Analysis of tourist behaviour based on the tracking data collected by GPS

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Abstract

In this short paper we develop an integral framework for the study of tourist mobility using GPS technology. After a review of tourism mobility research, this article introduces the two main elements of a visitor tracking technology developed by this research team: the methodology of collection and clean-up of data, and the analytic tools, using a web environment. Both aspects have been piloted in a visitor tracking project in the historical city of Tarragona, Spain, and could be extended and adapted to other destination types.

Keywords: Spatial analysis, Tracking, Tarragona, Global Positioning System

1 Background and research objectives

Mobility is unquestionably a fundamental aspect of contemporary life (Drummond et al., 2006) and leisure practices and should be a key object of tourism research. In spite of this, the difficulty of collecting data on the spatial behaviour of visitors (Meng et al., 2005) generally hinders the development of tools for a better planning and management of destinations, which actually consider how visitors move around and how they take their decisions in a space-time environment. On one hand, manual research techniques on visitor mobility prove to be hardly cost-effective and there are problems to develop visitor profiles based on them, for mere observation does not allow the gathering of qualitative data on visitors. On the other, they face relevant problems of privacy infringement.

This situation has radically changed with the development of a new generation of advanced tracking technologies (TT), detailed in various papers (Shoval & Isaacson 2006, 2007; Shoval, 2008; Spek, 2008) and in recently published books (Schaick & Spek, 2008; Shoval & Isaacson, 2010). Specifically, satellite communication (GPS), and the development of Geographic Information System (GIS) interfaces for this research, has greatly enhanced the capacity of collecting and elaborating data on human spatial activity and on the spatial behaviour of visitors in particular. We call this Advanced Visitor Tracking Analysis (AVITA). Linked with this technology development a number of experiences in tracking tourists are documented in the literature, implemented in different cultural and physical environments, at various spatial scales, as in Akko, Israel (Shoval, 2008), Loch Lomond and Trossachs National Park in Scotland (Connell et al., 2008), Gerona (Donaire et al., 2008) or Bilbao, San Sebastián and Vitoria, in Spain (Alzua et al., 2010).

This paper explains a step forward in tourism tracking analysis done by a joint research team between the PCTTO and the Department of Geography at the RV University. It is based in the previous experience acquired by a part of this team researching visitors spatial behaviour in Port Aventura (Russo, Anton Clavé and Shoval, 2010), Using data from visitors into the old city of Tarragona –a WHS located south of Barcelona- it develops an integral framework to get and analyse GPS collected data. This framework has been designed as a strong tool for tourism management that could be adapted to every destination. The objectives of this research are: the identification of the patterns of space mobility of visitors, in a global level and according with demographic variables (age, gender, profile, nationality…); analysis of space-time budget of visitors; the study the use of the main attractions in tourist spaces according with the daily cycle of visits and patterns of congestion and discovery of destination clusters based in segmented mobility.

This project was implemented as a pilot in the historical centre of Tarragona, a heritage city of prime importance, in the north-east of Spain including various tourist "sights" and cultural sites focusing on the Roman heritage. From the point of view of mobility and the specific characteristics of this study, it is a very peculiar space: though an openly accessible space, it consists of a walled historical conjunct, characterised by a limited number of entry points and a dense street-grid. This situation is not dissimilar from many other historical cities in Europe, like Venice, Bruges, Toledo, and many others, where spatial behaviour has been noted as one of the main issues determining inefficiencies in the use of public space and consumption – see for instance Russo (2002) for the case of Venice.

2 Fieldwork

The fieldwork of this project was based on control of every gateway in old city. In each, a control point was established, where GPS devices could be collected by visitors and given back at the end of the experiment in a given number of sampling days planned to represent the wider possible range of visitor types. Covering all accesses to the area has been conditional to the fact that participants' itineraries were independent from the experiment. The delivery process was planned into days of sampling. At the end of the visit the devices were recovered and qualitative surveys were performed, allowing a characterization of factors influencing spatial behaviour. Interviews focused on visitors' profiles (nationality, age, gender, lodging location and group types) as well as perceptions and memorable points of their visit. In 14 days of sampling, 436 surveys have been affected. Data depuration and spatial adjustment

Urban environments present a number of problems in the possibility to capture satellite data with sufficient coverage and accuracy. Multi-path errors also affect data collection by reflecting off surrounding terrains and so delaying GPS signals. This specific problem was solved through the design and implementation of an adjustment tool, based on basic assumptions about participants to the experiment:

- Inside the city walls, visitors can only move by feet, with an estimated velocity which does not exceed 15 m/s.
- Visitors' movements are bounded by the street-grid and walls
- The 10-second interval between two points of GPS data capture 10 seconds allows only a finite displacement.

Based on these premises, a "snapping tool" has been developed allowing the adjustment of spatial data, working in phases. First, raw GPS data are uploaded to a PostGIS database that reads and eliminates erroneous locations. The distance between p1 and p2, p2 and p4, p4 and p5 is about 50 meters, while p2 and p3 and p3 and p4 are separated by over 150 meters, so our tool removes the record (p3) that does not fit the first constraint.

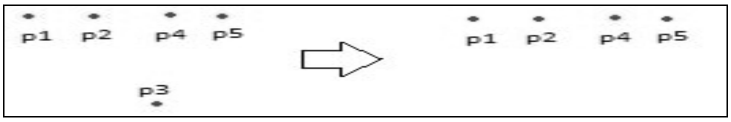


Fig. 1. Example of the filter

Secondly, we applied another algorithm to ensure that the assumptions are respected. To fulfill the first assumption, the filter adjusts the resulting points on the closest streets. This operation is made necessary by the scarce accuracy of GPS signals in the dense street-grid of Tarragona, which would at times situate people where there are buildings (a recurring problem in heritage towns). Figure 2 shows an example of this step. The "real" path followed by the tourist is the line; grey dots simulate the locations captured by the GPS and black points repositions them following the methodology described. In the example, the first four points as well as the last two have been "corrected". This is not the case with the other points that are repositioned in the next street, breaking the third assumption.

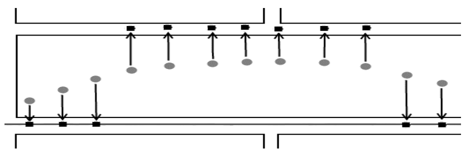


Fig 2. Repositioning directly to street

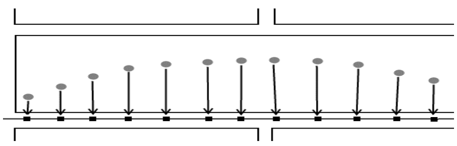
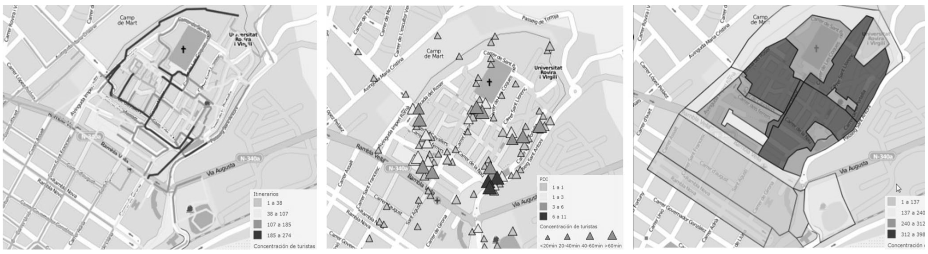


Fig 3. Point repositioning to nearest street.

To solve this problem and enforce the second assumption, we introduce a rule to reset the points. This condition rests on a test that the street next to the current point is connected to the street above. If the test is negative, it means that tourists would have had to cross a building in order to switch their path. This new street has to be a street near the current point and connected to the street before. In figure 3 we see the result of applying this algorithm fixing the problem.

3 Pattern Analysis

The analysis of the spatial data collected and depurated following the method detailed in Section 3 generates knowledge about the space-time behaviour of visitors. In this paper we focus on the development of a web interface tool, which enables to analyse data in real time (with daily updates), facilitating decision-making based on this knowledge. Different objectives are taken into consideration at this stage, and managed with proper tools. The first regards *itineraries*; the analytic tool can be used to know the routes followed by the visitors, globally or by visitors' segments (based on socio-demographic and/or time-specific variables - Fig. 5a). The second regards *nodes*; the analytic tool allows a visualization of the routes' intersections that concentrate the largest numbers of visitors, and the dominating trends in directions taken. This information is complemented by a table which gives details of the streets and the main flows. The third regards congestion; it is possible to visualize, globally or by segments, points with the largest congestion, which also yields information about the most attractive elements in the area (Fig. 5b). It also illustrates different area concentration values (global or segmented) based on functional polygons (commercial, restoration, museum…) (Fig. 5c) or absolute concentrations. These tools run in a web interface that can include other functionalities



(a) **(b)** **(c)**

Fig. 5 Visualization of the results of the analysis

4 Conclusion

This paper has illustrated how advanced visitor tracking could be organised and implemented as a fundamental research tool to improve destinations management. From this point of view our paper nuances a series of features which have strong commercial potential for DMOs of a wide range of tourist regions, and consequently for technological suppliers and research institutes. The research design showed the need to develop different experimental "logistic" procedures depending on the type of tourist environment and the focus of the research. In any case, though advancements in the method of the analysis of data are replicable, the success of each experiment relies on the development of a specific process of collection. Currently this team is implementing other tests in different destination types, which will eventually lead to an improvement and generalization of the methodology. In conclusion, this research is based on the need to "test" the adaptation of the tracking visitors in enclosed areas to open destination regions. It is therefore reasonable to expect that the application of AVITA in this kind of destinations will be groundbreaking.

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