Remote Location in an Urban Digital Model

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The work reported in this paper builds on previous work and deals with two particular aspects that contribute to effective interactive city modelling delivered to small mobile devices ‘on the fly’. Firstly, one strand involved in this study is probing into the perception and understanding of users while using different 3D city model representations on small screen devices. The second strand reported on is concerned with establishing the location of the remote users in an Urban environment.

Keywords: City modeling; wireless; mobile.

Introduction

There are now many examples of providing City Models in a form that can be accessed via an internet connection. An early example of this was by Maver et al. (2000) who showed that basic geometric data describing the city could be enriched by layers of supplementary textual information, or alternative graphical information such as vrml. Subsequently, Rakkolainen et al. (2001) reported on how city information could be delivered to mobile devices and considered some associated problems such as the integration of location-sensitive modelling using GPS.

More recently Fukuda et al. (2002) who considered how contemporary technologies could be employed to effectively deliver interactive city models for visualisation and planning; and more recently (2006) has described a system for remote, on-site representation of landscape and environment. Umlauf et al. (2003) have undertaken work that suggests that three-dimensional models enable users to understand cityscapes and identify locations better than symbolic 2D maps. The work of Umlauf et al. (2003) points to the apparent benefits of 3D representations of city models, compared to 2D maps.

In addition the general problems associated with small screen mobile devices remain. The small form factor necessarily limits interface possibilities, consequently smooth scrolling and panning can be difficult and screen visibility can be difficult in certain lighting conditions. In addition the problem of how best to switch to the associated textual information still remains. It is clear that next generation mobile services and devices will combine a wider range of functions with the ease of use. Such technology will become increasingly pervasive, and city modelling/information systems that mesh well with these technologies offer particular potential.

Mobile mapping

The improvement of CAAD tools, mobile technologies and the rising availability of wireless networks make the use of mobile mapping in wayfinding and navigation more feasible. The fundamental concept
of mobile mapping is to construct a platform or assistance which could offer people the service of finding the directions and routes in city. Additionally, there is increasing availability of good quality mapping available on-line (Google Earth/Microsoft Virtual Earth) to provide information about the city.

So that an effective system can be developed for a range of devices and uses, it is necessary to consider a variety of representation types for both 2D and 3D data to evaluate their effectiveness.

**Issue of mapping types**

Developments and improvements in the layout of map and model representations, textural and graphical arrangements are making mapping services more accessible. Additionally, the 2D and 3D representations are more widely available both in online and standalone applications. Commercial online mapping services, for instance, Google Maps and Multimaps.com both use 2D maps, photographs, and satellite images to construct mapping services which could not only be accessed through the Internet, but also available to download to mobile devices.

The use of 3D representation as a wayfinding and navigation interface is becoming more and more widespread at a consumer level. Early works have shown the possibility of conveying VRML model to mobile devices (Nurminen, 2006; Burigat & Chittaro, 2005) and have the potential to enhance wayfinding and navigation effectiveness (Nurminen, 2006; Burigat & Chittaro, 2005). In addition, there are also recent developments of mixing reality via integrating digital media such as images, video, or audio with landmarks or landscapes to structure a navigation system or a design tool (HP mscape, 2007; Fukuda et al., 2006). Significant advances have been made in utilising 3D model as wayfinding support to increase the comprehension and perception of city.

The initial work of this study is based on the prototype system of Liverpool which included two Archi-Tours, related buildings and heritage information (Berridge & Brown, 2002). The integration of pseudo-3D models, building images, and the description on buildings offers not only the configuration and form of significant landmarks which could be understood and recognised efficiently, but also the details narratives of city which could augment the comprehension of local information in its context. Moreover, the aim of Archi-Tours (figure 1) is to combine multimedia elements incorporating both conventional travel elements such as maps and travel guides, tourist and attractions websites through wireless networks and mobile facilities (Brown et al., 2006).

**Delivering of small-screen devices**

When it comes to delivering the map or model to small-screen mobile devices, there are several difficulties which need to be considered, for instance, the delivery speed of wireless networks, the Level of Details (LOD) of 3D models, and the arrangement of text, images, and 3D models.

First of all, the bandwidth of wireless networks and the efficacy of transmission are restricted by various environmental factors. Although, the problems of wireless bandwidth may yet be overcome by future technological developments, the objective of this study is to scale up a practicable and available digital city model which could be conveyed by existing wireless networks within an acceptable timeframe. Therefore, the means and LOD of constructing digital model which would affect the speed of...
rendering and displaying the representation are the key factors while accessing and downloading the model.

Secondly, the screen size has limitations in presenting both graphical and textual data at the same time. As Brown et al. (2006) mention, the major issues of small-screen devices representation is how to manage graphical, textual, and positional information within same small screen. Trying to place too much information (both text and graphics) within the confines of a small screen can result in an ineffective and illegible system. Nevertheless, demonstrating this information in separated screens may cause additional actions such as scrolling and dragging to grasp the details. The problem of arranging text, 2D image, and 3D model remains to be further studied.

Earlier work that demonstrated some of the features of online mapping services such as Google Mobile combined with a pseudo 3D model and the linear structure of the paper architectural tours is demonstrated by the Architours at www.liverpoolarchitecture.com. These were optimised for access and downloading from mobile devices through wireless networks (Berridge & Brown, 2002). The next stage of this study is to evaluate the effectiveness the differing representation styles of the various mapping services as shown in figures 2 and 3.

**Mobile location**

Satellite navigation and positioning systems are an area of growing significance in the field of wireless communications (Brown et al., 2001). The Global Positioning System (GPS) is the only fully-functional satellite navigation system as of 2006. The use of GPS receivers alone and in conjunction with hand held devices such as PDAs is very common now. PDAs, GPS receivers and GPS-linked PDAs are available with
an increasing number of capabilities at ever more affordable prices. A lot of research and work is being done to further improve these devices and to get maximum possible benefits from them. Basic GPS is the most accurate radio-based navigation system ever developed - suitable for most, but not all, applications (www.trimble.com/gps/dgps-why.shtml: March 2007). However, when accuracy of less than one meter is required, ordinary GPS receivers and GPS-linked PDAs prove not to work as reliably as expected. GPS location is only accurate to a few metres and especially near corners this can lead to the user being places in the wrong street in the model (Brown et al., 2006). There are problems of mis-location of the user i.e. the hand-held device tells the user that they are in a different location to their actual location --they may be around the corner from the location indicated by the system (Brown et al., 2005). So, various issues associated with navigation using GPS receivers have to be addressed to achieve reliable results. It is important that user will be located with acceptable accuracy in a 3D model of the city, on such devices. GPS receiver’s log file opened in Google Earth is shown in figure 4. Experiments were done in different locations/areas of Liverpool. The overall aim of these experiments is to establish the range of errors that GPS-linked PDAs will experience in urban locations. The following paragraphs give the generalized idea about the errors that GPS receivers and GPS-linked PDAs experience in urban locations.

Seven experiments were conducted in different locations, open and obscured, and in different receiver’s conditions, stationary and moving. The route to be used to get data was derived both from the need to get sufficient data to test the device in the context of city navigation and to incorporate existing known height and benchmark positions. Ordnance survey digital maps were used to get the coordinates of
the benchmark points. The Dell Axim X51v-624 was used as a PDA and the Dell Bluetooth GPS Navigation System – SIRF 3 Chip was used as a GPS receiver for this experiment. Efficasoft GPS Utilities software for Pocket PC v1.2 was used to collect the data on PDA. After getting the positional data from GPS receiver the next step was to examine its accuracy and Google Earth was used to examine data. Data from GPS receiver was in NMEA 0183 format and needed to be converted into KML format before using in Google Earth. GPSBabel software was used to convert data from NMEA format to KML format.

Results show that errors and error intensities of the GPS receiver vary from one location to another. The GPS receiver often fails to deliver continuous information in urban canyons. It was found that more obscured the location is, the greater the ‘down time’ is where no readings are available. In urban canyon environments GPS signals are often blocked by tall buildings and there are not enough available satellite signals to estimate the positional information (Youjing, 2003). Latitude and longitude deviations were more abrupt and sudden in obscured places than in open areas. It is particularly noticeable that altitude values in obscured locations are often more constant than open places. In obscured places, the height data some times remained constant or changed gradually and some times abrupt and big jumps were seen. On the other hand in open places, the altitude data had gradual changes most of the time, but sudden big changes were also found.

When viewing errors plotted on a Google Earth, the offset discrepancies can be due to GPS inaccuracy as well as inaccuracy in Google Earth images and maps. Figure 5 is the snapshot of GPS receiver’s data in Google Earth.

The errors in GPS positional information do not remain same for same area. Errors and error intensities are different at different times for same area, as shown in figure 6. GPS is an appropriate position sensor, however it has many limitations such as signal acquiring times and shadowing from buildings.
Some areas (such as obscured locations) tend to give larger errors than open areas. The same GPS receiver gives different levels of accuracy of positional information for same point/area at different times. The GPS receiver takes few seconds to few minutes to acquire position data.

The latitude and longitude accuracy of the GPS receiver is far better than altitude accuracy. The errors in height data (z-axis) are often very large (± 40m). In Google Earth, both typical and gross errors have been found in the GPS receiver data. Gross errors are corrected in car navigation systems by ignoring large sudden changes. A similar correction would be needed in a walking city navigation system.

Conclusions

After some years of development (Berridge et al., 2003) we are now beginning to see mapping systems, delivered to mobile wireless devices for use by pedestrians, finding real applications. With the ever increasing power and more widespread availability of handheld devices, we will begin to see a proliferation of applications that utilise this power. With increased portability comes issues both of usability and representation of the information. This paper seeks to considers some of the current practical issues that require further investigation and refinement to aid the development of such applications.

References


