Noisy School Kids: Using GPS in an Urban Environment

Duncan Whyatt[1], Gemma Davies[1], Marion Walker[1], Colin Pooley[1]
Paul Coulton[2] and Will Bamford[2]

[1]Department of Geography, Lancaster University, LA1 4YQ
Tel: +44 1524 510239 Fax: +44 1524 510269
d.whyatt@lancaster.ac.uk http://geography.lancs.ac.uk/
[2] Department of Communication Systems, InfoLab21, Lancaster University, LA1 4WA

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1. Introduction

The Global Positioning System (GPS) was initially developed by the US Department of Defence in the 1980s. Civilian use of GPS was primarily restricted to navigation, with the accuracy of the signal downgraded through Selective Availability (SA). Since May 2000, however, SA has been disabled, allowing civilian users to obtain positional fixes of much higher accuracy. This has led to improvements in existing applications such as in-car navigation systems and the development of novel, new applications such as pay-as-you-drive car insurance (Norwich Union, 2007) and electronic baby-sitting. Parallel developments in mobile computing have led to the advent of Location-Based Services (LBS) in which the information the mobile user receives is geographically dependent (see Brimbicombe, 2007, for a review of LBS).

GPS are not, however, without their problems. It can take a GPS receiver several minutes to obtain an accurate positional fix when first activated in a new geographic location (the 'cold start' problem). Accuracy may also be compromised by poor satellite configuration or signal blocking by buildings and large trees. Pertinently, one of the most common causes of poor reception comes from placing receivers in pockets or bags.

This paper describes a project in which 30 school children used GPS within a customised mobile phone application to capture their routes to and from school using a variety of different forms of transport. These data will ultimately be integrated with modelled estimates of traffic-based air pollution to determine individual estimates of personal exposure. Prior to this, however, the accuracy and consistency of positional data needs to be assessed. This paper describes some of the problems encountered when trying to clean individual GPS tracks prior to use in exposure assessment using a combination of spatial and temporal criteria.

2. Methodology

Thirty school children (aged 12-13) were each provided with a mobile phone running a customised application ('GeoBlog') designed to automatically capture the geographic position of the user at 1-second time intervals through Bluetooth connection to a GPS unit. The children were asked to turn on the GPS units prior to commencing their journeys to school (in order to obtain positional fixes) and to wear the units around their necks in order to maximise signal capture. A similar methodology was adopted by Duncan et al (2006) in their study of school journeys in Rockhampton, Australia. Upon arrival at school the children were asked to turn off the equipment. Similar instructions were provided for the homeward journey.

Four one-week periods of data capture were organized throughout 2007. The children were asked to use the mobile phones to take pictures and create text messages of things that 'interested' them on their journeys to and from school. Follow-up interviews were conducted with each child after each period of data capture in order to gain a deeper insight into factors affecting the choice of routes and associated photographs and texts. These findings will be reported in more detail in Pooley et al (2008).

3. Results

Initial visual assessment of the GPS tracks generated by the children over the four week period suggested that 654 / 1080 routes were sufficiently complete to merit further use in pollution exposure assessment. Conversely, 426 routes contained little or no positional data.

Figure 1. Sample Routes

The usable tracks reveal incredibly detailed records of journeys to and from school. In addition to the complexity of the routes themselves, these data can also be used to determine variations in speed of travel (by mode of transport), common routes and social spaces where children gather.

However, the usable tracks are problematic and cannot be used in exposure assessment without further processing. Some of these problems relate to the definition of the start and end points of the journey (home and school). Others relate to variations in accuracy and completeness between these two locations. A selection of these problematic cases are illustrated in Figure 1.

Figure 1a) depicts significant scatter around the home address, some signal scatter and drop-out en route to the bus stop, further scatter at the bus stop then a clean signal once travelling on the bus to school. Figure 1b) depicts significant scatter at the school as a consequence of leaving the GPS unit turned on in the classroom. Figures 1c) and 1d) show the difference between a high quality track produced by a child travelling to school in a car and a medium quality track produced by a child walking to school. The latter shows significant signal dropout as a consequence of dense tree cover along the footpath.

In theory, it should be possible to use a combination of spatial and attribute queries to clean up the start and end of such routes. In practice, however, this is difficult to achieve. Duncan et al (2006) use a buffering approach to accept or reject routes relative to home and school addresses. In our case, application of buffers is problematic since the children may be outside either location for a significant period of time (e.g., in the school playground) and these data need to be retained for exposure assessment.

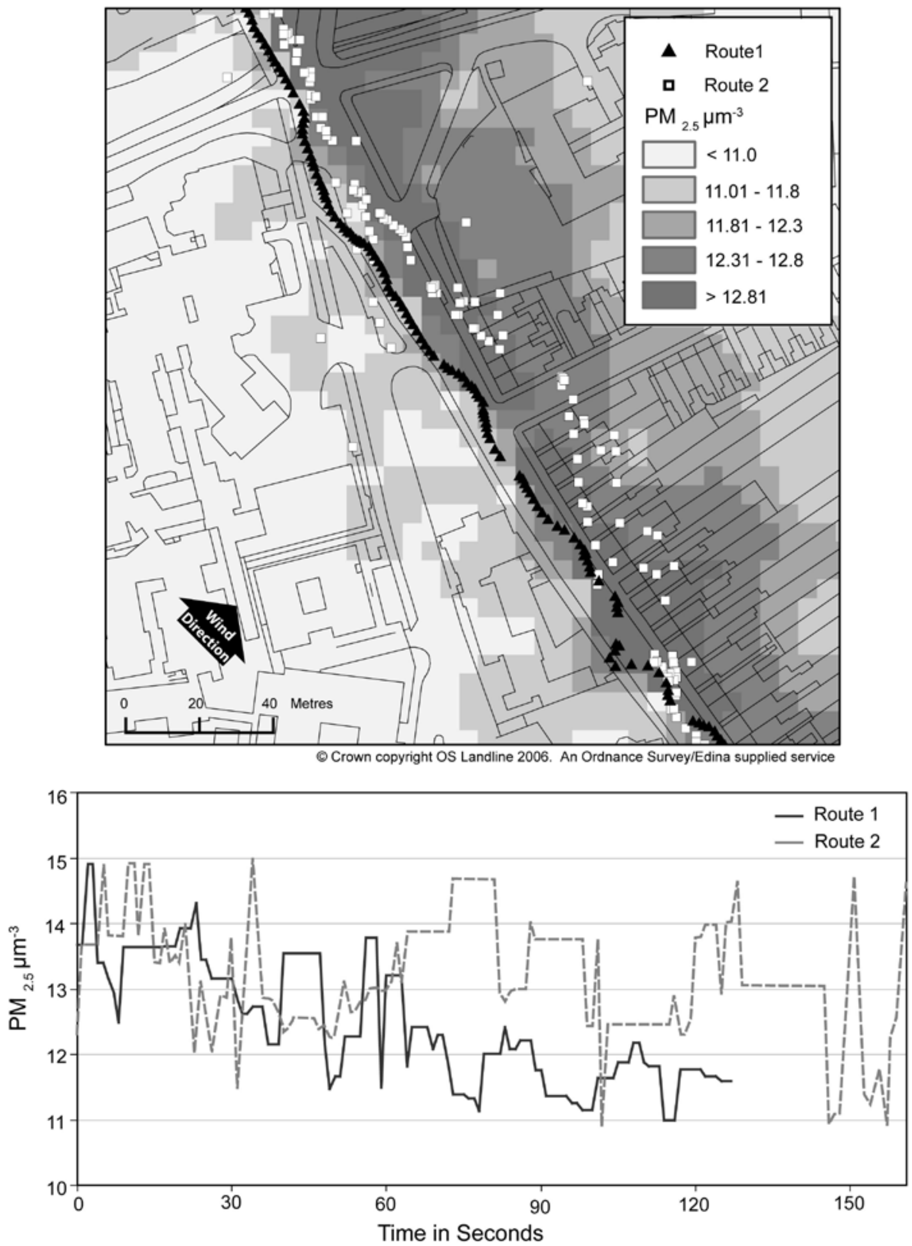
Du et al (2007) use a combination of speed and position to determine ‘dwell times’ which, if greater than some pre-defined threshold (‘time gap’) are taken to represent the end of a journey. This approach may be valid for vehicular based journeys, however, does not seem transferrable to journeys based on foot or bicycle. For example, some children leave home early in the morning, wait at bus stops, travel to school, then wait for considerable periods of time in the school grounds before entering the school buildings (Figures 1a and 1b). Implementing a rule based on the start of the school day is equally problematic. The first bell rings at 8:40am but our data suggests that some children are a considerable distance from school at this time.

In addition to location, speed and bearing the GPS units used in this study provide information on the number of satellites and the horizontal dilution of position (HDOP). One might expect that selecting positions on the basis of a large number of visible satellites and low HDOP would yield optimal results. In our experience, however, the opposite often applies, with continuity in route only possible through the use of positions based on less than four satellites and a high HDOP.

4. Discussion

In order to be useful for personal exposure assessment routes need to be accurate (low degree of scattering) and complete (few gaps between points). Examples of calculated pollution exposure from high and medium quality routes are shown in Figure 2. The higher quality route runs adjacent to a heavily trafficked road and on this occasion is generally upwind of high [modelled] pollution concentrations. The medium quality route, in contrast, is much more poorly defined with many data points falling within the downwind zone of high pollution concentrations. The resulting exposure profiles reflect this difference.

Figure 2. Variations in Personal Exposure (High and Medium Quality Route Data)



5. Conclusions

This project has generated a large amount of locational data which can potentially be used for a wide variety of purposes in addition to exposure assessment. However, these data are noisy. With over 600 potential routes at our disposal it is essential that we develop an automated means of cleaning these data. Attempts to date have highlighted the complexity of the task ahead. Each route presents a unique combination of spatial and temporal circumstances that cannot be addressed through the simple application of rules. This presentation will report on progress made to date and encourage suggestions of alternative approaches from conference participants.

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Biography

Duncan Whyatt is a Lecturer in GIS with interests in air pollution modelling at regional and local scales.

Gemma Davies is a GIS Officer who provides support for teaching and research within the Department of Geography.

Marion Walker was the Research Assistant on the project. She has a PhD in Educational Research and Human Geography and interests in school choice, qualitative methodologies and education policy.

Colin Pooley is Professor of Social and Historical Geography. His research focuses on changes within British society over the past 200 years with particular reference to migration, mobility and health.

Paul Coulton is a Senior Lecturer in Communication Systems and head of mobile game research at Lancaster University. He has been made a founding member of Forum Nokia Champion – a recognition and reward programme that honours a select group of mobile developers from around the world.

Will Bamford is a PhD student in the Department of Communication Systems studying under the supervision of Paul Coulton. He designed and wrote the GeoBlog application used in this study.