Citizen as a Sensor: The Barcelona Urban Mobility Use-case

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Abstract

Recently, and with the penetration of the *smart city* paradigm, urban mobility is becoming an active research area. We are specially focused on the real-time urban sensing using citizens as data sources. The explosion of mobile technology permits the transformation of citizens in active and passive sensors increasing the amount of information of our scope of study: the city. The usage of citizens as sensors results in low-cost infrastructureless framework that not only profits from the mobile facet of humans but also from their common sense detecting anomalous situations. These aspects are treated in two different scenarios specific for the city of Barcelona: one that allows us to obtain information about the state of the public transportation network and the other that detects clusters of activity within the urban environment.

Problem solved/Need covered/Opportunity raised

Sensing the urban environment through citizens generates new opportunities in acquiring information using an infrastructureless platform for understanding urban flows in real-time.

Keywords

urban mobility, citizens as sensors, mobile, smart citizens, social media, crowdsourcing, gamification.

Introduction

Researchers from different scientific areas have worried about the dynamics of urban environments, specifically focusing of how humans transit the city.
Dedicated sensors have been installed in cities to capture some data and try to understand the behaviour of such complex system, determined by the aggregation of the individual decisions.

Moreover, in recent years with the explosion of mobile technologies citizens have been given the capability to continuously share information anytime anywhere. This ubiquitous and continuous sensing capability combined with the humans' "common sense" transforms any device-holder in a potential proactive intelligent sensor, which extends the classical continuous-

sensing sensors installed in a certain location with an specific scope.

In this paper we propose two complementary ways to exploit the human sensing capabilities in order to understand their mobility patterns in an urban environment; namely, the information extraction of social networks and the acquisition of more accurate position information through the use of gamification techniques. Moreover, we describe our experience and barriers encountered when deploying our solution with the goal of understanding urban processes such as the identification of transitory areas of activity and mobility patterns in the public transportation network (PTN).

Urban macro vision through social networks

Because of their popularity and geo-positioning capabilities, we opted to use Twitter as the first source of information. This social sensor provides us with information (in the form of geolocalized tweets) to observe and detect alterations of several parameters such as areas of activity, temporal patterns or mobility routes, which define the Urban Chronotype of the city.

Both processes of tweet-collection and analysis presented certain technical barriers that have been solved with the development of our Urban Sensing Platform. This platform ensures the acquisition in near real-time of all the tweets, without the requirement of any
private partnership with Twitter as commonly done by other researchers, allowing deployment in any system.Moreover, it is important to understand the role of people within the city to better understand their behaviour. Our platform has been enriched with a semantic-intelligence module that contextualize the geographical origin of users, obtained from their Twitter profile. Categorizing users as locals or foreigners with respect to the city of study allows for a detailed behavioural pattern analysis differentiating their urban habits.

We performed an experiment during the controlled and exceptional situation of the celebration of the Mobile World Congress (MWC) in Barcelona. Our knowledge about this specific event allowed us to compare the average urban chronotype of the city (in the normal state without external influences), with that obtained during the event, allowing us to observe different behavioural patterns within the city.The empirical results obtained have shown the behavioural patterns of the city in its normal state and during the event, where substantial differences have been observed in the areas of activity of the city after applying geospatial data mining techniques, determining the success of our urban social sensor.

Urban micro vision using citizens as sensors

However, profiting from the information proactively shared by the citizens in the social media applications only gives us access to a restricted subset of the potential information

that represents the urban chronotype of the city. Specifically, optimizing the urban public transportation network (PTN) in real-time is a research challenge intensively studied. However, to achieve such optimization it is necessary to have complete knowledge of the state of the network. Unfortunately, the transportation company's existing infrastructure does not provide complete information of the load of the network (in cities such Barcelona it is only controlled the access stations of travellers, but not the exits neither the load of the vehicles or the transportation lines), and the social media applications (as the previously used) do not provide the incentives for users to continuously share their position within the network.

For such reasons, and to obtain more accurate real-time information about the near real-time state of the PTN, we have created an ad-hoc sensor in the form of a app that profits from the sensing capabilities of travellers and, while open, continuously share the citizen geoposition (latitude, longitude and altitude) to our centralized server. However, we faced two problems: why will users open an app that sacrifices part of their battery life? and how can we obtain enough critical mass of users to make this crowdsourced sensor work? To solve both questions we have created an upper layer using gamification techniques. With a competitive real-time trivia-like game that incentives users to use our app: the game serves as an individual incentive to open the app, and the real-time competition with other users and friends ensures the virality and the long-term usage of the app.

With the gathered real-time data from the commuters of Barcelona we are able to understand the load of the PTN, obtaining also a commuter behavioural profile in the system in various situations (e.g. demonstrations, or unexpected incidents). Our modelization using a dynamic network data structure allows us to apply graph theory algorithms to optimize the behaviour of the system in several aspects and even build a route recommender system.

Results

If selected, we will add into the visual presentation the key findings with respect to the crowdsourced geolocalized information referred to Barcelona.

Urban Chronotype of the city during big events

During the MWC2012 we detected that the number of Twitter users providing the specific locations of their posted tweets was significantly incremented. Moreover, we could observe that the distribution of the origins of the users changed along the three weeks of the experiments, changing the number of tourists with respect to the locals.

GeoUsers Distribution

GeoUser's origin distribution
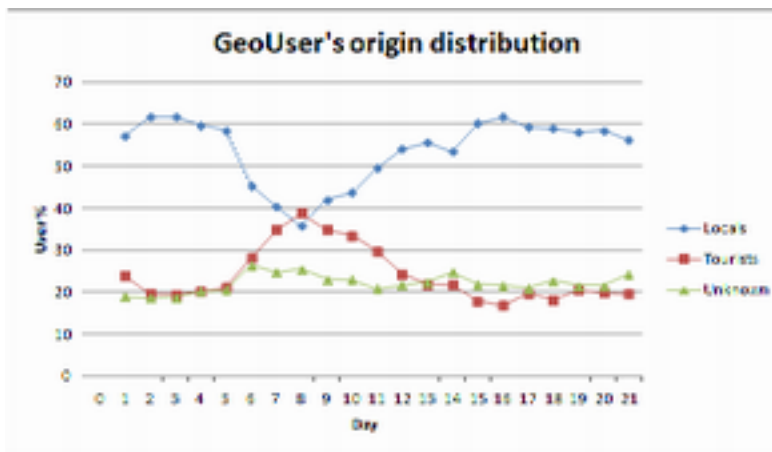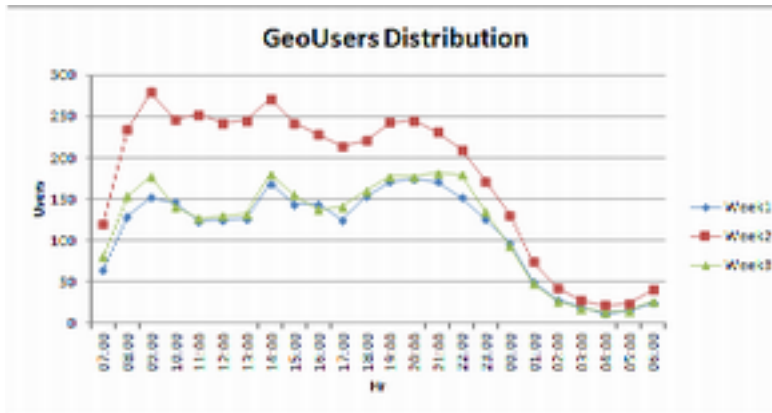
Urban Chronotype of the city in real-time

Patterns discovered through the Urban Chronotype of the city: The following figure shows the Twitter geo-localized messages clusters detected during the MWC. As an illustrative example, we can identify known areas of the city such as Las Ramblas, Sagrada Familia or Plaza España.

The Barcelona's public transportation network usage in real-time

Through a mobile application we are able to track the travellers into the Barcelona's public transportation network in real-time. We are gathering the public transportation flow through an observatory in order to model and understand the behaviours and patterns of the Barcelona commuters. We could observe in the figure the route of a commuter with the bus number 7.
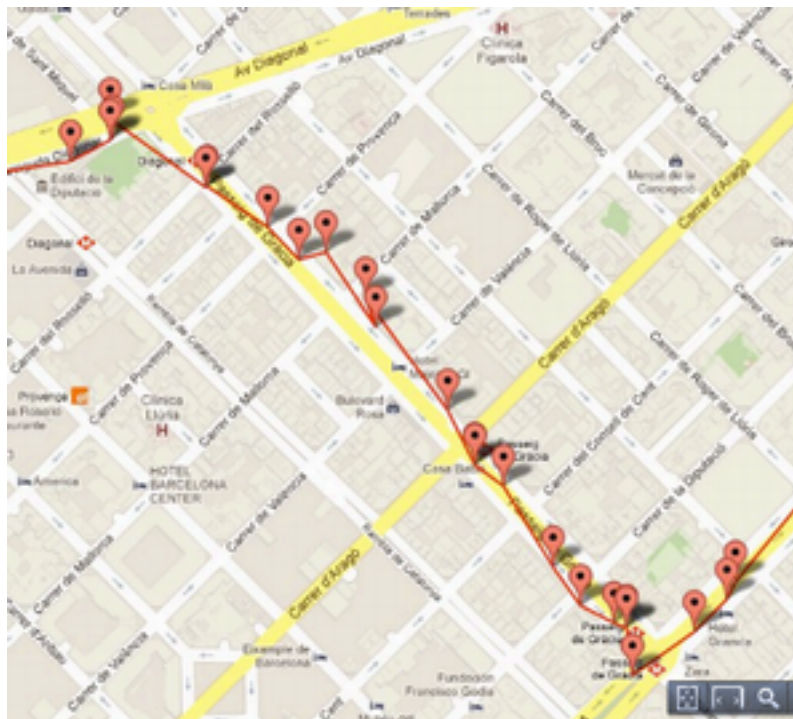
Behavioural patterns of the Barcelona's public transportation network

The observatory detects aggregated patterns and behaviour of the urban flows. The main goal of the observatory tool is the understanding of the public transportation network through crowdsourced information provided by their users.
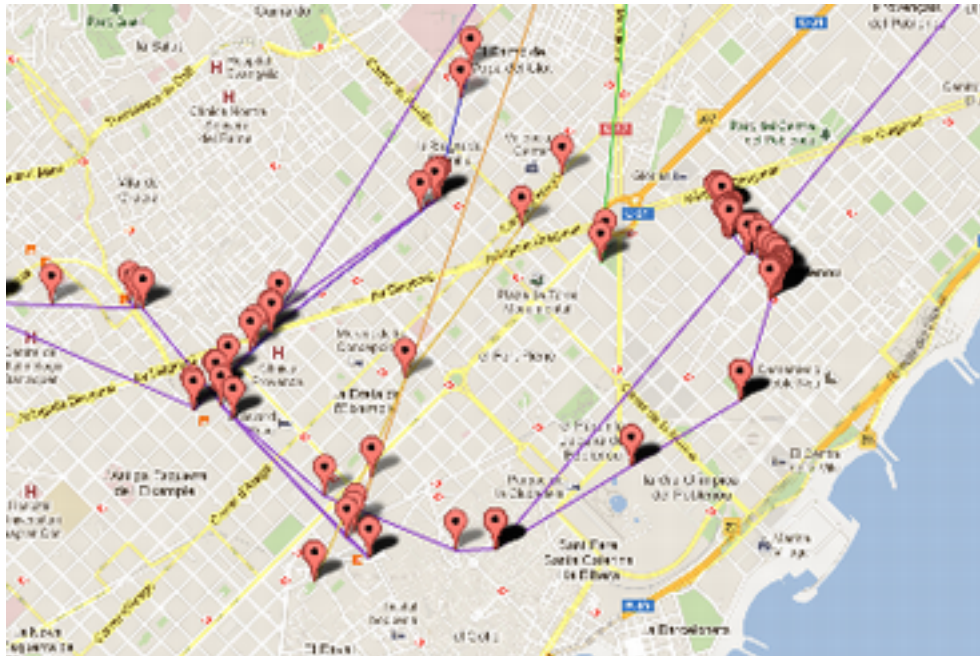
Conclusions

These two specific applications have given us different but complementing visions of the urban flows: a macro vision, captured from the proactively shared social media contents, and a micro vision, with dedicated apps sensing an specific subject such as the PTN.

Nowadays, the concept of smart city appears with a top-down vision where citizens receive the services implemented by the city and the government. As we proposed, the proper usage of the collected information would provide a more complete picture (micro and macro) with near real-time information of the object city allowing for a significant improvement of the urban performance, with no specific investment on hardware infrastructure. This idea is in alignment with the bottom-up paradigm (defended by other researchers such as Jane Jacobs, Usman Haque and Adam Greenfield) where build-up cities need the interaction of the citizens with the widespread use of their mobile devices and geo-positioned applications providing information of their environment in real-time.

Acknowledgements