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THE GPS REVOLUTION IN SPATIAL RESEARCH

INTRODUCTION

In recent years, the rapid development and availability of small, cheap and reliable tracking devices has led to a growing amount of spatial research using such technologies. GPS devices offer researchers the opportunity for continuous and intensive high resolution data collection, never before possible in spatial research. The ability to collect time-space data in such high resolutions in time (seconds) and space (metres) for long periods of time opens up the possibility of drawing new lines of inquiry and creates opportunities to formulate new research questions that could not be previously asked. Could the potential impact of tracking technologies in the spatial sciences be compared one day to the impact of the introduction of high-resolution digital platforms in other fields, such as MRI in medicine, the electron microscope in chemistry and biology, or the Ikonos earth observation satellite in remote sensing? Perhaps this 'prophecy' is a truly wild exaggeration, but perhaps not.

Although there is a Russian GPS Global Positioning System (Glonass) in operation, the best known and most commonly used is the United States Department of Defense's (DOD) GPS, officially referred to as NAVSTAR: Navigation System with Timing and Ranging. Both systems were originally conceived as military navigation systems. The American system became fully operational in 1994 (Kaplan, 1996); it was initially available to military personnel only, with the DOD deliberately degrading the satellites' civilian signal in order to deny civilians access to its system. In May 2000 the DOD terminated, as it was known, the Selective Availability (SA) procedure, opening up the system to individuals and for commercial applications across the globe. In recent years, GPS devices using the American system have become relatively cheap. They have various uses in civilian navigation, and GPS has become an embedded feature in many new cellular phones (also chapter 3).

GPS is a one-way broadcasting system. The satellites send a signal, which is then picked up by essentially 'passive' receivers (Zhao, 1997). This means that in order to track the device, it must be able to send data via an external communication protocol (for example via SMS or GPRS). Alternatively, the device could have the ability to store the obtained locations in time and space on an internal hard disk or a memory card that will later enable data retrieval. The accuracy of Global Positing Systems varies greatly and is dependent on the nature of the terrain, (open rural as opposed to dense urban), weather conditions and the extent of the GPS receiver's exposure to the sky. The receiver will provide an accurate reading only if it is directly exposed to the satellites' signals. Any obstruction, regardless of whether this partially or fully blocks the signal, can result in an imprecise reading. However, a regular GPS device can obtain a location with a deviation of about 3-5 metres on average (Shoval & Isaacson, 2006).

At the time of writing (January 2008), a whole new generation of GPS receivers have just entered the market. The new generation is designed to be more sensitive than the current generation of GPS receivers, allowing them to pick up signals in more challenging environments. Furthermore, the new devices are also lower voltage, allowing them to work longer without the batteries needing to be changed or charged. See Illustration 2.1 for an example of three new small GPS loggers with low energy consumption. This low energy requirement enables the devices to function for several days and to keep the data obtained during this period of time. All three devices are currently on sale for less than 70 Euro.

Illustration 2.1 Three new GPS loggers. From left to right: Royaltek RGM-3800, i-Blue 747, BT335.

SOME EXAMPLES OF IMPLEMENTATION FOR SPATIAL RESEARCH

To date, research into time-space activities using tracking technologies – for example, the Global Positioning System – has been largely limited to transport studies, and specifically to studies tracing the spatial routes of motorised vehicles (see for example Zito et al., 1995; Quiroga & Bullock, 1998; Murakami & Wagner, 1999). Analogous studies focusing on the spatial activities of pedestrians have, however, been rarer. One possible explanation for this state of affairs is that gathering data from pedestrians by this means is more complicated than doing so for motorised vehicles (cf. chapters 5, 6 and 7). Whereas for a car the advanced tracking system is simply one more accessory, which, easily installed will not affect the nature of the data collected, in the case of pedestrians the tracking system has to be both small and 'passive' so as not to disrupt or affect the subject's normal behaviour. These requirements were difficult to meet until recently when small, lightweight and highly sensitive receivers with long operation times began to appear on the market.

Below, I wish to present, very briefly, two cases regarding the implementation of tracking technologies in spatial research. The first case relates to the sophistication of a location kit that is used to collect data for research focusing on the outdoor mobility of elderly people with cognitive disorders. This kit enables the researchers to measure not just the time-space activity of the research subjects, but also the level of their participation in the study. The second case relates to the ability to 'pixel' environments using the high-resolution nature of the GPS-obtained data.

The Use of Advanced Tracking Technologies for the Analysis of Mobility in Alzheimer's Disease and Related Cognitive Disorders [1]

This project addresses the measurement of mobility of elderly people with mild cognitive disorders by taking advantage of advanced tracking technologies (see the following website for more information: http://geography.huji.ac.il/sentra/index.html, accessed 24 July 2008). In this project we track people for one month, and due to the features of the tracking kit used, know at any given moment whether the research subject is participating in the research by carrying the GPS device about, as opposed to leaving it at home when going out. This system consists of a GPS receiver with a GSM modem, an RF transmitter that resembles a watch and is worn on the wrist (see **Illustration 2.2** for the elements of the kit) and a monitoring unit located in the home. The waterproof RF transmitter allows us to know whether or not a research subject has the GPS device with him, while the multiple sensors in the 'watch' also indicate whether it is being worn on the wrist. The GSM modem sends

Illustration 2.2
Elements of the location kit of the SenTra project.

Personal Watcher
RF component

STaR Monitoring Unit
GPS Reciever
GSM modem
RF component

Home Monitoring Unit
RF component

the obtained data to the project server and enables us to monitor the location kit from a distance, for example to obtain an indication of the charge level of the batteries.

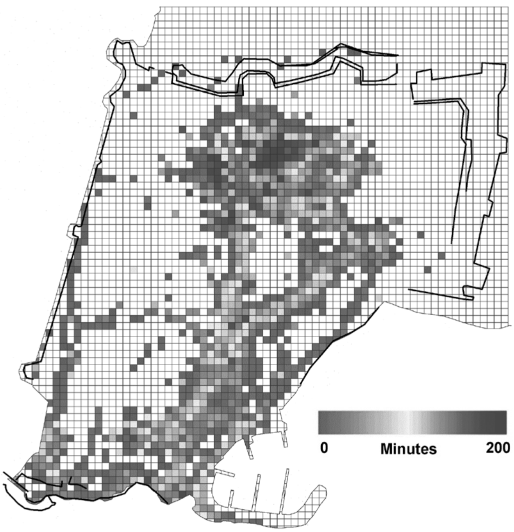
The data obtained in this project are used to develop typologies of out-of-home activity in order to explain differences in mobility based on a wide range of socio-structural, personality-related and environmental variables. Those typologies will be based upon a wide range of geographic variables that could only be defined due to the high resolution nature of the data collection. One type of variable is related to the places of activity considered as 'nodes' (for example: the number of nodes visited per day, the time spent at them, their location in space and their type). The other type of variable is related to routes taken from one place of activity to the other, considered to be 'tracks' (examples are: walking versus driving, walking speeds and walking distances and number of walking trips per day). In addition, the research aims to assess the impact of the use of advanced tracking technologies on the quality of life of dementia patients and caregivers, as well as evaluating its potential as a diagnostic tool. The explicit consideration of ethical aspects involved in the use of tracking technologies is a substantial component throughout the project.

'Pixelating' Urban Environments

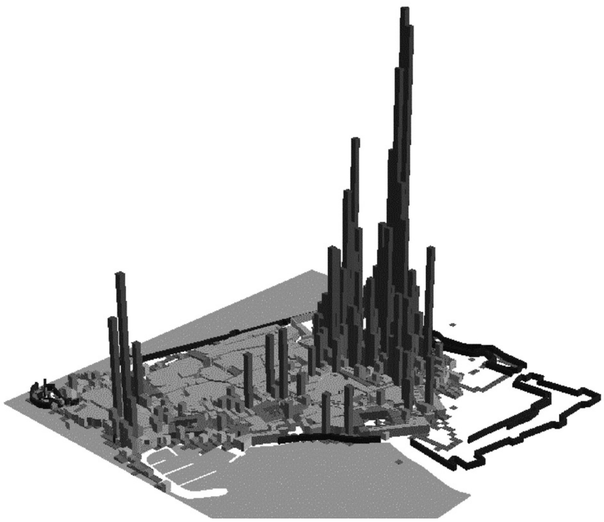
The high accuracy of GPS enables the micro-analysis of environments using various methods. Having examined the behaviour of the participants as individuals, we can now aggregate the information collected to achieve a better understanding of how people consume space. Thanks to the high resolution of the data obtained by GPS, it is possible to actually pixelise places to very small units of observation. In the case of the World Heritage Site of Akko (Acre), Israel, the town's urban space was divided into squares measuring 10 by 10 metres, and the total number of signals picked up by all the GPS receivers of all the participants per square counted (for more details see Shoval, 2008). Obviously, the size of the grid's square depends on the size of the urban space studied, with larger scale studies requiring larger squares and smaller ones smaller squares. In a recent study in the Mini-Israel Miniature Park, the chosen resolutions were 4 by 4 metres and 2 by 2 metres.

Illustration 2.3a and 2.3b depict which areas in the town boast high levels of concentrated tourist activity and which suffer from a dearth of tourists. Indeed, looked at 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. The illustrations also reveal which of the possible routes linking Akko's various centres of activity are most commonly used.

Illustration 2.3a and 2.3b
Visualisations (2D and 3D) of aggregative analysis of visitors' activity in the Old City of Akko (Acre).



Intensity of Activity in Old Acre Cell - 10 x 10 m



Intensity of Activity in Old Acre Cell - 10 x 10 m

CONCLUSION

Advanced tracking technologies could do much to facilitate and indeed improve empirical research in the field of urban studies. Firstly, these technologies can track subjects in time and space over long periods of time, and do so passively, thus reducing the burden placed on the subjects to a minimum. Secondly, they provide researchers with a far more accurate database than before, and moreover a database marked by an extraordinarily high degree of temporal and spatial resolution. These technical advantages could, in turn, serve to advance current but also open up a great many new, previously unfeasible, lines of inquiry in urban studies. Advanced tracking data collection methods could, for example, be used to improve our understanding of retail and consumption geographies, or to measure and assess the vitality of city centres (Ratti et al., 2006; cf. chapters 7 and 8). They could also be exploited to investigate the phenomenon of urban segregation in its various manifestations. To date, owing to the data available, most such studies have tended to focus upon residential type spatial segregation. Now, with digitally-based tracking methods, it will be easier to explore production, consumption and recreation-based spatial segregation as well.

While these technologies' huge, albeit as of yet potential, value as tools for gathering data on spatial-temporal behaviour is more than apparent, there are nevertheless several issues that have to be dealt with by researchers before they can be fully and effectively exploited. Firstly, there is a logistical problem that relates to the difficulties involved in distributing and collecting the tracking devices during the experiment. Often complicating the research design, it is nonetheless a problem that could be solved with a little imagination. The second issue is mainly a moral and an ethical one, specifically the way in which these devices may impinge upon individuals' right to privacy. As Levy has noted, 'In the future our cell phones will tag and track us like FedEx packages, sometimes when we are not aware' (Levy, 2004: 81; cf. chapter 1). Indeed, tracking technologies raise serious concerns regarding infringements on privacy and add a geographical dimension to the 'surveillance society' (Lyon, 2001) and the abilities to better track the 'digital individual' (Curry, 1997). This is not a new issue, as even today commercial mobile phone companies can identify the location of their cell phone users (Foroohar, 2003), and often use this knowledge to bombard customers with unwelcome information about nearby functions and events (Curry, 2000; Fisher and Dobson, 2003). The question of the mobile phone users' privacy is one that most countries' legal systems, including that of the United States, have failed to tackle fully and as such is a question of considerable and global importance (Renenger, 2002). There is also another complication: do people, once they know they are being tracked, change their behaviour, and if so how?

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