as designed by Ildefons Cerdà in the XIX century, and its width is slightly more than 20 meters [8]. The urban transformations that accompanied the Olympic Games in 1992 changed the role of this street in the urban hierarchy. From a traditional car-oriented road, it became a pedestrian-oriented public space. This was possible by modifying the car mobility of the street. In fact, the first and last part of the street is only for pedestrian use, as well as a large side street area in front of the buildings, where *dehors* and seating are populating the urban space.

Enric Granados has also a large open space, like a Mediterranean square, in correspondence of the crossing with Aragò Street, where one playground for kids and one for the *petanque* game cover the most of the area. Art galleries, cafés and bakeries connect the buildings with the people passing along the street, offering a quiet relaxing place, contrasting to the noising crowd of people and cars on the nearest main axes.

B. Forum

The area surrounding the Forum rises on the old industrial pole of Poblenou, an urban district that has been renewed during the end of the XX century and got ready for hosting in 2004 the Universal Forum of Cultures (Fig. 7) [34]. This area is a key-point of the city layout; in fact, it is where the Diagonal Avenue meets the Mediterranean sea.

Fig. 7. Fòrum de Les Cultures. Map source: Google Inc. Image source: Autors' own production.

The area is pointed by a number of new architectures, with building, skyscrapers and open spaces designed by very famous architects, providing a new character to the area. Actually, the area could become more attractive but it needs a renovation design. The Museu Blau, which is the Barcelona Natural Science Museum, is surely a starting point. Then, once the seafront will be completed, its accessibility could generate more curiosity and willingness to walk until the end of the area. Nevertheless, the connections between these interventions are lacking. The large paved esplanade provides a sense of incompleteness. No seats, nor trees, nor shadows, are shaping this open space, which appears not so much attractive for tourists, but neither for local people, who are mostly skaters and bikers. In fact, the size of the place and buildings, together with a general lack of facilities and attractions, make this area outsized for pedestrians.

V. Results and Discussion. Maps and Visualizations

The data from the CYBERPARKS app that have been used during this STSM provided a number of information which can be very interesting for analyzing the small design scale. Nevertheless, users were currently very limited and the outcomes were not reliable for a direct application.

Thus, the STSM focused on the use of Twitter data for identifying possible applications on the design of public spaces. The scale comprehends the whole city for understanding how the two case study areas relate to the rest of the urban space.

To start the analysis, the first step concerned the identification of available data on the two areas. Data coming from the CYBERPARKS App and from the collecting of Twitter messages were overlaid on a map providing different elements to consider (Fig. 8).

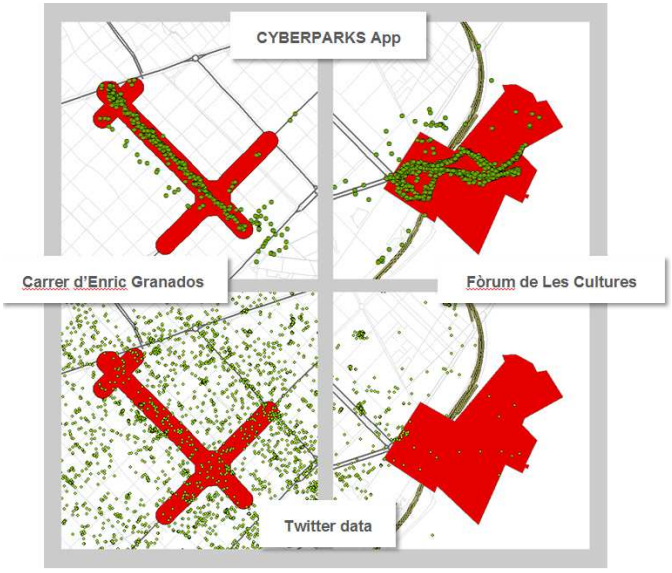

Fig. 8. Maps of data available for the two areas: GPS data form the CYBERPARKS App (on the top) and from Twitter messages (on the bottom). Image source: Authors' own production.

First, data from the CYBERPARKS App are very dense and provide continuity, so that users' paths can be easily identified, while Tweets are diffuse in both space and time dimensions. Second, CYBERPARKS App data are mostly located in the two areas, whereas Tweets cover the whole city / region /country / continent /globe. As a consequence, while the GPS app provides very detailed information on a place and on single users movements, Tweets can provide more general information on how a place can be hierarchized on the basis of different spatial and non-spatial elements. Third, CYBERPARKS users are aware that their data will be used for spatial analysis, while Twitter users' do not generally consider this possibility.

A. Tweets Density

The first map generated by tweets data shows the density of messages sent per walkable cell (a 400m x 400m cell, as defined by O'Sullivan and Morral [20]). The map represents the total amount of geo-referenced messages sent within Barcelona (Fig. 9) during the period January 7-19, 2015.

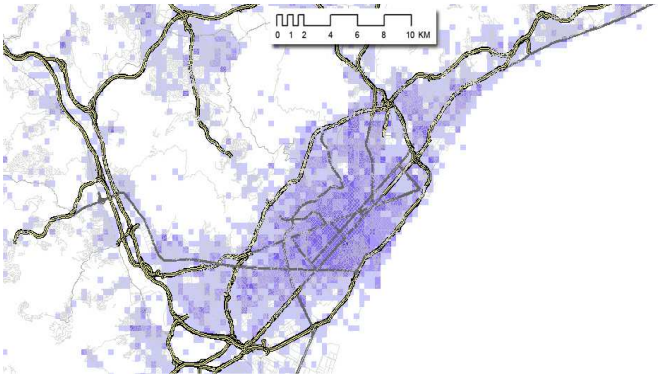

Fig. 9. The density of Tweets sent per walkable cell (400m x 400m). Image source: Autors' own production.

This kind of map can be very useful in highlighting the presence of particular place, such as touristic attractions, transport mode exchange hubs, or public spaces such as universities or shopping malls. Looking at the cells with highest densities, it appears evident the high concentration of tweets in the area of Plaça de Catalunya, which is the key-point for the public transport within, towards and outwards the city of Barcelona. Otherwise, it can also be used to highlight low density places, such as rural areas, natural places or abandoned areas within cities.

Although only a small part of demographics use Twitter, their number is so high to obtain an effective perception on the use of the city, providing spatial clusters which can be further analyzed, especially in their inter-relations.

B. Users' movements

The map below connects the tweets sent by each single user according to the temporal sequence. This map does not show the actual paths of users, but it connects all the places where each user has been (Fig. 10).

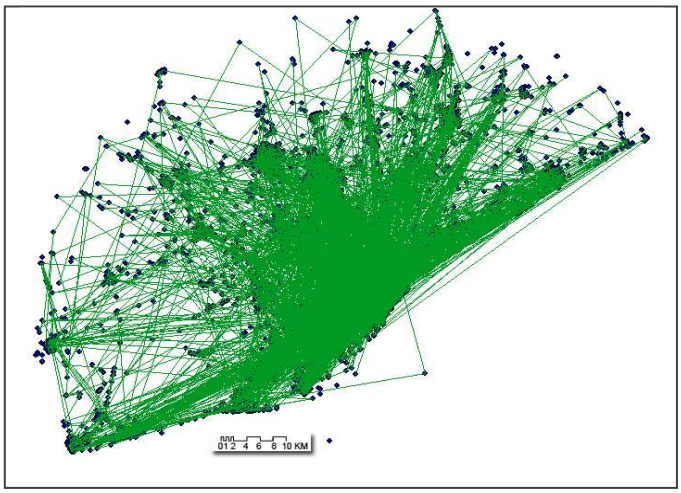

Fig. 10. Links between each subsequent tweets for each user over the whole metropolitan area of Barcelona, January 7-19, 2015. Image source: Authors' own production.

Although lines are not paths, it is evident the centrality of the city center and the direction of main axes outside the city. The same visualization has been realized considering only the users who tweeted from almost one of the two case study areas (Fig. 11).

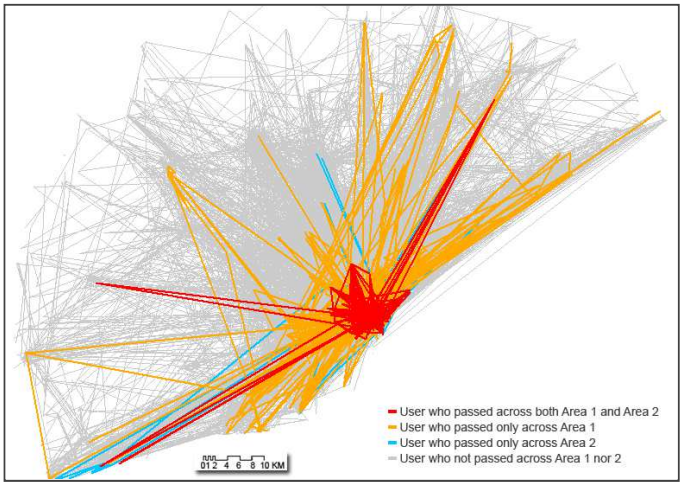

Fig. 11. Links between each subsequent tweets for each user who tweeted from one or both of the two case study areas in the period January 7-19, 2015. Image source: Authors' own production.

C. Road congestion according to Tweets

One interesting map can be generated using the subsequent Tweets location overlaid on the road network. Using the shortest-path algorithm, the lines connecting subsequent Tweets is superimposed to the actual road system, whose map has been downloaded from the Open Street Map (OSM) portal [35]. The higher the density of Tweets on the road, the larger will be the width of road line.

Similar to the example on Eric Fisher's maps [23], the map show the importance of some axis in the urban layout. Of course, this map will not be useful for planning a transport system, neither on mobility because railways and tramway

tracks were not considered, but it can provide other information on social behavior. For example, it is really interesting the high density of tweets on the road towards the university campus in Bellaterra (the red circle on the map, Fig. 12).

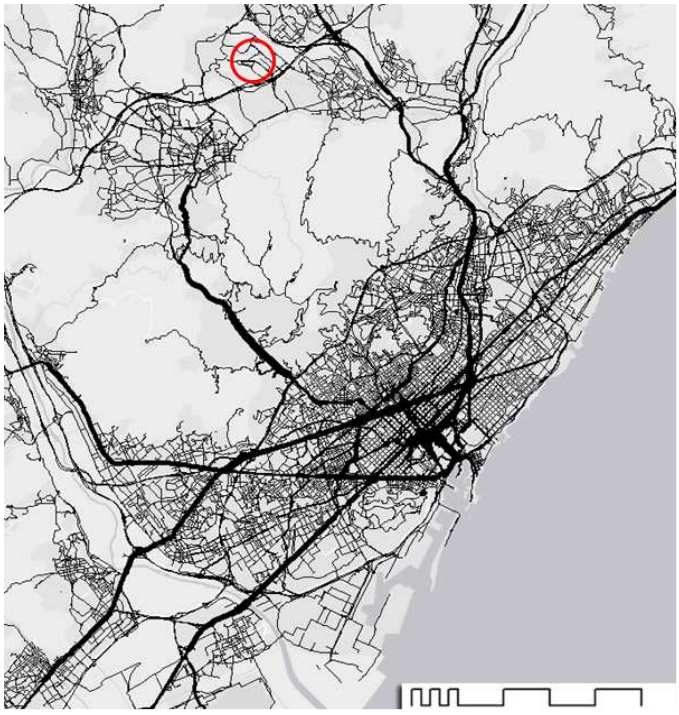

Fig. 12. Twitter Axis Congestion. The red circle is the Universitat Autònoma of Barcelona in Bellaterra. Image source: Authors' own production.

D. Week days visualization

This set of maps has been realized considering both the spatial and temporal information of subsequent tweets.

Splitting the Tweets according to the day of the week, it is possible to see if there are some sensible variations in the use of the space. Subsequent tweets are connected by semi-circular arches, whose radius is proportional to the spatial distance which separates each couple of tweets.

Thus, it is possible to see that displacements during Wednesday 14 have been shorter than other days, or that during Sunday 18, the activity around Plaça de Catalunya is significantly decreased in comparison to the rest of the week.

Using 3D arches instead of line laying on maps allows to connect distant points without providing suggestions on users' paths and preventing wrong information.

The visualizations consider only the Twitter users who have been tweeting from one of the two case study areas.

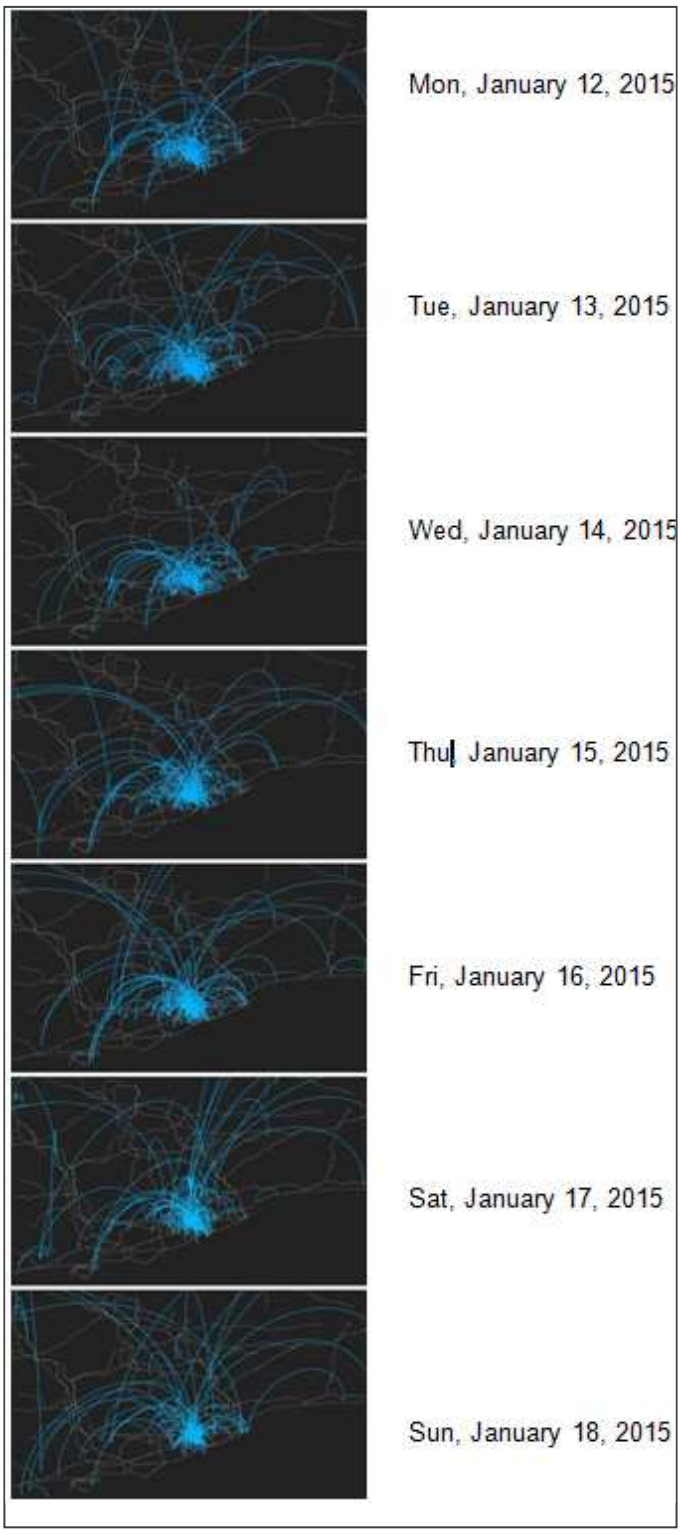

Fig. 13. Tweets sent day by day during the week January 12-19, 2015. Image source: Authors' own production

E. Daily hours visualization

Splitting the Tweets on the time steps which cover the 24 daily hours, it is possible to better understand the city life. In fact, the number of tweets increases during the evening, reaching a peak at 9.00-10.00 pm, as resumed by the radial diagram in the center of Figure 14.

To generate these views, all the geo-referenced Tweets between 7-19 January have been used, for a total amount of 103,404 Tweets.

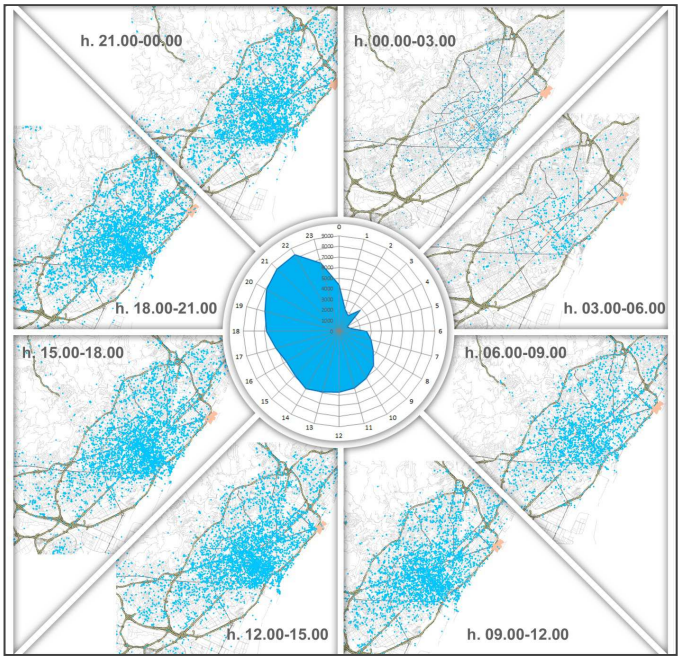

Fig. 14. Number and location of Tweets during the day. Image source: Authors' own production

It is particularly interesting to see how the city center and some specific axes remain active also during the night time, while other areas are practically abandoned.

Other possible visualizations concerning the daily hours have been realized using a three-dimensional visualization similar to that about the week days. However, differently from that one, the following visualization is dynamic (Fig. 15).

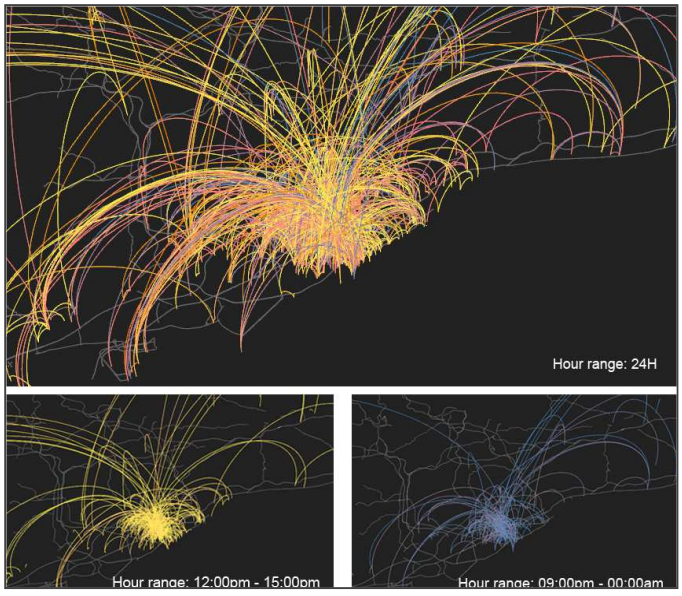

Fig. 15. Dynamic visualization of tweets during the day. Image source: Authors' own production

In fact, a sliding cursor allows the viewer to explore data and choose the range of hours to visualize or to view the sequence of tweets hour by hour.

This visualization has been realized using only the Tweets of users who passed across almost one of the two case study areas. Such kind of visualizations can be very effective for the analysis of land use and, in general, for decision and policy making processes. In particular, it can quickly express the concentration and sprawling of people over the urban area. The clusters of tweets can help identifying density of activities within the city.

F. Languages maps

The first log-in in Twitter makes users to choose a language. This setting can be known through Twitter free API. Therefore, maps concerning the language of users can be generated (Fig. 16).

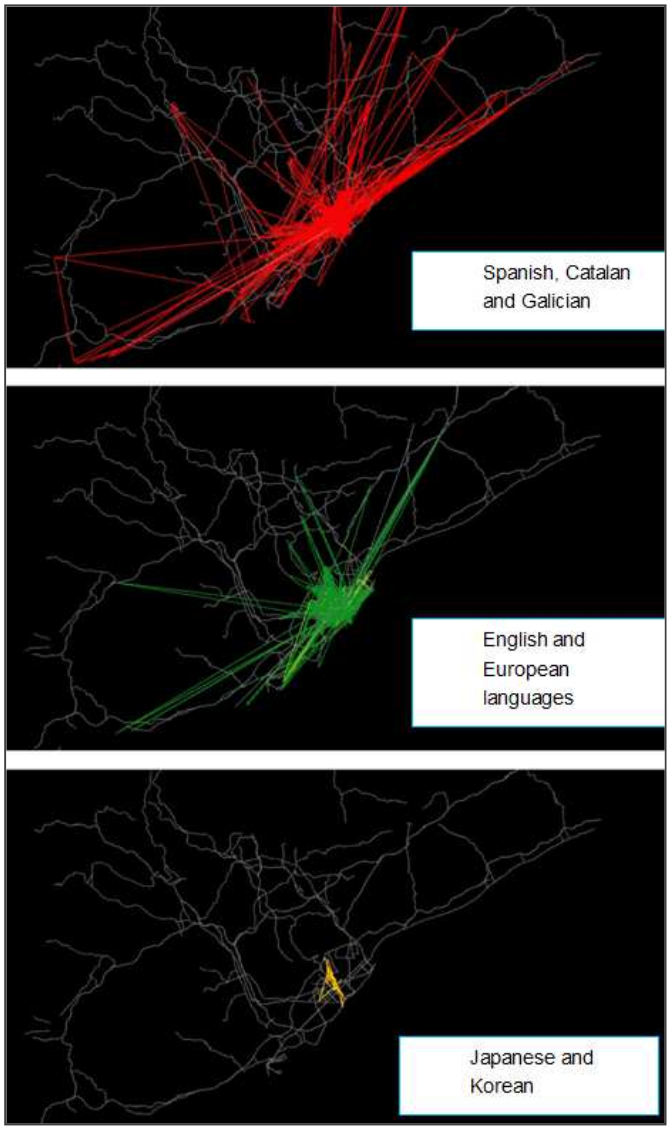

Fig. 16. Use of urban space according to Twitter users' chosen language. Image source: Authors' own production.

Using only the Tweets of users who passed by almost one of the two case study areas, these maps have been generated differentiating users by the chosen language of their accounts. The result is very particular, because it highlights the use of tourists from local people, outlining also some attitudes of tourists: higher is the distance they come from, smaller and more oriented towards famous arts and architectures is the area they visit.

VI. Conclusions and future developments

The brief overview on the state of the art shows how spatial planning is facing a transition to a new undefined status. The recent trend led by the "smart city" concept has opened the spatial planning to a logic of numbers and data. City-sensors as well as UGC systems constantly provide huge amounts of data which can be used to supply to citizens' demands.

In this context, two main branches are developing. The first branch is a data-oriented and technology-driven approach, which makes use of quantities for assessing and justifying decisions. Eye-catching visualizations are the most evident outputs of such an approach, where analysts and statistics prevail on the human experience of professionals and experts.

The second branch uses these new technologies to improve the human abilities and it is mostly used to support the decision and policy-making processes. Particular efforts are spent in understanding how data can support and be complementary to the traditional approach, providing new insights on spatial issues. The debate on the use of big data is nowadays shifting from a technology-driven vision towards a more human dimension, introducing the concepts of people friendliness and a human-to-human approach [36].

To achieve this social vision, the collaboration between different experts such as urban planners and data analysts and designers appears essential in order to guide them towards relevant questions and policy issues [31]. Then, the communication at different levels becomes one of the most important elements in structuring the planning processes. Simple visualizations can help in achieving this task, offering opportunity for both horizontal and vertical communication.

From a technical point of view, some considerations are necessary for improving future map production. First of all, paths created using subsequent tweets are just possible routes and probably not the real ones covered by users. A method for dealing with this issue is necessary. Secondly, the density of tweets on the two areas is very few. This implies that the use of Twitter data is most suitable for larger scale than the micro-urban areas. However, the continuity along space and over time can be useful for understanding the context of these urban areas, providing important element for considering their hierarchy position within the whole metropolitan/regional area.

Until now, the analysis has not considered the content included in the twitter messages. However, a method for obtaining the most used words, tags and receiver has been determined. In fact, a computational analysis of the text can provide further data on public space. For example, the filtering of tweets can be processed on the base of keywords related to public spaces (i.e. parks, architecture, fountain, dirty, clean, tree …); this can provides information on the specific places, but it can also provide suggestions in looking for efficient keywords and/or opinions from users.

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