Monitoring Impacts of Visitors with Aggregative GPS Data

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Abstract. Recent technological developments have produced a range of sophisticated and readily available digital tracking technologies, of which the best known is the Global Positioning System [GPS]. Yet, despite this remarkable surge in technology, researchers in the field of tourist studies have failed to take full advantage of what these relatively new systems have to offer. Tracking technologies are able to provide high-resolution spatial and temporal data that could potentially, aid, augment, and advance research in various areas in the field of tourist studies. This article present the possibility to use aggregative data obtained from GPS receivers in order to better understand the impact of visitors on destinations. The data presented in this paper were collected in three different locations: PortAventura amusement park and the Mini Israel theme park (two enclosed outdoor environments) and the Old City of Akko in Israel (a small historic city).

Keywords:. Historical Cities, Theme Parks, Pedestrians, Tracking, GPS.

Introduction

Tourism in general, and in cities in particular, is a growing sector. Much urban tourism, researchers find, is concentrated in well-defined areas within the city. Leisure and cultural tourists are spending more of their time in the CTD (central tourist district), an area that usually includes a historic city center as well. Business travelers spend more of their time in the CBD (central business district) and in conference centers. Due to the increasing numbers of tourists, the spatial activities of tourists throughout different parts of urban centers are some of the forces that shape city centers as we know them today.

Tracking technologies present a great opportunity for the study of the impact that tourism has on urban centers and urban systems, as a result there is growing literature that documents the implementation of those technologies in tourism research [1], [2], [3], [4], [5]. Data collected using these technologies are more exact and can be gathered with greater ease and on larger scales in comparison with the time-space data that have been available until now.

One approach when looking at the data collected is to put the tourist in the center of the discussion and present the ways in which the analysis of time-space data

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collected using advanced tracking technologies can contribute to understanding the tourist's spatial activity throughout his or her visit to a destination. However, in this paper we use another approach. We look at time-space data collected using advanced tracking technologies but place the destination at the center of the discussion, enabling a greater understanding of how spatial activities of visitors generate different space throughout the location at different times and how visitors consume the destination itself.

The data presented in this paper are aggregated figures that present the combined activity of many visitors in time-space throughout a destination. Such analysis can facilitate decisions such as where to set up new attractions and where to promote private-sector tourist services. This different angle opens many new points of view and questions that can now be addressed using high-resolution spatial data; these were virtually unobtainable using the traditional methods of data-collection on spatial activity.

New possibilities that arise include estimating the physical carrying capacity of attractions throughout the destination and of the destination itself; locating areas that remain out of the scope of the tourists' routes and that have unrealized potential that can be developed; and determining the effect that the time of day, weather, days of the week, and the seasons of the year have on the spatial consumption of the tourist destination.

Tourism, especially activities located within urban areas, which comprise a large percentage of the tourism industry, could greatly benefit from the kind of digital tracking methods that are able to trace pedestrian routes over long periods of time and, additionally, can do so both accurately and consistently. This is because the business, commercial, and leisure activities of most cities are largely concentrated in the city center, which is thus distinguished by high levels of pedestrian movement. This is true even in more developed urban economies, which have seen a move of business activity to the periphery in recent years; the town center in these remains at the heart of the town's social, cultural, and administrative life [6].

The cases discussed in this paper use GPS technology. The data is collected by distributing GPS devices to visitors at a destination. This data can be downloaded from the devices when they are returned at the end of the visit and can also stream into the system in real time using cellular communications to transfer the data.

Aggregative Data Obtained from GPS Devices

Below we present some results from studies that were carried out using GPS receivers in three different locations: PortAventura amusement park and the Mini Israel theme park (two enclosed outdoor environments) and the Old City of Akko (a small historic city).

1.1. PortAventura

An example of an exploration of aggregative time-space activities of visitors within a destination is a study that was conducted in the PortAventura amusement park. The project was a joint venture of the Universitat Rovira i Virgili School of Tourism and Leisure, the Hebrew University of Jerusalem, and the theme park itself.

PortAventura theme park is located in Catalonia, Spain, next to the holiday resort of Salou, approximately one hour's ride south from Barcelona. Though identified with Universal Studios, the park is owned and operated by the Caixa banking group, which bought Universal Studios' shares in the park in 2004. Adjacent to the park are four hotels operated by the park and many others that are privately owned. In recent years, the park has exceeded four million visitors annually.

1.1 Park Structure

PortAventura is divided into five thematic areas. Each area represents a different geographic region and is designed according to the landscape and cultural characteristics that distinguish that location. The thematic areas are: the Mediterranean, Polynesia, China, Mexico, and the Far West. The Mediterranean area is located at the park entrance, while the other four areas are arranged in a circle. This means that a visitor who arrives at the park has to cross the Mediterranean section and then decide whether to circle the park from the right, starting from Polynesia, or from the left, starting from the Far West (see figure 1).

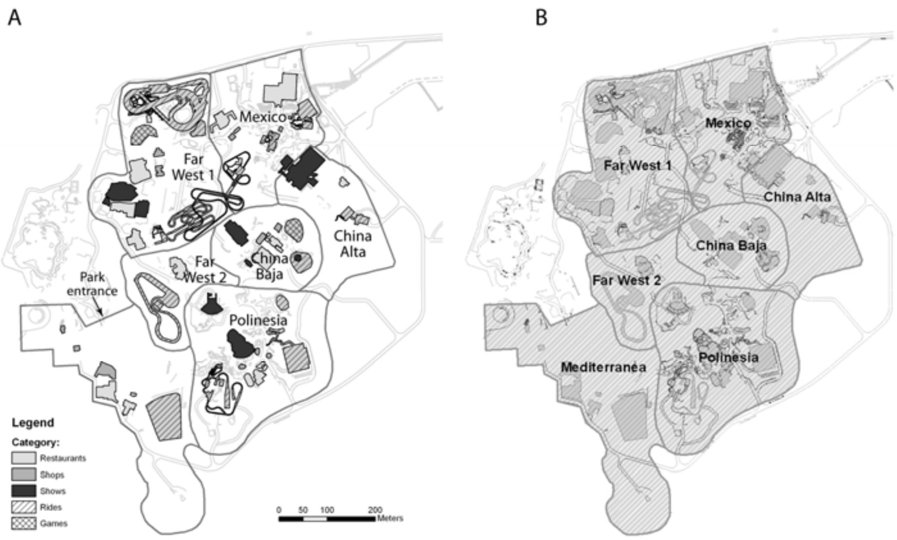

Figure 1: Map of PortAventura theme park

1.2 Fieldwork and Sampling

The fieldwork for the PortAventura study was conducted in two phases of one consecutive week each. The first phase took place during the spring of 2008 and the second phase during the summer of 2008. The sample was restricted to families with young children. Of the 288 families who took part in the study, 277 families were included in the final analysis (96 percent). Three different types of data were collected for each family using three different data-collection methods:

- Visitors' socio-demographic and personal data were collected by park employees at the park entrance using a conventional questionnaire.

- Time-space data were obtained from the GPS devices, which were set to sample the location of the visitors every ten seconds.
- Data regarding the visitors' decision-making were collected using designated software. When visitors returned from the day at the park, GPS data were automatically processed, and a table specifying the park sites visited by the families was produced. This table allowed the interviewers to question the visitors as to their motivations and decision-making processes during their visits.

The sample of visitors who were asked to participate in the research was restricted to families with young children. This choice was motivated by the fact that a small group was needed to make the sampling statistically significant, and that this group was of interest to the park management.

There were a total fourteen days of sampling in two rounds of one week each, in April and July 2008. Twenty GPS loggers were used. A total of 288 GPS tracks were recorded and 254 interviews were conducted by the park's staff. The missing interviews were primarily due to the fact that the park did not have staff available to interview all of the participants in a timely fashion. Before the study began, the park's management hoped to interview approximately one quarter of the participants; the results far exceeded everyone's expectations.

Information collected from eleven participants was excluded for the following reasons: four participants carried devices that turned off during their visits; six participants had devices that did not function properly and thus the spatial data were incomplete; and one participant who participated was mistakenly included (he did not meet the inclusion criteria). The size of the final sample used for analysis included 277 participants, or 96 percent of the total sample.

The external conditions within the park differed between the two phases of research. The park was open for nine hours a day in April (10:00 a.m.–7:00 p.m.) and for thirteen hours a day in July (10:00 a.m.–11:00 p.m.). In April there were low temperatures with light showers from time to time and in July there were high temperatures with one day of extreme weather conditions that included heavy rain in the afternoon and evening.

1.3 Time Distribution

Figure 2 details the average amount of time the participants spent in various parts of the park. The first thing that the reader notices when looking at the diagram is the striking imbalance in the integrated amount of time spent in each zone and the relation between the time spent in the different areas.

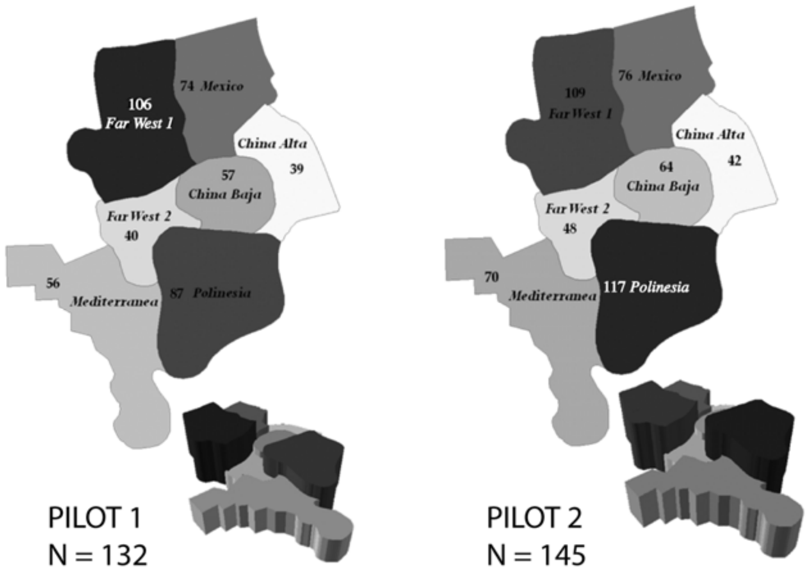

Figure 2: Average length of stay (min.) of all visitors in the park's thematic areas

The subjects spent the most time during the first pilot, in the Far West section of the park (Far West2). The extra time that the visitors had in the second phase due to the longer opening times was mostly spent in Polynesia. This is a very interesting finding. One would think that the time that was added to the visitor's time budget as a result of longer hours of operation would either be divided evenly over space or divided over space in proportion to the popularity of the zone. Knowing that most of the additional time allocated to visitors is spent in one zone has great importance for the park's management, which must allocate employees throughout the park and needs an understanding of how to deploy its staff in the most efficient way. These findings are very useful when considering the operation costs incurred as a result of the longer operation hours.

If a city were studied in a similar manner, the results obtained by analyzing the way in which space is consumed could help the city's tourist authorities formulate a more reasonable tourist planning policy: a policy aimed at managing tourist flows in a more rational manner, a policy deliberately designed to relieve the burden from the town's more congested areas, both at set times and in general, by, among other things, encouraging tourists to explore other, less crowded sites. The result of such a policy would be a more equally distributed pattern of tourist temporal and spatial activity, one that could benefit both tourists and the town as a whole.

1.4 Temporal Cycles of a Destination

Figure 3 shows where the participants spent their time throughout the cycle of a day at the PortAventura theme park in each of the two phases of the study. The longer opening hours in the second phase can be seen on the x-axis. These graphs were created using the map of attractions produced by the park's management. The map contains five different types of attractions: rides, shops, shows, restaurants, and games. Each attraction was represented using a polygon shaped to include the waiting line for the attraction and the area of the attraction itself. This is important because many of the rides are very fast and locating the participant riding on a roller coaster can be difficult if the participant does not spend time waiting on line.

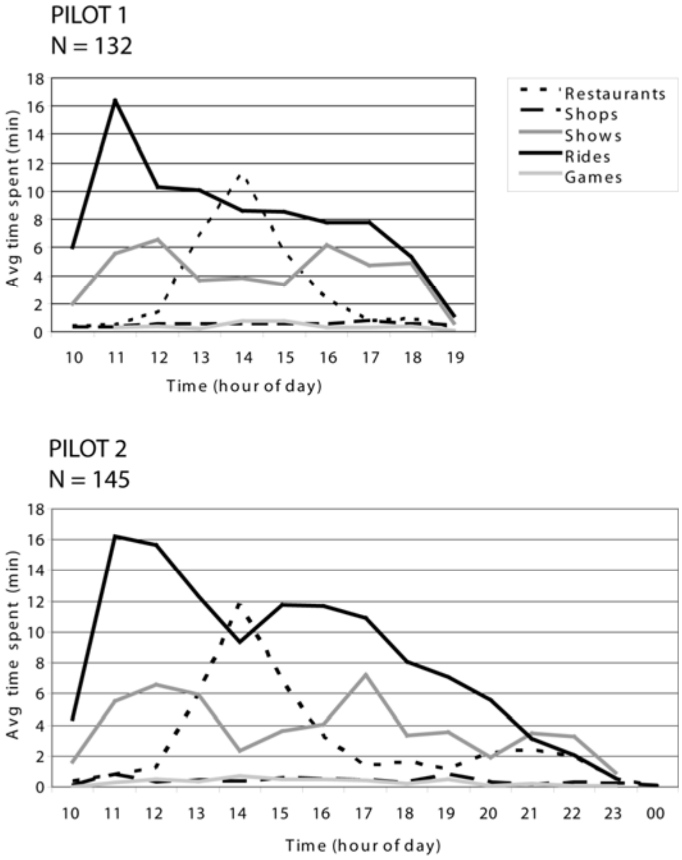

Figure 3: Visitors' time budget by hour of the day, PortAventura

The total volume of activity was at its highest shortly after the park opened and all of the GPS devices were distributed. As the day progressed, the total volume of activity diminished as people slowly left the park. Both figures show a similar pattern: people enter the park and rush to get on rides, resulting in a peak in the ride graph. As the day progresses, people spend less and less time on the rides. The restaurant graph shows a clear peak at lunchtime during both phases and another much smaller increase at dinnertime during the second phase when the park was open until midnight and people ate their dinner there. Peaks in the show graph can be explained by the schedule that most of the shows follow (some shows are open all of the time and people walk in and out as they please). Both games and rides display very low volumes of activity. This may have nothing to do with the actual spatial activity of the participants; it may be linked more with the limitations of the GPS technology, which had difficulty locating participants within the very small store and game polygons. In addition, the stores were mostly located within built structures, making for a more challenging environment for the GPS.

2. Mini Israel Miniature Park

Mini Israel is a park located in Israel, midway between the capital, Jerusalem, and the economic center, Tel Aviv. The park hosts hundreds of miniature models of key locations in Israel. The layout of the models in the park does not reflect the physical structure of the country; rather, the park is shaped like a Star of David.

A study of the time-space activity of visitors to the park was carried out in the summer of 2006. During the study, visitors to the park were approached and asked to carry GPS units with them throughout their visit. The park is outdoors and has very few buildings; it is therefore an ideal location for using GPS technology.

The data obtained in the study were used to create a typology of the use of the parks by visitors. Four categories of the areas in the park were created based on how those areas were used by visitors. This analysis is presented as a demonstration of a practical tool for understanding the spatial activity within a destination and managing the way visitors flow through an attraction.

To carry out this analysis, the area of the park was divided onto a raster (a grid); each cell was sized at 2 x 2 meters. The number of visitors that passed through each cell in the grid was counted. The cells in the grid were then classified into two categories: high-traffic cells and low-traffic cells (figure 4A; high-traffic areas are dark and low-traffic areas are light). At the same time, another raster was calculated. In this raster, the average length of a visit was calculated for each cell. As with the first raster, the results were divided into two categories, cells with long average stays and cells with shorter average stays (figure 4B; cells with high average stays are dark and cells with low average stays areas are light).

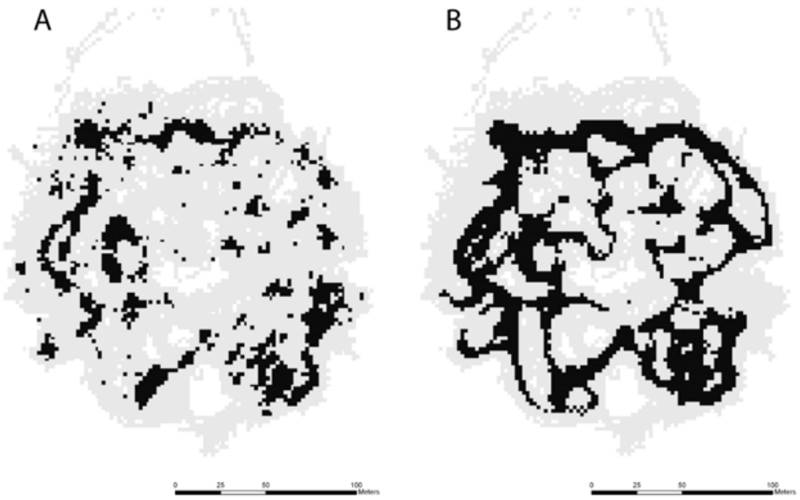

Figure 4 (A): Classification of cells into high-traffic and low-traffic cells according to the amount of people that passed through each cell

(B): Classification of cells into high average and low average according to length of stay

Combining both categories using the criteria presented in the table below resulted in a grid with four categories. The categories are displayed in figure 5. Each category explains the way that the visitors to the park used its space. Some areas in the park are used as corridors through which people pass but do not spend time; other areas serve as basins that channel the flow of people into them.

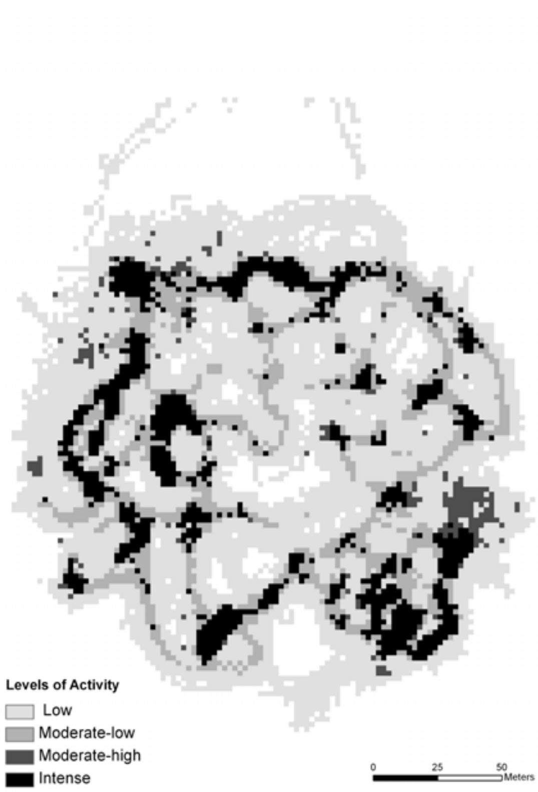

Figure 5: Classification that reflects the usage of the space throughout the Mini Israel park

Table 1: Cell classification, defining activity in each cell

	Low-traffic Area	High-traffic Area
Short Average Stay in Cell	Low activity, low traffic, and short stays.	Moderate–low levels of activity, high traffic, short stays.
Long Average Stay in Cell	Moderate–high levels of activity, low traffic, long stays.	Intense activity, high traffic, and long stays.

3. The Old City of Akko

Akko is one of the world's oldest continuously inhabited towns in the world. In 2002, UNESCO added Akko's Old City to its list of World Heritage sites, bringing it to the attention of the international tourist market and prompting Israel to devote more resources to the town's development.

3.1 Visitors' Impact and Management Implications

The GPS devices carried by the experiment's subjects throughout their entire tour of Akko's Old City were used to collect data on the subjects' locations. They did so by registering the precise location and exact time each location was logged. This spatial-temporal information was recorded at an extremely high level of intensity: one location per second. This meant that if, for one reason or another, the GPS satellite signal was blocked, as is often the case in dense urban environments, it was possible to reestablish a connection, and thus obtain a reading, the moment the device acquired a direct line of sight to the satellite system; this in turn meant that any breaks in the track sequences were reduced to an absolute minimum.

The aggregate analysis analytical approach looks at the subjects' effect on the city or how the city is "consumed." Based upon aggregate data rather than single observations or clusters of observations, such a city-centered analysis can be used to indicate which are the more popular sites and neighborhoods in a town and which tend to be neglected; or, alternatively, which of the town's routes are well worn and which remain virtually unused.

The data obtained using the GPS devices were analyzed in aggregate. Such an analysis, which ignores the individual visitor, serves to reveal how the urban space is exploited or "consumed" by all tourists. In our case, the high-resolution data provided by GPS were used to create a "pixilated" map of Akko, which highlighted just how the town's urban space was consumed. The spatial consumption was measured by percentage of time spent in the different locales plus the intensity of activity per cell of a size of 10 meters x 10 meters, which is two times above the average accuracy of the 5 meter accuracy of the GPS units used in this study (see figure 6).

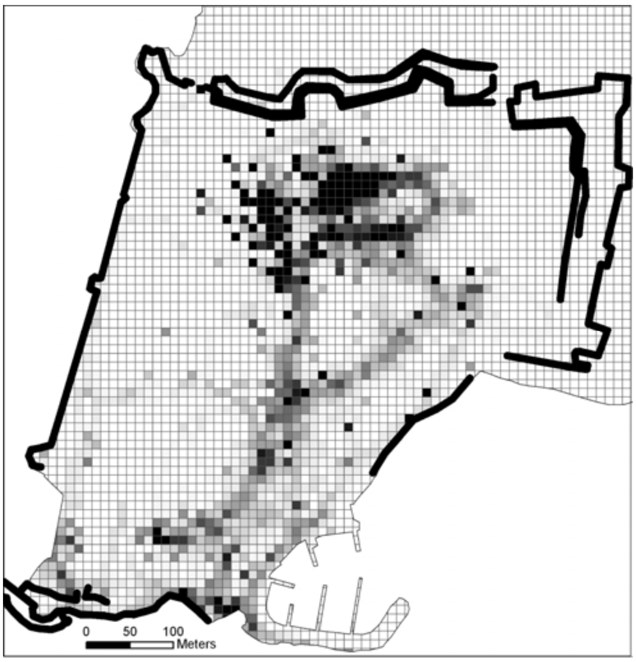

Figure 6: Tourist activity in Old Akko—two-dimensional

3.2 Pixelating the Town

Another means of examining temporal and spatial behavior in aggregate, one which similarly exploits the advantages of the GPS system in terms of providing accurate and high-resolution data, consists of dividing the town's urban space into squares and counting the total number of signals picked up by the GPS receivers per square. Obviously, the size of the grid's squares depends on the size of the urban space studied, with larger-scale studies requiring larger squares and smaller ones smaller squares.

Before it is possible to begin the discussion on three-dimensional visualization, it is important to note that in this chapter the three-dimensional visualizations are actually pseudo-three-dimensional figures. The figures are rendered in a way that gives the illusion of a third dimension but, since they were created on a computer screen and printed on paper, this remains an illusion only.

Adding a third dimension opens new possibilities for plotting time-space data. Before discussing the main contribution that the third dimension allows for (i.e., for representing time, as discussed in the literature review) we will present a group of figures that use a third dimension to represent factors other than the time that has passed (Figure 7). The third dimension, along with the color that was used in the two-dimensional figures, can help the researcher to understand the different amounts of time that each unit represents. Adding a horizontal dimension helps the researcher to understand the difference between the different quantities; this is made possible due to the fact that height is a scalable dimension while color scales are much more difficult and less exact for the human eye to interpret. This technique of plotting is very effective in studying the general impact that spatial behavior has on the location being studied.

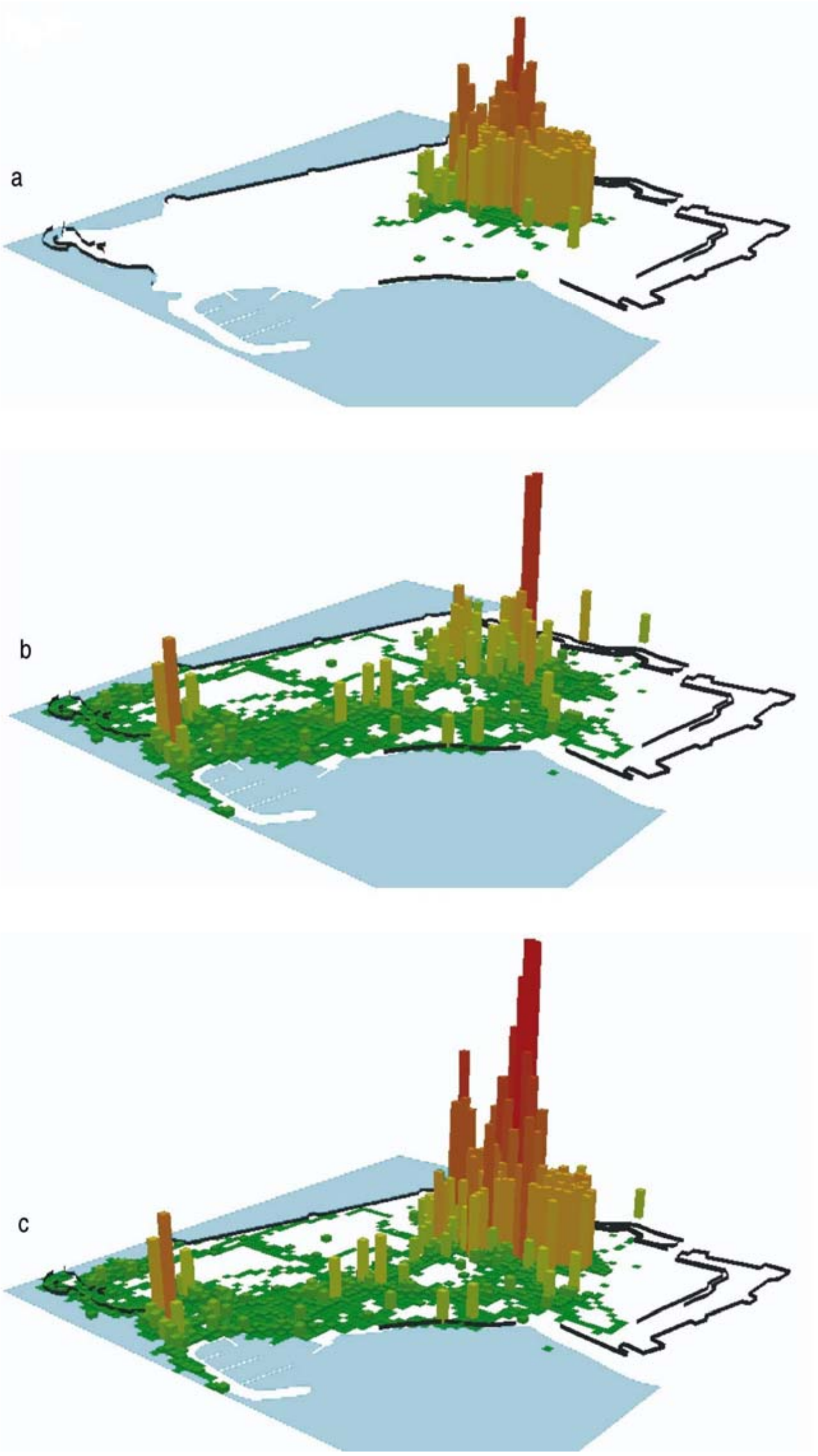

Figure 7: Tourist activity in Old Akko—three-dimensional

This technique allows the researcher to distinguish between “Hot Spots,” locations that are well-exposed to the visitor; “Not Spots,” locations that do not exist for the visitor and are not visited at all; and transition areas through which the visitor passes but does not stop to spend time. This technique analyzes all of the time spent in the city and therefore is useful for learning about the city; however, it is not effective as a tool for shedding light on individual tourists.

Figures 6 and 7 depict which areas in town boast high levels of concentrated tourist activity and which plainly suffer from a dearth of tourists, darker colors mean more intensive levels of activity. Indeed, viewed as whole, the map exposes a marked spatial imbalance between the town’s sites, an imbalance rooted in the way Akko’s tourist industry developed over the years. Of all the columns in figure 7c, the most prominent column is located in the area containing the visitors’ center, the underground Crusaders’ Halls, and the Turkish Bath House.

The figure also reveals which of the possible routes linking Akko’s various centers of activity are the most commonly used. Apparently, most visitors to Akko tend to move in a southerly direction: setting off from the visitors’ center and ending up, by way of the local market, at the Templars’ Tunnel and the restaurants alongside the marina. Once the subjects who only visited the Crusaders’ Halls are weeded out from those who explored the town’s other sites as well, the resulting diagrams’ topography, not surprisingly, changed. Thus, figure 7a, based solely on the sequences of those subjects who limited their visit to a tour of the visitors’ center, Crusaders’ Halls, and Turkish Bath House complex, contains a single concentration of fairly tall columns; while the topography of figure 7b, based on the remaining sequences, is, predictably, much more diffuse.

Tourist flows in Akko’s Old City are dispersed unevenly throughout the town’s various locales, with a great many visitors venturing no further than the visitors’ center, the Crusaders’ Halls, the Turkish Bath House complex, and the Templars Tunnel—all sites run by the Old Acre Development Company. These findings, it should be noted, match those obtained by other similar studies, which also analyzed the spatial activity of tourists in small historical areas.

Conclusion

The study of visitors’ time-space activity in the various destinations presented in this chapter added to our knowledge of spatial and temporal behavior of visitors. This knowledge can and should be exploited to better regulate tourist flows throughout the destinations studied.

Thanks to the GPS- or cellular-derived information, tourists may now be encouraged to visit previously deserted parts of a destination, from the scale of a miniature park to the national scale. Tourists can be prompted to visit popular attractions at specific times in order to reduce congestion and to allow them to fully benefit from their time in the city. Such information can also facilitate decisions as to where to set up new attractions and where to promote private-sector tourist services. In each and every case, the result of research will be the reduction of congestion in hitherto overcrowded, over-exploited areas and the general enhancement of the physical and social carrying capacity.

Lew and McKercher [7], [8], have suggested that urban tourist flows clearly have a tendency to spread themselves unevenly, both spatially and temporally. As a consequence, while the more popular sites and access routes in a destination often suffer from over-crowding and severe congestion, others are severely under-exploited, a state of affairs that points to a grossly inefficient use of economic and social resources and one which is ultimately unsustainable as well. There is clearly an urgent need for tourist management schemes designed to maneuver visitors around destinations in a more rational way. Such schemes would doubtless benefit from tracking-technology-based studies that are a remarkably efficient means of collecting a mass of high-resolution data on the spatial and temporal behavior of tourists.

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