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Overlaying Paper Maps with Digital Information Services for Tourists

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Abstract

Despite the increasing availability of various forms of digital maps and guides, paper still prevails as the main information medium used by tourists during city visits. The authors describe how recent technologies for digitally augmented paper maps can be used to develop interactive paper maps that provide value-added services for tourists through digital overlays. An initial investigation into the use of these maps to support visitors to the Edinburgh festivals is also presented.

Keywords: tourism; maps; digitally augmented paper.

1 Introduction

Maps play a central role in tourist activities, not only during visits, but also in the planning and preparation stage. After the visit, they may also be used as a reminder of a route taken and places visited, possibly acting as a form of index to various mementos such as tickets to historical sites, information leaflets, photos and videos. A major focus of electronic information services to enhance the tourist experience has therefore been the provision of digital maps and guides for city visits. However, paper continues to prevail as the main information medium used by tourists during city visits. Recent ethnographic studies have suggested various reasons for the low uptake of digital tourist services for mobile devices such as PDAs. These include, not only the limitations of current devices, but also the failure to recognise, and hence support, the ways in which tourists work with traditional paper maps.

While a number of research projects have addressed these challenges by looking at better ways of designing digital maps for mobile devices, an alternative is to investigate means of enhancing paper maps through emerging technologies for digitally augmented paper. In this way, optional value-added digital services for tourists can be provided based on traditional forms of printed maps, thereby gaining the best of both worlds and avoiding the potential divide between high-tech and low-tech tourism. Different activities can be supported by a range of digital overlays that link positions on the map to appropriate digital information and services. This paper describes the technologies and infrastructure required to support interactive paper maps and the outcomes of initial studies on the development and use of such maps. In particular, a map-based system developed for visitors to the international Edinburgh festivals is described.

Section 2 discusses the use of maps by tourists and related projects on digital or digitally-augmented maps. Section 3 provides an overview of current and emerging technologies for digitally augmented paper and Section 4 describes how these can be used in conjunction with appropriate software infrastructure to develop interactive paper maps. Details of the interactive map system developed for the Edinburgh festivals and the user studies undertaken there are presented in Sections 5 and 6, respectively. Concluding remarks are given in Section 7.

2 Tourists and Maps

Tourists make heavy use of maps before, during and after city visits. Before a visit, tourists will use maps to help plan activities and also learn about the general layout and social zones of cities. These pre-visit activities are increasingly supported through web sites which may even offer interactive maps and associated services to help with the planning of a visit. Tasks performed during a visit have been categorised as *locator*, *proximity*, *navigation* and *event* tasks (Reichenbacher, 2001). Locator tasks are concerned with questions such as “Where am I?”, and “Where is *X*?”. Proximity tasks deal with finding objects or people located near to the user’s current location. Navigation tasks involve route finding either from the user’s current location to a given location or object, or between any pair of specified objects/locations independent of current location. Event tasks deal with finding information about what happens at a given place. Finally, it is important to recognise the use of maps post-visit as both a personal reminder of places visited and also a means of sharing experiences with family and friends.

First digital mobile maps tended to focus on the navigation task, but recent ethnographic studies have emphasised the need to support all categories of map-based tasks commonly undertaken by tourists during visits. A number of interesting observations on the use of maps and guides by tourists during city visits are reported in (Brown and Chalmers, 2003). Most notably they remark on the continued prevalence of paper maps and guidebooks and the affordances of paper to which this may be attributed. Paper as a medium has many advantages over digital media in terms of how people can work with it, both individually and in groups. It is portable, cheap, robust, foldable, needs no electric power and can be annotated easily by various forms of marker or attachments such as Post-Its. Further discussion of the affordances of paper are given in (Sellen and Harper, 2001), whereas motivation for the retention of paper in mobile environments can be found in (Norrie, 2003).

Initial ethnographic studies on the use of maps by tourists in the city of Zurich were carried out during a one week doctoral workshop organised by ETH Zurich in the summer of 2002. Tourists were observed and videoed while shopping, visiting art galleries and museums, using the public transport system and arriving at the main railway station. These studies highlighted the different needs of tourists depending on the current activity. The zones and locations of interest may shift depending on whether one is looking for night-life, shopping or trying to locate a hotel. Also the navigation task may vary depending on whether one is loaded with luggage and looking for the way to a hotel or enjoying a sunny afternoon exploring the historical sites. In the case where special activity-based maps were used, such as the public transport maps found at tram and bus stops in Zurich, tourists frequently experienced difficulties relating these to other general maps.

It is important to stress that tourism is a social activity, with tourists generally travelling in groups with a high-degree of intra-group interaction and collaboration. Tourists frequently collaborate around a map and guidebook, holding the documents next to each other and using pointing actions to locate positions on the map and relate items within the documents both to each other and to the physical environment. Combining and comparing information is a key tourist activity and much of the enjoyment of the visit is the social interaction involved in these tasks of dynamically planning activities and learning about the environment. Collaboration around mobile digital devices such as PDAs is awkward both because of display size and required positioning for clear reading. Further, the limited screen size makes it difficult to view documents simultaneously and it is tedious to have to switch back and forth between documents. Some projects have therefore experimented with the use of tablet PCs (Brown and Laurier, 2004), but this has clear drawbacks in terms of tying up the use of both hands. Studies carried out by the authors and other members of their research group in Zurich have confirmed that, in addition to maps and guides, tourists frequently carry bags, clothing such as jackets and pullovers and hold the hands of children or partners. It is therefore important that mobile devices can either be easily carried within pockets or bags, or attached to the users in some way.

Given all of the issues raised above, numerous projects are addressing the issue of designing better digital maps and guides for tourists. An overview of various technical challenges and approaches are presented in (Malaka and Zipf, 2000). Some projects have focussed on issues of context-awareness e.g. (Abowd et. al., 1997; Cheverst et. al. 2000; Reichenbacher, 2001) or collaboration (Brown and Laurier, 2004; Dunlop et. al., 2004), while others have concentrated on HCI issues and investigated advanced visualisation schemes for maps and multi-modal interaction. For example, the Deep Map project has investigated the use of various 2D and 3D visualisations as well as speech interfaces based on natural language processing (Malaka and Zipf, 2000).

Alternatively, one can aim to retain rather than replace paper as a key mobile information medium for tourists and to provide digital services as an optional overlay. The basic forms of printed maps would remain unchanged, but tourists with appropriate digital devices could interact with the map and have access to additional information, especially that which is dynamic or may be dependent on context such as time and location. A number of previous projects have investigated the use of paper as an interface in mobile environments and specifically tourist applications. For example, in the Campiello project (Grasso et. al., 2000), paper flyers and newspapers were distributed around a city and could be used to activate services or input data to a community information system. The project used scanning technologies to detect activated check boxes for service requests or text entered in special capture areas. This meant that users had to go to special kiosks located around the city in order to access digital services. Also, links to digital services were via special component areas printed on paper such as check boxes and comment boxes and did not support arbitrary linking of text and images to digital services. In contrast, the project presented here builds on recent developments in technologies for digitally augmented paper to enable links to be created from any position within a printed document and, further, to support real-time interaction in a mobile environment.

3 Digital Augmentation of Paper

The digital augmentation of paper can be achieved by some means of either encoding digital information on paper or being able to detect physical positions on paper and have a server which links these to digital resources. An example of the former approach is the use of standard printed barcodes to encode a unique resource identifier. Another example of this approach is DataGlyphs developed by Xerox to encode digital data on paper using patterns of forward and backward slashes representing zeros and ones (Hecht, 2001). If the pattern is small enough, these digital encodings can be contained within images in such a way that they are not visible to the human eye but can be detected by special scanning devices. DataGlyphs were used within the Campiello project to encode document and person identifiers on documents, the latter by means of attaching personal stickers (Grasso et. al., 2000).

The detection of physical positions on paper can be achieved either by attaching the paper to a special device or by means of encoding the position information on the paper itself. The educational toy LeapPad (http://www.leapfrog.com) is an example of the former since the special books are positioned on a pad and a tethered stylus used to point to positions within them. The mimio Xi (http://www.mimio.com) and PC Notes Taker (http://www.pegatech.com) systems for capturing writing on whiteboards and A4 paper, respectively, involve the use of external devices to track pen position ultrasonically and locate position within a page. If a document has to be located on some special tablet or desk, this has obvious restrictions in terms of mobility. On the other hand, systems such as PC Notes Taker which involve clipping a device to a document tend to be page-based rather than document-based. The alternative solution of encoding position information within printed pages has obvious advantages in terms of flexibility and mobility but requires special paper or printing technologies.

Anoto (http://www.anoto.com) developed a solution based on an almost invisible pattern of infrared-absorbing dots printed on paper and special digital pens which have a camera situated alongside the writing stylus as shown in Figure 1. The pattern of dots encodes x-y positions in a vast virtual document space. Camera images are recorded and processed in real-time giving up to 100 x-y positions per second. The technology was developed to enable the digital capture of handwriting and several pages of handwriting can be captured and stored within the pen before being transmitted to a PC. Both Nokia and Logitech have digital pens on the market based on this technology. Hewlett-Packard is now offering business solutions for the automatic processing of forms in large enterprises based on Anoto technologies. Since current digital pens are intended for handwriting capture rather than general interaction, they transmit data to a PC only on demand. In the authors' research on software infrastructure and tools to integrate printed and digital information services, pens specially modified by engineers of Anoto are used to send data directly. With this modification, the pens could be used both for real-time interaction as well as writing capture. The following sections describe how interactive maps can be realised using this technology to detect positions on a page and a combination of a cross-media link server and innovative web-publishing platform to invoke services and deliver information.

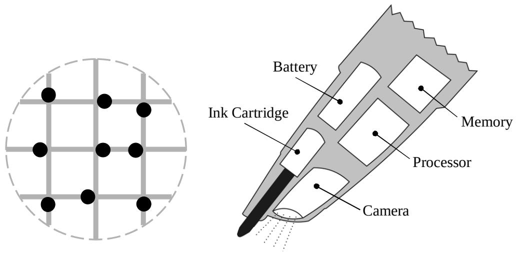

Fig. 1. Anoto Technologies

Another technology which has the potential to yield a low-cost solution for interactive maps was developed in the context of the EU project Paper++ in which the authors participated (http://www.paperplusplus.net). Positions on paper were encoded using a grid of almost invisible barcodes printed in conductive ink. A prototype reader costing only a few Euros was developed that could read position information by measuring the inductivity during a swiping action. The prototypes were sufficient to carry out initial user studies, but there remain many open issues in terms of investigating alternative printing and reader technologies to obtain better performance and reliability, while keeping costs low. Further details are given in (Luff et. al., 2004).

4 Interactive Paper Maps

As described earlier, paper maps have many advantages compared to PDAs and other electronic map solutions in terms of mobility and readability. However, digital map applications can provide additional functionality such as the computation of the optimal path between locations or access to information about places of interest, shops, restaurants or public transportation. While geographic information about a city tends to be fairly static, additional information about various locations is often dynamic. Information about cultural events taking place in a city is one form of very dynamic information, but public transportation and places of interest are also subject to change. For example, (Brown and Perry, 2002) report on an interview with the manager of a new youth hostel in Glasgow who talked about the problems of it being “off the map” since it was not shown on any of the tourist maps and guidebooks.

To combine paper and digital services, a printed city map can be used as the primary user interface through which supplementary digital information and services can be accessed. The system described is an extension of the cross-media link framework developed by the authors as part of the Paper++ project (Luff et. al., 2004). The primary idea is to define active areas on a paper document which are linked to digital information. The Paper++ server receives positional information from a pointing device such as an Anoto digital pen and then checks whether it is contained in any active areas specified by simple or complex geometrical shapes.

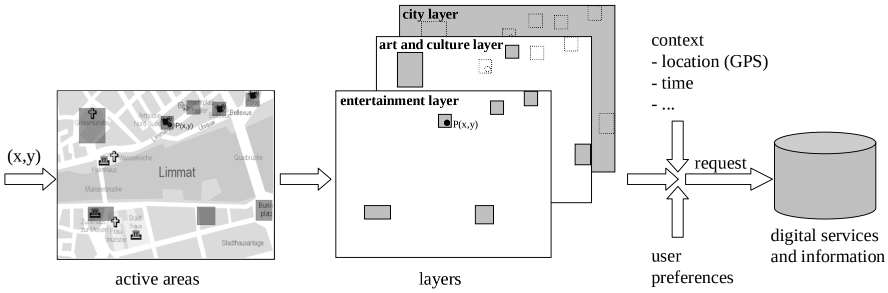

Fig. 2. Mapping of Positions to Digital Services and Information

The digital information bound to any map location may depend on the application's current state. Each active area is associated with a virtual page layer and areas cannot overlap on individual layers. The explicit order defined over the set of layers determines which link has to be activated if the position selected lies within multiple overlapping areas. Specific layers may be activated or deactivated dynamically based on contextual information. The factors involved in server processing are shown in Figure 2, indicating that the response to a request will depend upon, not only the position, but also the current set of active layers determined by contextual parameters such as location and time, and also user settings. Note that a general framework to support this mapping process is provided and the designer of a specific map can decide how to use this layering facility. For example, layers may be used to represent different activity maps or they could also be used to provide a form of “zooming” effect where information on different layers corresponds to different levels of detailed zoning within a city. Details of the server are given in (Norrie and Signer 2003).

An interactive city map of Zurich was implemented as a first application. A map of the city centre was printed using the Anoto pattern and a PDA used to visualise the supplementary digital information. Different layers are used to support different activities. For example, one layer gives cultural information and another information about entertainment. A third layer, the city layer, provides general information about the city and its public transportation system. A user can customise his personal map by selecting the active layers. Therefore, the same map can provide information about shopping facilities and cinemas for one user, whereas another user gets information about museums and historic sites. Note that a second version of the map was produced using the Paper++ technologies, demonstrating that the framework is independent of the specific technologies used to detect positions on paper.

Next, the Edinburgh festivals were chosen as a setting to investigate the use of interactive maps as part of a more general mobile information system where all forms of task (locator, proximity, navigation and event) play an important role. This involved integrating the cross-media framework with a web publishing framework that supports context-awareness and multi-channel delivery.

5 Interactive Map System for Edinburgh Festivals

Every August, the city of Edinburgh hosts a number of festivals, including an international arts festival, a book festival, a film festival and also the Edinburgh Festival Fringe with more than 250 venues and 1700 shows. During this period, the city is littered with various forms of printed information such as venue maps, official brochures, daily programmes and event flyers. With so many events on offer, many visitors select events at short notice and based on contextual factors such as location and time. The Edinburgh festivals therefore provide an ideal environment for testing mobile information systems and, specifically, the use of interactive paper maps.

The system developed was based on the interaction components shown in Figure 3, namely a special brochure containing a map and event lists printed with Anoto pattern, a digital pen and an earpiece used for voice interaction.

Fig. 3. Edinburgh Festivals System

A central server has a database with information about venues, events, restaurants and also user reviews. The map is marked with venues and a user can request information about a venue by simply pointing with the pen to the appropriate location on the map. The system will then initiate a voice dialogue that allows the user to get general information about a venue or the events being held there.

A user also has a GPS device, enabling the system to detect their location and support locator and navigation tasks. For example, there is a “Where Am I?” button on the map page. The system helps the user locate their position on the map by telling them the general grid position, together with a placement guide within the grid e.g. “Grid F5, top right”. If the user then points with the pen within that grid, the system will give feedback telling them where to move the pen to arrive at the precise location. This map locator functionality is a novel feature of the system as it links from the digital sphere back to paper to help users find locations on maps which can often be a frustrating and time-consuming task. Similarly users can locate events listed in the brochure by pointing to the venue and being told where to find that venue on the map. This mechanism can also be used to locate registered friends using the system. In addition to location information, the system also uses time to help users locate events taking place in spatial and temporal proximity.

The system was based on an integration of the framework for cross-media linking described in the previous section and an advanced web publishing platform OMSwe which was also developed at ETH Zurich. OMSwe supports multi-modal and context-dependent access and includes a powerful context-engine that enables many different application-specific notions of context to be modelled and controlled (Belotti et. al., 2004). The system uses a special versioning system to represent context-dependent objects and since all aspects of a web site – content, structure, logic and presentation – are represented as objects in the system, all aspects can be made context-aware. Both content and presentation are dynamically composed during the process of requests according to context state, producing an XML content document and XSLT templates. An XSLT transformer is then called to generate the final result document. In this way, it is easy to dynamically change, not only the content of a web site, but also its presentation form, including formats for different channels. In the case of the Edinburgh Festivals system, the web publishing platform was used to generate HTML for access via general web browsers, PDAs and head-mounted displays, WML for access by mobile phones, VoiceXML for voice interaction and PDF for the generation of event lists which were then printed on paper with the Anoto pattern.

6 User Studies

General observation studies of tourists and tests of the demonstrator system took place in Edinburgh during August 2004. Usability trials were carried out during a three-day period and involved a mix of semi-structured interviews, unstructured user trials and user questionnaires. The semi-structured interviews were carried out with a mix of expert users from the HCI field and non-expert users who were general tourists visiting the festival. A number of these took place in a controlled laboratory environment so we could focus on design issues and were sure to obtain good quality video and sound. The unstructured trials were carried out in public places where tourists tend to spend time between events and included Princes Street Gardens and the area outside of Edinburgh's main concert hall which is also located close to a number of theatre venues. In these trials, the tourists were given a very brief introduction to the idea behind the system and then left to experiment with it, referring to a help page in the event brochure and asking for further instructions where necessary. Video recordings were made of the trials and a log kept of all interactions with the system. After the trials, users were interviewed and a questionnaire completed. A total of 3 expert users and 8 non-expert users completed detailed trials lasting around 45-60 minutes with full video recordings. In addition, we carried out a number of smaller trials as well as observing and videoing tourists in various venues as well as in public spaces such as streets, bars and cafes.

Generally the response to the interactive map was positive and users found the map-based interaction intuitive. One problem encountered was that users sometimes showed a certain reluctance to point with the pen as they were concerned about accidentally marking the map. We have found this to be a general problem associated with the dual mode of the modified pen which can act both as a selection and writing device. Ideally, the pen itself should have a mechanism to switch between modes, for example, clicking on the end to retract the writing stylus and switch from writing to selection mode. Users were enthusiastic about the map locator functionality, finding it both intuitive and extremely useful. More problems were experienced with interaction through the printed event lists as here it was less clear to users what response to expect from pointing to various positions on the page. In the case of event lists, there are many possible design layouts that can be chosen and, given the novelty of the technologies, there is a lack of design guidelines. Here the feedback from the user studies provided valuable input towards experimenting with alternative designs in the future.

Users were less positive about the voice interaction aspects of the system, some expressing a preference for some form of visual display or a more limited system of audio output rather than interactive dialogues. In part this was due to the design of the voice interaction which is based on grammars dynamically generated from the event database and, in some cases, tended to result in long option menus which are problematic in voice only interfaces. While some of these factors can be resolved through improvements in design, we plan to experiment with other modes of interaction in the future such as using PDAs for visual browsing in conjunction with interactive paper maps.

7 Conclusions

An approach for implementing interactive paper maps based on emerging technologies for digitally augmented paper together with a flexible cross-media linking framework has been presented and a brief report given of first user trials. On the whole, these user studies were very positive, although many challenges remain in terms of both the design of digitally augmented documents and the technologies required to support them. One main issue is the choice of interaction modes, some users expressing a strong preference for some form of visual interface such as PDAs, while others express a preference for voice. Clearly the level of acceptance of voice interfaces will increase as the technologies for text to speech synthesis improve. From our point of view, what is important is the need for a general and flexible framework that is able to support any form of interaction, including mixed-modes, and allow experimentation in real environments. The investigations to date have demonstrated that this is possible and the authors plan to compare alternative interaction modes in future user studies both in Zurich and in Edinburgh.

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