Smart Environments and their Applications to Cultural Heritage

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Workshop Introduction

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SUMMARY

Cultural and natural heritage applications have proved to be an attractive vehicle for ubicomp researchers. Several projects have developed data collection tools, museum or city visitor guides as a means of demonstrating various concepts including location and context awareness and smart building environments. Together, these represent two ends of the 'production' process of bringing cultural and natural heritage from the research environment to its consumers. The intermediate analytical, archival and curatorial stages are less well represented, but also provide considerable scope for ubicomp research.

The workshop invited researchers and practitioners from the ubicomp and heritage communities to share their experience, to envision future directions beyond existing demonstrators, and to examine directions towards deployable and interoperable systems. This volume presents the ten best papers received. They address many classes of ambient: touristic routes, cities, parks, archaeological sites, ancient buildings, and museums. They address the issue of using ambient intelligence to extend the users perception level, their learning abilities or their productivity; in fact the user is not only the information consumer but also the producer, as shown, for example in the papers on growing tour guides and on collecting context tagged data. Most are not focused on technology; rather they concentrate on its application, and they envisage strong support from the ambient intelligence in simplifying the interfaces (Bay, Garzotto, Ghosh, Jung, Li-Wei, Roffia) and in creating innovative services, and new expectations for the users (Sklenar, Niu). Or they describe approaches and propose ideas to understand the environment and its past (Malkin, Sukigara). One paper addresses the design of applications to be run in smart environments and provide guidelines for moving Multimedia Cultural Applications from Stationary to Mobile Location-Aware Devices (Garzotto).

Many papers show how to tailor information access and presentation to a user location recognized from various sets of sensors, but there is also one paper (Niu) that shows how to tailor information with respect to user preferences and interests, through the generation of personalized guided tours based on dynamic ontologies; this is an interesting research area that can boost the power of smart environments not only in the cultural heritage domain.

The authors originate from many parts of the world, including Africa, Australia, United States, Asia (Japan, Korea, Republic of China, India), and Europe (Belgium, Italy, Switzerland and UK), and, most important of all, they let us envisage a clear short and medium term research path towards the application of smart environments in the creation, management and dissemination of cultural and natural heritage. Such a path is strongly interdisciplinary, and this must be understood by the research planners: unfortunately, while the scientific committee of this workshop includes in the same percentage experts in technology, humanities and cultural heritage communication, most of the papers come only from Science and Technology institutions. However, the committee feels that a ubicomp research community and a market focused on the applications of smart environments to cultural heritage are emerging and intends to invite to the next events experts in the economics of cultural heritage and tourism.

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Keywords

Smart Environments, Ubiquitous Computing, Context Management, Cultural and natural heritage, Sensors, Human-Computer Interaction, Data Acquisition, Collection Management, Visitor Guides, Education, Edutainment.

1. BACKGROUND

The research area variously known as Ubiquitous Computing, Pervasive Computing or Ambient Intelligence derives much of its inspiration from Weiser's vision [1] of a third age of computing beyond the current 'Personal Computing' paradigm and the growth of the Internet. The vision is characterised by the ubiquitous presence of networked computing devices, on the person, in vehicles, in the fabric of buildings, in consumer products, etc. We are already some way towards this with embedded processors and mobile phones greatly outnumbering conventional computing devices but, in our present environment, only a minority of these devices are networked and even fewer are more than minimally interoperable. In this imagined future, we will interact directly with only a small proportion of the devices around us. Unlike today, where the computer is often the centre of attraction, many of these devices will be peripheral and will disappear into the environment where they will provide information, services and control functions as and when they are needed. In the ubiquitous paradigm, a personal computing environment should be truly personal in that it accompanies the individual wherever they go and whatever they are doing. It should not, however, be limited to the capabilities of our conventional desktop or laptop machines. Instead, it should also be able to adapt to its immediate environment and to make use of location specific services. Equally, the environment should be able to adapt to its occupants by offering services that most closely correlate with their needs.

For many reasons, applications in the domains of cultural heritage have proved to be especially popular amongst ubicomp researchers for demonstrating innovative ideas. Amongst these reasons are the inherent mobility of potential users, a wide diversity of attractive materials for presentation, and the potentials of tourism and associated markets.

2. UBIQUITOUS COMPUTING, CULTURAL HERITAGE AND UBICOMP05

To date, most demonstrator applications in the cultural and natural heritage areas have concentrated on data collection systems and on various forms of visitor guides. These have been seen as obvious applications of context-aware and, more specifically, location aware technologies.

Location-awareness has been an especially popular subarea of context-awareness. The technologies used are mainly short-range infrared, ultrasonic or radio signals for indoor applications, such as museum guides [2], [3]. Outdoors, Global Positioning System (GPS) receivers have been widely used for data collection [4] and urban visitor guides [5]. Some of the Workshop papers investigate these and also alternative solutions. Bay, for example, uses computer vision techniques to precisely locate the spotted object and to access related multimedia contents. We suggest that such precise location and orientation information provided by image analysis can be used in multisensor location systems to periodically correct accumulated position errors.

Many examples using location as a key aspect of context illustrate the idea of smart environments in which information and services applicable to immediate local needs are emphasised. In most cases, the locations of interest are typically those of the mobile user and of static exhibits and structures. The location of portable artifacts has received less attention, but there is clearly scope for applications that support the specialist analysis of collected data, and the management of museum collections.

A key ingredient in building context and location-aware services for smart environments is an infrastructure for managing and disseminating contextual information. We can now envisage the deployment of infrastructure support for the full spectrum of activities from initial data collection, through the essential analytical, archival and curatorial stages, to the end products of public and scholarly presentation, education and edutainment.

Applications need not be restricted to an individual museum or visitor site. The concept of ‘cultural routes’ (recently introduced by Neil Silberman and Daniel Pletinckx of the Ename Center for Public Archaeology and Heritage Presentation, Ename, Belgium) seeks to bring together related attractions within a region and to offer thematic routes that would be attractive to individuals and family groups pursuing self-organised vacations. This, in turn, adds complexity to location models, and suggests a link with more conventional navigational tools.

This wider range of scales brings with it a need for careful consideration of established ubicomp concerns, including:

1. networking and communications
2. the suitability of different devices for use in a range of situations
3. interoperability of devices and infrastructures
4. support for tool building
5. support for content authoring
6. and, of course, personal privacy .

Position papers addressing these and related themes were invited to the Workshop.

It turned out that, with the exception of the support for tools building (Bay, Li-Wei, Jung), none of the above mentioned system issues was directly considered by the authors. Most of them, instead, focused on their own application or on design methodologies, while the technology was mostly taken for granted, as pointed out by many of the scientific committee reviews.

The papers are therefore subdivided in the following sections:

1. Building context related knowledge bases
2. Methodologies for embedding contextual knowledge in mobile applications
3. Location and orientation subsystems
4. Ambient intelligence for outdoor cultural experiences

2.1 Building context-related knowledge bases

The main benefit of smart environments in cultural heritage applications is to increase the effectiveness of information access and presentation thanks to the knowledge of the user’s context provided by the smart environment itself. This implies that a comprehensive context-related knowledge base exists. Therefore there must exist proper methods to build such context-related databases and to make them smoothly available to the users. Two workshop papers are focused on this issue: Sklenar relies on today’s nearly global location awareness and connectivity to provide smart guide users with a means (i.e. a dedicated simple interface) to contribute to the knowledge base by adding new point of interest, and related metadata, such as location, description, and preferences of the potentially interested users.

Sklenar points out that such a simple system could contribute to the “growth” of unbiased and effective tourist guides, with many implied benefits, including the discovery of interesting locations well ahead to their appearance in the standard guides. The paper addresses both functional and system related issues, including inter-node communication, automatic preference related data access and implied privacy needs.

Ghosh, on the other hand, shows how a context-management infrastructure can be used by archaeologists in building a knowledge base that can be available to the researchers, but also, eventually, to others visiting the same area.

Both of these applications require a proper information flow from data acquisition to data presentation, and therefore raise interoperability issues, as pointed out by Garzotto.

2.2 Methodologies for embedding contextual knowledge in mobile applications

In the past, much access to cultural heritage digital presentations took place on the home PC or in virtual theatres, often far from the real exhibits. Virtual museums and virtual reconstructions are examples of such a usage model, where the user experience is confined within the software application, in a decontextualized space. New horizons disclosed when cultural heritage applications went mobile, offering an opportunity to use digital contents not to replace but to reinforce the value of the experience within a cultural site, when the visitor is in front of the materiality of the exhibits or naturally immersed in the addressed real context. To be effective, such mobile applications must be sensitive to the user context and must be developed according to specific design guidelines. Three papers address these issues.

Garzotto's paper analyzes the differences between stationary and mobile multimedia cultural heritage applications. It provides a comprehensive set of practical design guidelines to build a context-aware mobile application starting from a stationary version.

Roffia's paper shows how the use of context information can help to simplify the user interface of mobile multimedia guides, and argues that in this type of application the context can not be limited to the user's location and orientation. Rather a logical context component is required to identify the level of abstraction of the user's focus of attention, according to the hypothesis that it will always be possible to identify a hierarchy in the cultural heritage site organization. For example, in a museum with many displays of small objects, such a logical coordinate is required to understand if a visitor looking at a shelf is interested in an individual exhibit, in the set of exhibits located on the shelf or in the entire display case.

Niu's paper considers the need to personalize the mobile guide according to preferences initially set by the user. Once the preferences that act as components of the user context are set, the system, adapts the tour to the user's preferences using an approach based on ontologies. Eventually, the user can inspect the way in which the information displayed has been adapted, and may change their user model to improve the personalized behaviour of the guide.

2.3 Location and orientation subsystems

The development of smart environment applications requires a considerable integration effort, and suitable tools are required to support both application set up and algorithms verification.

For example, in the cultural and natural heritage domain we need to devise new sensory solutions in order to recognize the users activity and their focus of attention, with the goal of anticipating their intentions; research on sensor systems for wearable devices should be carried out, the main goal being to close the gaps — that is cancelling all discontinuities — between the visitor, the environment and the platform.

Similar challenges may have to be considered in other domains. Bay, Li-wei and Jung address three frameworks that use different technologies to support the implementation of location and orientation aware distributed, mobile applications.

2.4 Ambient intelligence for outdoor cultural experiences

The idea of a time machine that comprehensively visualizes the history of the cities is not novel. For example, back in 1999 it was used in a virtual reconstruction of Bologna city center, to cover the historical period from the XIIIth to the XIXth century (Nume project, [11]). This model could be enjoyed in a virtual theatre or on the web, but it could not be accessed aligned with the user's location on a mobile device.

Two papers in the workshop show that such a historical experience can be fruitfully enjoyed walking in today's cities. The lack of immersiveness of current mobile devices is compensated by the cognitive and emotional impact of simultaneous access to the reality and to the digital representation of its history. The paper from Malkin describes a digital graffiti system implemented in Manhattan, along a religiously significant boundary, the route of the former 3rd Avenue elevated train line. By deploying optical tags that provide hyperlinks from physical locations to the web, conceptually similar to the web-signs in the CoolTown program at Hewlett Packard Laboratories, web-based information can be accessed along the route, using mobile phones. Contents include text and photographs of the locations as they appeared from fifty to one hundred years ago.

Sukigara's paper considers the problem of collecting, sharing and using information about ruins and other remains, and suggests a location-aware time-machine to provide mobile users with a unified vision of the history, the politics and the religion of large civilized areas. To this end multimedia contents aligned to the user point of view but shifted back in time are presented, confirming in this way that aligning contents with the user's viewpoint is a very versatile technique that can be used in many cultural heritage applications, as also proposed within the workshop by Li-wei and Roffia.

3. ISSUES NEEDING FURTHER INVESTIGATION

Many ubiquitous computing issues remain to be examined by the "smart environments for cultural heritage" community. Some are outlined in this section.

3.1 Networking and Communications

Addressing communications over the range of scales envisaged in the previous section will require different scales of communication. This suggests that devices should be able to adapt transparently to the available networks, taking account of Quality of Service offered whilst minimizing costs to the user.

Reliability and availability of connection is also a well-known issue. When data collectors work in remote locations, mobile phone networks are invariably the only available form, yet even these may lack continuous coverage of many mountainous areas and locations far from population centers. Similar problems may arise, albeit less frequently, for those following cultural routes which pass through remote rural areas. Even indoors, where WiFi or Bluetooth connectivity is available, coverage may be partial or bandwidth may be reduced as the number of participants increases. The problem may be particularly acute in modern buildings containing large amounts of structural steel.

In summary, heritage applications will need to address the full range of connectivity and communications issues that have been recognized by the ubicomp community. At Ubicomp05, Workshop W13, organized by Prof. Shiro Sakata from Chiba University, is dedicated to wireless networking and communications in ubiquitous computing; the interested readers are invited to address to the related material.

3.2 Devices and Interoperability

So far, most heritage-oriented systems have typically been based around a single class of user terminal device, such as a production PDA. In a few cases, specialized devices have been developed to address limitations of commercial products. However, looking to the future, we must be prepared to deliver services to a variety of different devices, including special purpose terminals that are beginning to replace an earlier generation of audio guides, but also PDA-like machines and, especially, smart phones owned by the visitors.

Even if it is not yet clear whether a general-purpose "life navigator" [6] accompanying all of our mobile experiences may ever really exist, certainly current standard devices are often inadequate. For example, in the cultural heritage domain, it is doubtful that standard PDAs can be successfully used as museum navigators, for reasons including a lack of embedded context-management support, an inability to be accessed hands-free, internetworking bandwidth, and limited screen size and brightness

Better solutions may be provided by application-specific navigators with ergonomics optimised to meet the user requirements, and with functional specifications inspired by research in context management and activity recognition, context-based usability policies, context-based resource and power management, space modeling, and technology convergence. Mobile device architecture and design is a factor in the success of smart cultural and natural heritage applications and needs further investigation.

In the cultural route model, there is also a requirement for interoperability with vehicle and personal navigation systems, as well as across and, possibly, between support infrastructures. These infrastructures may be commissioned and operated by different commercial or governmental institutions, yet visitors will need to move smoothly between their coverages. There are many open issues of importance to the ubicomp community concerning how this might be achieved with a minimal impact on the developers, implementers and managers of these separate systems. Ideally we should be able to build once, yet interoperate with many.

Within the Workshop, Garzotto considers the need for a sort of interoperability between stationary and mobile devices called "cross-channel workflow". This is a requirement to support user-centric rather than device-centric ubiquitous computing already considered by other authors (e.g. the CMU Project Aura team http://www.cs.cmu.edu/~aura/). In cultural heritage smart environments the envisaged applications are, for example, the preparation at home of a personalized itinerary to be enjoyed en route with the support of the electronic guide, or the annotation of travel notes, to be developed when back home, at the home station. Key issues at the design level are, in this context, the interaction paradigms that assure smooth access to the user and consistent information flow between the "interoperable" devices.

3.3 Content Authoring

Usually, when we access a medium, two actors are involved: us and the medium itself (e.g. the computer, the stage, the television screen, the newspaper). In contrast, at a cultural or natural heritage site, and more generally in most mobile context-related applications, there are three actors: ourselves, the mobile device and the "target" of our attention, i.e. an application-specific real object (e.g. the exhibit in a museum). Multimedia content, therefore, should not surrogate the target real object, as normally happens in a DVD or on the Internet, but should be the catalyst of the "resonance" between the users and their environment. So, we need to find new cognitive models, new ways of mixing audio, video and text, new methods to handle interactivity and to create "contextual multimedia" for on-site access.

While the design trade-offs of context-aware mobile applications are clearly addressed in Garzotto's paper, the specific issue of content authoring was not addressed by the Workshop participants. In contrast, this issue is currently considered by many cultural institutions: for example, the contents under development within the MUSE project [7], are based on research carried out at two Italian museums, the Certosa e Museo di San Martino in Napoli, and il Museo di Storia della Scienza in Florence. The time has come to investigate content authoring methodologies for location-based services and the experience gained in cultural and natural heritage applications may have the potential to be used in more general frameworks.

3.4 Personal Security and Privacy

Privacy is a recognized issue in ubiquitous computing, albeit one that has received relative little attention. In the kinds of systems covered by this workshop, it will be an important consideration where many users will be expected to visit multiple sites/museums and where there may be benefits to the user experience to be gained by sharing information about the user's activities and interests between sites. Potentially there may be conflicts between personal privacy and commercial interests as different sites may be operated by separate companies who may view visitor information as commercially confidential. The issue of personal security and privacy is considered by Sklenar in his paper on growing a tourist guide with the contribution of the tourists: in such application, *"the device knows the tourist location and personal preferences, and is sending this data out to some server somewhere. Hence the mechanism to do this would have to ensure that a user's identity is kept secret. Randomly generated keys could be used to link requests with resulting generated location lists, making sure the server cannot link the data it receives to any particular person."*

At Ubicomp05, Workshop W4 organized by Prof. John Canny from the University of California, Berkeley is dedicated to privacy in ubiquitous computing; the interested readers are invited to focus on W4 website.

4. CONCLUSIONS

The papers presented here provide a snapshot of current research directions in several related areas. They have been grouped under four headings reflecting the topics addressed by their authors: Building context related knowledge bases; Methodologies for embedding contextual knowledge in mobile applications; Location and orientation subsystems; and Ambient intelligence for outdoor cultural experiences.

We began by suggesting that smart environments, ubiquitous computing and context-aware systems had much to offer to a broad spectrum of cultural heritage applications, ranging from the production of knowledge, through the research, management and conservation of collections, to public presentation. The papers presented here confirm our impression that the majority of effort to date has been focused on the two ends of this 'pipeline'. The application of ubicomp technologies across this spectrum of activities in a way that addresses the issues covered in section 3 (networking and communications, devices and interoperability, content authoring and personal privacy) remains a challenge to the research community.

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Workshop Organizers

Nick Ryan is a member of the Pervasive Computing research group in the Computing Laboratory at the University of Kent, Canterbury, UK. The group has a wide range of experience, particularly in deploying systems in rugged outdoor environments. He has worked in ubiquitous/pervasive computing since the mid-nineties, concentrating in the area of data capture and information access applications for use in the field sciences, including archaeology and ecology [4][8]. This work led to an interest in support infrastructures for a wide range of ubiquitous applications, including the development of the Kent MobiComp infrastructure [8][9].

Tullio Salmon Cinotti is a member and one of the proposers of ARCES a Research Center on Electronic Systems for Information and Communication Technologies at the University of Bologna, Italy. He works on context-aware computing, concentrating on applications requiring unobtrusive ambient intellegence. He is the coordinator of MUSE [7], the project originating WHYRE [10], a context-sensitive wearable computer for museums and archaeological sites.

Giuseppe Raffa is a PhD student at the University of Bologna and he is also a member of ARCES. He works on localization and context recognition in mobile indoor and outdoor cultural heritage applications, and he concentrates on the interaction between the sensors output and the human-computer interface.

All three are involved in EPOCH, the European 6th Framework Network of Excellence on Intelligent Heritage (www.epoch-net.org). EPOCH is a network of more than 80 European cultural and technological institutions joining their efforts to improve the quality and effectiveness of the use of Information and Communications Technology in Cultural Heritage. Ryan is a member of the EPOCH Board of Directors and is responsible for coordinating efforts in the areas of mobile, wearable and ambient computing. Together with three other EPOCH partners, Ryan, Salmon Cinotti and Raffa are currently involved in the EPOCH project CIMAD, an exploratory implementation of a framework for smart CH environments supporting distributed and mobile on-site applications, from data capture to public dissemination.

Building context-related knowledge bases

Growing a Tourist Guide

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ABSTRACT
In this paper, we propose how a truly ubiquitous tourist guide could be 'grown' by its users by ultimately relying upon them to be the suppliers of a comprehensive list of interesting locations. We describe how these locations would be added, and how they could be shared across an infrastructure to effectively reach all users that have an interest in them. We then outline how effective this particular strategy could be in reaching groups of users interested in particular cultural areas.

Keywords
tourist guides, cultural tourism, ubiquitous computing, mobile computing, learning, adaptiveness, smart environment, usability, context management, sensors

1. INTRODUCTION
The advent of mobile and ubiquitous computing technology in the past years has meant that more and more users now possess, and even carry at all times a device with a display, usable amounts of processing power and memory, and potential connectivity. As a consequence of this, and also due to current GPS and cellular cell infrastructures, it is also possible for these users to achieve location awareness throughout the world. This means that if an application were to be written in such a way as to utilize these resources and at the same time be compatible with a large percentage of existing (and future) user devices, it would be possible for it to become a truly ubiquitous system, available in most corners of the world. This potential has led us to have another look at the one of the much discussed applications of nomadic, mobile, and ubiquitous computing: the electronic tourist guide.

This paper is organized as follows: Section 2 provides an overview of current (electronic) tourist guides, with a mention of the problems and issues we believe are inherently present in them summarized in Section 3. Section 4 then describes how these issues could be overcome with the 'growing a guide' methodology we propose, with Section 5 dealing with the workings of our proposed guide at the user level. Section 6 deals with the influence our guide could have on cultural heritage applications, while Section 7 analyzes and concludes the paper.

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2. CURRENT SOLUTIONS
Current electronic tourist guides and systems can in our opinion be classified into three main categories:

- electronic maps
- location-aware electronic maps
- intelligent location-aware systems

These seem to be a natural layered evolution of one on top of another, with technological progress making each progressive evolution possible.

2.1 Electronic Maps
These are the most rudimentary electronic guides, and essentially consist of collections of electronic maps usually held on a PDA and accessed by the user whenever he or she wants to find a route or directions from location A to location B, or when he or she just wish to browse a map. The bulk of these systems are usually not context aware, not location aware, and generally not anything aware, and truly just serve as an electronic version of a standard printed map, perhaps with some added route generation features. A large assortment of examples can be found at: http://www.pocketgear.com/ in the 'Travel' section. Several of these solutions contain lists of locations that are believed to have some importance, (and can have their own symbol on the maps interface) and that can in some cases be updated via a server. A nice example of such an application is Vindigo [1], a feature-rich electronic map which works on your mobile phone.

2.2 Location Awareness in Electronic Maps
As the next evolution, a number of these electronic maps now have the possibility of using a GPS plug-in, which can make use of, for example, a Bluetooth GPS sensor kept in the general vicinity of a user's PDA. Thus the application becomes location- aware, and can be used to generate routes and location specific directions from the user's current position to a destination of their choosing. Examples include the Port@able Guide and Port@ble Navigator systems [2]. This form of context awareness is, in our opinion, the first key to the development of any intelligent tourist guide system.

2.3 Intelligent Tourist Guides
What we believe to be the next evolution in the electronic map application collective is the addition of some sort of intelligence. Usually this is in the form of suggestions tailored to the requirements of a user on the move, and in the world of tourism this means suggesting the most popular locations to visit in the tourist's vicinity. This might mean the most popular historic, architectural, modern, or recreational spots, city landmarks, or places of natural beauty.

Notable examples of systems such as the ones described above include:

- Gulliver's Genie
- Crumpet
- George Square

2.3.1 Gulliver's Genie

Gulliver's Genie (Genie) is a context-aware tourist guide for roaming tourists [3]. The main objective of the system is said to be "dissemination of context sensitive information to tourists with particular emphasis on meeting the needs and expectations of cultural users". What is interesting about this system is that it tries to provide multimedia content to a user based on his or her personal preferences through a multi-agent system. It also attempts to do this 'in a timely manner', via limited pre-caching of potential multimedia presentations of interest (based upon general location) until a user's future location is 'known' at which point the correct presentation is assembled and displayed. We believe in this particular example, the location prediction in conjunction with user preferences analysis makes for a powerful and smart tool.

2.3.2 Crumpet

This EU funded project is similar in essence to Genie, in that it also applies "location-aware services, personalized user interaction, seamlessly accessible multi-media mobile communication, and smart component-based middleware or 'smartware' that uses Multi-Agent Technology" [4] to the tourism domain. Particularly noteworthy about this system is the notion of learning user preferences implicitly through a statistical analysis of context history, namely the types of location that a particular user tends to visits more often. This is a feature which, if working correctly, could help a tourist guide system achieve more accurate and importantly far more interesting results for a dedicated user.

2.3.3 George Square

The George Square system is another intelligent electronic map, but this time with what we consider and important twist: it allows its users to add certain data into the system. Essentially, users of this system are encouraged to share their experiences with others through photographic, voice and location data. This data can then be viewed by others through a collaborative filtering algorithm that uses historical data of previous visits to recommend photos, web pages and places to new visitors [5], as suggested by previous visitors. We consider this use of collaborative ubicomp key, as will be demonstrated in Section 4.

3. ANALYSIS AND COMMENTS

One issue that we have identified with a number of intelligent tourist guides such as the ones described above, and which is definitely prevalent in the previous incarnations of electronic maps, is the problem of authoring location information. Most electronic maps and guides claim to have obtained their important location lists from 'reputable' sources in the form of various tourist bodies, heritage organizations, city councils, or popular newspapers. This is an understandable approach, as these listed entities are likely to have some form of the desired data, and probably have an interest in making this data available to as many tourists as possible. Another source might be other map sites, which might gather location lists for commercial reasons. But herein lie several problems.

First, we believe that data thus obtained must be naturally biased by the opinions of the body that compiled it. Hence 'popular destination' data obtained from a city council, for example, will not be a sound statistical analysis of all the city locations that tourists found beautiful or considered to be interesting, and why. Instead, it might rather be a broad list considered to be noteworthy by the locals, which (although usually a good indicator) could either be a smaller subset or a much larger superset of the locations that tourists actually find attractive. Any available metadata about any location so gathered will probably be further biased by metadata authoring due to similar reasons. In any case, this location/metadata tuple will be compiled for the average general tourist, and thus might have a broad category designed to satisfy the majority (and rightly so), but perhaps not be specific enough for someone with specific tastes.

With locations lists from commercial sources, we believe this issue is even more compounded, due to money issues. A restaurant guide of a town might not contain any establishments that did not register with the restaurant guide authors, or contain skewed metadata about those restaurants that paid a premium subscription fee, for instance. If such data is sold on, it would provide an electronic user guide with a usable basis, but we believe that a different approach altogether should be used.

Thirdly, many remarkable areas and locations around the globe are not covered by any location list database. Whether this is due to the fact that they might be in a category that is not covered in any location list, or in a country where luxury items such as location lists are unheard of, it means that traditional methods of covering these locations with electronic guides will fail.

4. A TOURIST GUIDE THAT GROWS

The solution we propose for dealing with the above problems is this: we believe that it should be the users themselves that should ultimately populate a tourist guide system with their own list of locations. Combined with a notion of a centralized location server and a way to share user-added locations between devices either via the server or directly in a collocated situation, it should be possible to dynamically generate a list of interesting locations far superior to any that could be generated statically by a tourist guide creator and shipped with their product. This list generation and update scheme that we propose is summarized in Figure 1 below.

Further, we propose that as each user creates a location within his or her device, and hence in the whole system, the user should provide metadata about the location. Hence, this location would then only be delivered to users which specify that they are interested in a particular type of location by making a comparison against some personal preferences data stored on their own mobile device. This approach does not directly exclude the initial seeding of the system with a list of widely accepted interesting location and metadata, but rather complements it. The initial seeding would ensure that the system is able to provide results from the first instant of being put in service, and refines itself as it goes along. Particular areas could then become populated by naturally generated patterns of user-defined locations via 'standard' usage by a number of interested visitors, with little work necessary before product distribution.

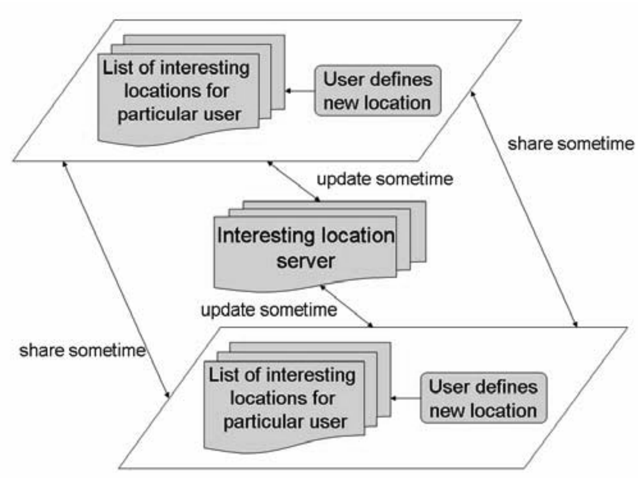

Figure 1. The location list generation and update scheme

One could also claim that such a scheme would allow for almost unbiased location list authoring, as the bias at the author end could easily be considered a plus at the recipient's end given the recipient has similar preferences. In essence a personal bias/preference could be made to work for better accuracy when suggesting to others with similar interests.

Further, this location generation scheme would allow for any corner of the globe to be populated with locations. This is of course assuming that GPS and/or GSM cells are now available almost everywhere.

4.1 Getting Updates from a Server

Users should be able to get an update of interesting nearby locations from the guide's central location server whenever they wish and have connectivity. A good idea would be to do it before a holiday, so doing an update for a known future location should be an option, as of course when arrived at the actual general location. Requesting an update when no connectivity is available should result in a scheduled event waiting for connectivity, at which point the update would happen automatically. Further, as the guide is location aware, we propose that it should proactively update itself when it notices that it is in a new location. Whether to actually do this automatically or not should of course be up to the user. In any case, we envisage that the general process would generally happen so:

Whenever an update is requested, the user's preferences and location (or future location) are sent to the server. The server would then be in charge of calculating a measure between the user's preferences list and all the locations available in the general vicinity (which would be definable). A list of <location,metadata> tuples would then be sent back to the user.

Although this is not in the scope of this paper, a very important consideration to make at this point is one about security and privacy: the device knows your location and knows your personal preferences, and is sending this data out to some server somewhere. Hence the mechanism to do this would have to ensure that a user's identity is kept secret. Randomly generated keys could be used to link requests with resulting generated location lists, making sure the server cannot link the data it receives to any particular person.

4.2 Collocation-triggered Updates

Further, as the spirit of this guide is in the collective effort of its users to build it up and make it better, we believe that it would be possible to make devices that use the guide update themselves by talking to each other when in close vicinity of one another. This could be initiated by the users, and could work in a similar fashion as users sharing mobile phone address book contacts via Bluetooth or IR, over coffee when discussing what they had just seen, for example.

It could theoretically be up to the device to occasionally search for other guides within earshot and initiate an update, and in this case security of the type mentioned in the section above would play an even more central role.

5. AT THE USER END

We believe that almost all of the infrastructure described in section 4 should in effect be hidden from the user. The user should of course have control of when and what to send/update, but once this is initially set up, updating the system could become automatic.

Essentially we propose that our system should have standard smart electronic map functionality with GPS navigation and route generation, and on top of that the following features should be present:

5.1 Intelligent suggestions to the User

Although the infrastructure from section 4 should ensure that a user only gets updates relevant to themselves, we believe that there should be an intelligent mechanism on top of that to ensure that location suggestions/information is delivered at the right time and in the right way.

The intelligent proactivity (or suggestion) mechanism we propose for our guide is loosely based on Figure 2 below. As one can see we expect to integrate the user's distance from a list of nearby appropriate locations together with the user's preferences and other available contextual data through an intelligent proactivity enabler, that would be in charge of formulating a suggestion on the user device.

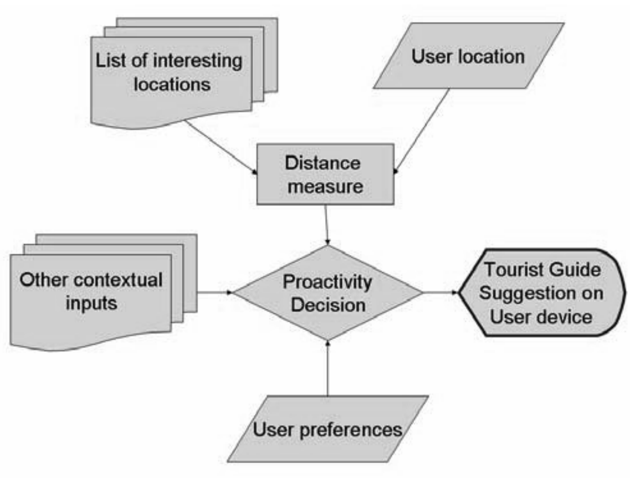

Figure 2. The user targeted suggestion scheme

Describing the details of this is not really the scope of this paper, however we are considering a Bayesian Belief Network approach. Key to this approach is the principle that a BBN may be both hardwired with initial response patterns, and also automatically learn and (re-)calibrate itself later. In fact, it can initially set up in a default mode, and then as it is being used it can learn from user activities, thus being able to automatically calibrate itself towards a particular user after it is deployed and as it is being used [6]. Further, with a satisfaction measure of the location just suggested easily available via analysis of the user response to the suggestion (i.e. was the suggestion followed?), a reinforcement learning scenario is also possible.

5.2 Adding locations

Whenever a user finds a location that they consider to be striking, important, or noteworthy in some way, we envisage that the guide should have an easily accessible button on its user interface that would allow a user to add a new location into his device (and into the whole tourist guide system by proxy due to the nature of the update schema).

Further, to make dissemination to users with similar interests possible, users should author information about locations. The data authored should include some keywords, a category classification, some data relevant to the given category classification of the location (e.g. if it falls under a 'place to eat' category, opening times & cuisine type might be an idea, etc..) and perhaps a picture if the device has a camera. A series of checkboxes on one screen should be enough to provide this data, with a possibility to add more later at the hotel for example.

A further enhancement we propose is that similar to the work carried out by [7], a user could potentially get a gentle 'nudge' to add a location if he or she spends considerable time at a particular location, or when GPS signal is lost upon entering a building.

6. CULTURAL HERITAGE RELEVANCE

We believe that the architecture described in sections 4 and 5 can be effectively brought into play when being applied to culture-specific or interest-specific applications. By this we mean that if one expert user visits a particular area, say Canterbury City Center for example, and is particularly interested in the subject of Norman architecture, then if that user adds a significant amount of locations labeled with 'Norman architecture' metadata, then his or her activity would enable future enthusiasts on that subject to come into the City center and use their guide for this subject specific tourist activity with great ease. Essentially, this aspect means that particular areas could achieve 'location seeding' by an expert user. This could of course be done manually in the locations database, but one would have need of the subject expert at some point in any case.

This in our opinion is a powerful feature, as it allows our guide to be easily configured for subject specific activities in particular areas, and in fact means that any area with a clear view of the sky (if using GPS) may beconfigured as an interest hotspot for a certain group of people with certain preferences. A large archaeological site could be 'populated' by experts from the heritage organization in charge of it for future guests, for example, rather than leaving this task to random visitors.

One important point we wish to make at this stage is that any such activity as described above would not interfere with any of the basic functionalities of the guide, and indeed the area would still be perfectly usable to any users with different interests and preferences. In fact areas of different interest could easily overlap, while allowing natural user-generated patterns to emerge as well.

7. ANALYSIS & CONCLUSION

We believe that a system like this is a step forward in that it has the potential to provide true ubiquity and unbiased service to tourists in most corners of the world.

It would be a system that learns from its users to better work for its users, and one which could intelligently and proactively suggest from a wide, unbiased list of locations that *you* like.

Further, its potential to seed areas by experts would make it a good choice for local entities in charge of tourism and heritage sites at particular locations or areas, as this feature would allow for localized delivery of information to tourists without having to develop any local infrastructure.

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Ubiquitous Data Capture for Cultural Heritage Research

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ABSTRACT
In this paper, we outline the MobiComp context-aware support infrastructure and a testbed application FieldMap that provides access to previously collected information and supports data collection in the field.

Categories and Subject Descriptors
J.0 [**Computer Applications**]: General, field sciences; J.5 [**Arts and Humanities**]: Archaeology; J.4 [**Social and Behavioural Sciences**]; H.3.4 [**Systems and Software**]: *Distributed systems*.

General Terms
Measurement, Documentation, Design.

Keywords
Smart Environments, Ubiquitous Computing, Pervasive Computing, Context-aware, PDA, GPS, Data Collection, Archaeology, Cultural Heritage.

1. INTRODUCTION
Our interest in this area began with the Mobile Computing in a Fieldwork Environment project (1997-2000) in which we began investigating how mobile devices and context aware software might benefit the field activities carried out in a range of disciplines, including archaeology, anthropology and ecology [1] Since the completion of that project, we have developed a simple infrastructure, called MobiComp, which is intended to support the development of context aware and ubiquitous applications. One such application is FieldMap, essentially a simple handheld GIS and recording system based on our earlier experience of field survey requirements. FieldMap acts as an advanced testbed for MobiComp, and has been developed over several years of close cooperation and field trials with archaeologists from the Groningen Institute of Archaeology in the Netherlands. The MobiComp infrastructure and the FieldMap application, both written in Java, are outlined here and described in more detail elsewhere [5].

2. FIELD SURVEY REQUIREMENTS
Data collection in archaeological research may take many forms. Whilst much work is confined to relatively inexpensive desk-, library- or museum-based studies of secondary material, including literature and artefacts, the highest costs are incurred in the field-based collection of primary material through field survey and excavation. Mobile and ubiquitous technologies have much to offer in these areas, particularly if they can help to improve the speed, efficiency and accuracy and to reduce errors in data capture. An early example of such systems applied to excavation is presented in [2] and a more recent example is reported at [3].

Unlike excavation, which typically concentrates on small areas such as parts of a single settlement or human activity area, field survey may extend to cover a region of hundreds of square kilometres. In its more extensive form, individuals or small groups may roam over a large area, visiting previously known and other potential settlement areas, and recording landscape features and artefacts found on the ground surface. This approach is often used as a part of the preliminary investigation of an area prior to more intensive and systematic survey.

Before undertaking a preliminary survey, archaeologists would normally have spent much time studying documentary sources and museum material to gain an understanding of previous knowledge of the area. Much of this information would have been entered into a GIS and associated database. However, whilst the use of desktop information systems is now the norm in archaeology, access to much of this information is also desirable when in the field.

In the past, this requirement could only be met by carrying paper-based information, including annotated topographic maps. In a rugged landscape, or in windy or wet weather, such material can be difficult and inconvenient to use. One of the key functions of FieldMap (figure 1) is to provide a single handheld source of all information relevant to the surveyor's needs. The device and its associated GPS receiver can be carried in a pocket until needed. During preliminary survey, the user's current location can be superimposed on vector or raster map layers, thereby aiding the relocation of previously known sites, and information about these sites can be displayed by tapping on their map symbols.

The second key requirement is context-aware data collection. The aim here is to minimise the amount of information that must be entered manually by annotating collected notes with contextual information. As a minimum, this includes user identity, date, time and location. FieldMap allows existing notes to be edited and new ones to be created. These may be associated with a single point location, or attached to simple geometric shapes such as lines, circles and polygons. The shapes may be drawn manually on the displayed map, or

Smart Environments and Their Applications to Cultural Heritage, UbiComp'05, September 11–14, 2005, Tokyo, Japan.

collected automatically using the GPS data while the user walks over the area of interest.

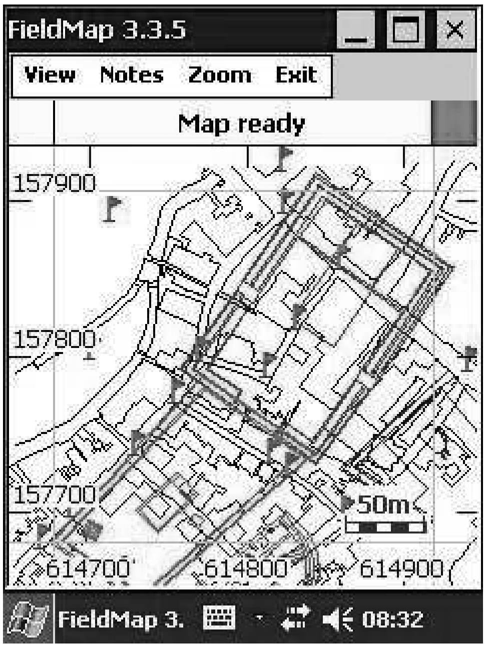

Figure 1: FieldMap map display showing multiple vector layers and clickable symbols representing previously recorded notes.

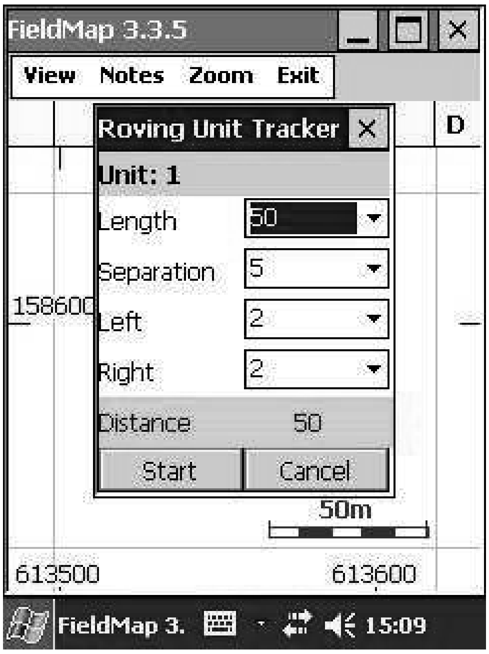

Figure 2: RovingUnitTracker dialog used to define the parameters for a survey unit.

Intensive survey methods typically involve a team of people systematically covering a landscape area and recording all artefacts found on the surface. The end result is often a set of map layers showing the density distribution of material of different types or periods. Approaches range from sampling to total coverage. A typical sampling approach is to use a team of, say, five people to collect material within 50x50m units. One member of the team paces out the size of the unit and marks its corners. The members of the team are then arranged 10m apart along one side of the unit. They then walk in straight lines to the opposite side, picking up all material found within one metre either side of their path. In this way, each member covers a two metre wide strip, with a resulting 20% sample of the covered area. At the end of each unit, the finds are gathered together, assigned an initial type and period and bagged for later study. Details of the unit location, size and all finds are recorded, usually on paper forms.

The process of pacing out the units before they are surveyed is time consuming, and the use of paper forms with subsequent transcription into a database is likely to introduce errors. Saving time and minimising such errors are the remaining key requirements addressed by FieldMap. Here, a RovingUnitTracker interface provides a mechanism for capturing all data needed to describe land units surveyed by the team. The geometry of the area covered is calculated from the number of walkers and their spacing which are entered into a simple dialog (figure 2). As the team moves forward, the dialog shows the distance covered and an alarm sounds once the required distance has been covered.

3. INFRASTRUCTURE SUPPORT

As described in [5], the core element of the MobiComp infrastructure is a context element store called the ContextService (figure 2). This represents a simple interface to a tuplespace, extended with event notification. It acts as a store for context elements and enables coordination between the components of context-aware applications. The approach here is similar to that employed in several other ubiquitous computing support infrastructures, for example the Stanford Event Heap [6]. Tracker components monitor sensors and other context sources and insert elements into the store. ContextListeners receive notification of put and remove events. Tracker and Listener interfaces may be combined to form context aggregators or to perform transformations.

In its minimal form the ContextService is simply a local cache for context elements allowing application modules running on an unconnected single device to share a common context store. More typically, the service is used in a connected or intermittently connected environment where ContextClient and ContextServer components handle communication between multiple devices behind the ContextService interface. Here, two modes of operation are possible. A more detailed outline of these different modes of operation is available at [7].

The first is intended to support simple sensor networks in a permanently connected LAN. One or more devices act as context stores. These receive context elements from simpler embedded devices, such as the Dallas Semiconductors TINI [8], and can respond to requests from other applications running in the network. The embedded devices run Tracker components to monitor sensors, and their local ContextServices include simple clients that, on joining the network, use multicast service discovery to locate one of the main services, and then establish a socket connection to pass their context elements to the service.

The second mode, more appropriate for mobile applications, uses an XML protocol over HTTP to pass context elements to one or more servers at known URLs. The protocol also allows applications to request contextual information about other devices from the servers. The servers act as central repositories and enable independent applications to share contextual information. When a mobile device contacts a server, its current network address and other capabilities are provided as part of its context. So, in an infrastructure-based or ad-hoc wireless network, individual devices may discover each other's addresses from any node acting as a central server. Mobile devices such as PDAs and laptops may include HTTP servers as part of their ContextService, so they are then able to directly exchange contextual information.

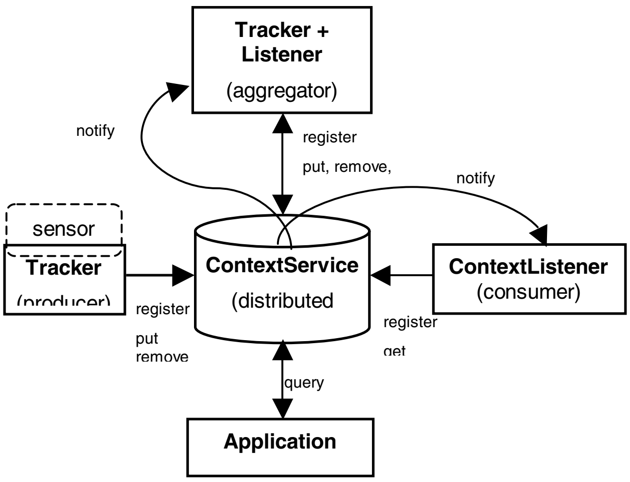

Figure. 3: The MobiComp infrastructure

However, whilst WiFi networks are suitable for applications intended for use within a limited area such as an urban centre, museum or visitor centre, their power drain on small devices limits their utility for field data collection. For the types of application considered here, WiFi is typically only enabled when the devices are within a small area such as a temporary field office.

Outside in the field, users may choose to run their devices in a disconnected mode, storing contextual information including all captured data locally. On return to the field office at the end of each day's work, WiFi is enabled and the devices attempts to connect to an HTTP ContextService running on one of the laptops in the office. Data collected during the day is then uploaded to the laptop server, and can be distributed to PDAs used by other field teams. In this way, each team starts the next day with a full complement of project data available on their PDA.

This approach works well for large projects in which several survey teams are active in the field over a period of several weeks. However, for smaller projects, and those where individual or small groups of specialists may visit the survey area at different times, an alternative, intermittently connected, mode may be more appropriate. Here, the PDA connects to the Internet at predetermined intervals via a mobile phone GPRS or UMTS link. Whenever a connection succeeds, recently acquired data is uploaded to a remote server, typically at the user's home institution.

This mode provides a near real-time tracking capability that would allow colleagues back at base to follow progress in the field. Although, this is rarely an important requirement of archaeological projects, it does provide an added benefit of increased reliability by providing secure backup of collected data and so protecting against possible PDA or other equipment failures in the field.

The HTTP server component is a Java servlet with equivalent capabilities to the *put*, *get* and *remove* operations of the ContextService. Unlike other implementations of the ContextService, it does not support the notification mechanism where devices register an interest in other devices, or specific context elements, and subsequently receive messages whenever these change.

When running on a small device, the infrastructure components include a small web server to support this, and other, servlets. HTTP request from the local or remote devices are then serviced by retrieving current context from the local store, typically the cache associated with the local ContextService. The cache is flushed to stable storage at regular intervals, overwriting previous values of context elements. Thus both cache and stable copy contain only current context elements. This same mode may be employed on laptops and desktops. However, for a field office server, or one back at the project base, it is more appropriate to use a DBMS to achieve persistent storage and maintain context history.

The current implementation of the persistent context store uses a PostgreSQL server, and takes advantage of the built-in rule mechanism to support historical queries. For example, it is possible to extract a client's location elements over an arbitrary period of time. An extension to the servlet XML protocol enables remote clients to use this capability. This store has proved effective over several years use with applications that employ a relatively small number of context elements with known semantics. However, the lack of a general query interface exposed through the servlet limits its potential for wider use.

However, as new applications are developed, new sensors become available, and an increasing number of people and devices are using the MobiComp services, the need to support much larger variety of context elements and tracker devices has become increasingly important. Our current aim is to allow new trackers to register new context elements together with information about their structure and semantics, and to allow clients to search for any form of relevant context.

The first steps towards this more generic handling of context is to enable trackers to register an XML schema fragment describing the structure and data types of the context elements that it may produce. To describe the semantics of the elements, trackers may also register OWL class definitions. Whilst these extensions are still at an early stage, we have also been working with an experimental context store that uses an eXist XML database [9] as the back-end to the HTTP servlet. Although, this makes the handling of historical context queries more difficult and, currently, rather inefficient when compared to the PostgreSQL database, it does allow us to easily add an XQuery interface to our servlet, with considerable potential for servicing arbitrary and potentially complex queries from clients.

4. EVALUATION

Since 2000, we have taken part in field survey projects undertaken by the Groningen (Netherlands) Institute of Archaeology at two field sites in Italy. This has formed part of a continuous program to develop and test FieldMap. Improvements and new functionality have been designed, implemented and tested in collaboration with the archaeologists who now consider FieldMap to be sufficiently robust and use it as a normal part of their research and student training.

Generally, the system works well and is sufficiently stable for production use by the teams of students participating in the Groningen survey campaigns. We are, however, always pushing the limits of PDA capabilities as new, experimental, functionality is added, and the scale of the field project data increases with successive seasons of work. Each field trial brings new problems, many of which can be traced to the limited memory of the devices, though we now have reservations about the Java runtime system.

We have been using the Jeode JVM, an implementation of the now outdated Personal Java, for the last few years. This runtime system is no longer widely available and has, for some time, been showing signs of age and lack of development. For the next period of field trials we hope to have completed the necessary changes to allow FieldMap to run under a J2ME CDC Personal Profile runtime environment and we will probably adopt the IBM J9 virtual machine [10] for this purpose.

Although the experimental wireless synchronisation is working, it is not being used yet as a part of normal field practice. Maintaining advanced databases and wireless networks is, we feel, too complex for many end-users to feel completely comfortable with the processes involved. In our next series of trials we will aim to provide automatic synchronisation between the PDAs and a master version of FieldMap running on a laptop, thereby hiding the complexities of the ad hoc network and database configuration from the users.

5. CONCLUSIONS

This paper began by setting the background to archaeological field survey methods and how these are addressed in the FieldMap application. FieldMap is a handheld GIS program designed to enable rapid data collection and information sharing in the field. It was built to serve two purposes; firstly to support experiments in the use of handheld devices in the field and, secondly, to provide an advanced testbed for the MobiComp infrastructure.

MobiComp, an experimental system for supporting distributed context-aware systems, was then briefly described. We also described current work on extensions to the MobiComp context store aimed at providing a more general and extensible ContextService.

Finally, we presented a brief evaluation of the system, pointing out some limitations and our plans to overcome them.

6. ACKNOWLEDGMENTS

We are particularly grateful to Martijn van Leusen and Peter Attema of the Groningen Institute of Archaeology. Since 2000, they have welcomed us as members of their survey projects in the Agro Pontino and Sibaritide [9] regions of Italy and, with many of their colleagues and students, have played an active role in the development and testing of FieldMap. Further development of MobiComp as part of an infrastructure to support smart environments across a range of cultural heritage applications is supported by the CIMAD project within EPOCH [10], the European Network of Excellence in Processing Open Cultural Heritage (IST-2002-507382).

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Methodologies for embedding contextual knowledge in mobile applications

Porting Multimedia Cultural Applications from Stationary to Mobile Location-Aware Devices: Design Trade-offs

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ABSTRACT
In this paper, we compare the peculiar design issues of mobile location aware applications against the design of more traditional (i.e. stationary) multimedia systems, and describe some critical design trade-offs. The discussion is funded on the experience achieved in several projects in the field of cultural heritage where we "ported" .interactive multimedia applications from stationary to mobile context aware devices. One of these projects is shortly presented in this paper, to exemplify the general discussion.

1 INTRODUCTION
Location-aware mobile devices enable the development of multimedia interactive applications that offer innovative experiences to end users. These applications create situations where users can experiment *real-virtual contiguity* (the real experience and the digital experience are interplayed), *enhanced reality* (the mobile device strengthens the quality of the real experience, while on stationary applications, the application *is* the experience), and *enhanced virtuality* (the reality strengthens the appeal of the digital experience). The *situation* in which mobile location aware applications are used (including the user's physical position, motivations and goals) and the peculiar *technological characteristics* of these applications (e.g., screen size, pointing tools, localization mechanisms, communication infrastructure) set a number of design *constraints* and introduce a number of new *design issues*. In this paper we discuss some critical *trade-offs* in the design of mobile location aware multimedia applications, and compare them against the design of more traditional (i.e. stationary) multimedia systems. Our "lessons learned" distill the design experiences we achieved during several projects in the field of mobile applications. One of them is shortly presented in this paper, as a case-study to exemplify our general discussion.

2. A CASE-STUDY
Within the EU-funded project HELP, we developed two multimedia interactive applications concerning the temporary exhibition of Edvard Munch's prints, held at the Kupferstichkabinett of the Staatliche Museen zu Berlin in Spring 2003 (www.munchundberlin.org). The first application (hereby referred as "Munch-stationary") was designed for a stationary fruition (also by persons with visual disabilities) on a traditional internet connected PC outside the exhibition site [4]. Its purpose is to promote the exhibition, to improve users' knowledge about the works of the Norwegian painter and their historical contextualization, and to offer practical support in planning a visit. After few months, we developed the second application (hereby referred as "Munch-mobile"), intended for being used on a mobile context-aware device during the exhibition visit. Munch-mobile runs on a standard palm-held device equipped with a mobile browser and a wireless network card. It exploits WLAN access points to access the internet and to detect the approximate user position (his current room) within the museum. Its goal is to amplify the users' experience *during* the visit of the exhibition, to help them find their way around, to strengthen the readability of exhibited objects by offering the relevant multimedia contents on site in front of the exhibits. The two applications can be regarded as two versions of a single *multichannel application.* They adopt the same "coordinated image" (in terms of colors and logotypes) and use the same software architecture, dynamically building the pages from a shared data base of multimedia contents and data structures. The software architecture delegates the presentation logics to the (stationary or mobile) client device, which manages user interaction and data (dis)play; and the business logic to the server, which interprets the requests from the presentation level, executes the data retrieval from the shared multimedia data base, returns the required contents and presentation templates to the presentation level via the network infrastructure using the HTTP protocol. Both the stationary and mobile versions provide navigable multimedia contents related to Munch's life, his graphic works (figure 1). and printing techniques, and practical information concerning the exhibition.They also offer interesting insides on Munch contemporary painters and of their works (which influenced, or were influenced by, Munch). Still, the two versions organize contents in different ways (in few cases, also managing different content items), and provide different navigation and interaction paradigms, as we discuss in the following section. The experience achieved in HELP and other projects (in particular, MUSE [6][10][11]), and a design-oriented review of existing literature [2][3][7][8][9] [12], has helped us to understand some trade-offs that a designer may need to face when developing a mobile context aware web applications, either "from-scratch" or by porting an existing stationary application.

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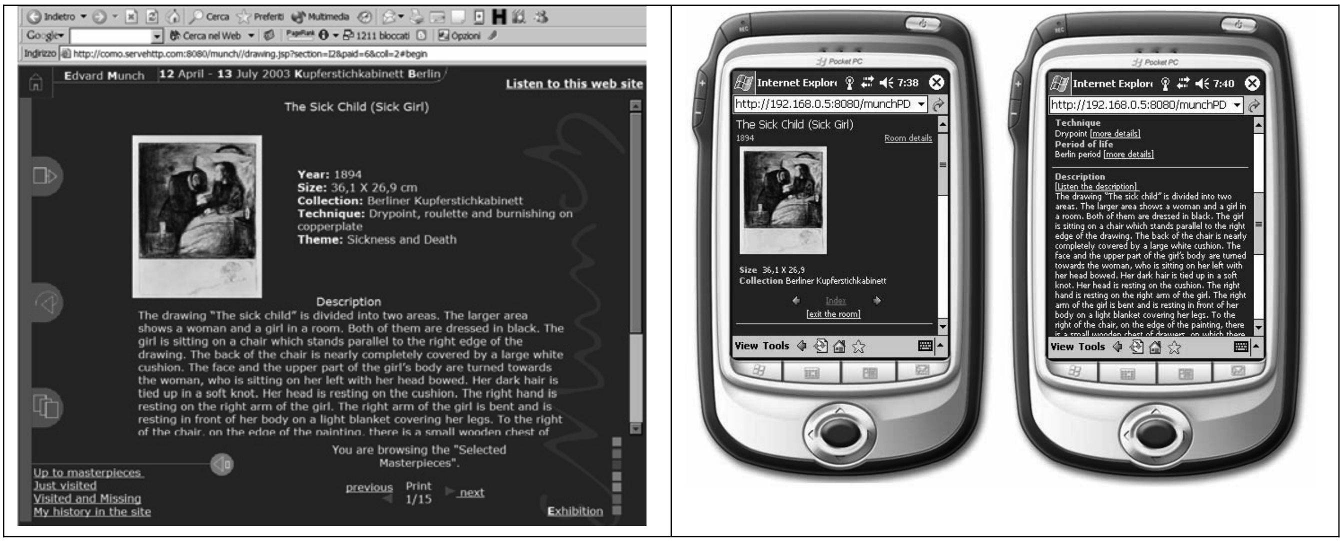

Figure 1 – A "page" about a Munch's print in the stationary (left side) and mobile version (right side)

3. DESIGN TRADE-OFFS

Trade-off 1: Text and Audio

A long text is obviously not appropriate for a mobile device screen, since it would require too much scrolling to be read. Long texts should be either shortened or split in parts and presented in multiple screens (see figure 1). In addition, we must consider that the main concern for a mobile application (unless it is for pure entertainment) is to amplify the user experience with the surrounding real world: the device should support the real experience, and not be the essence of it. In a museum, for example, the user should look at the exhibits, rather than the device screen.

As a consequence, it might be more appropriate to replace a long text by an *audio*, rather than to restructure it. Audio is particularly appropriate for mobile devices: it has limited network performance requirements, does not require any screen space, is non intrusive w.r.t. the on-site experience, and is something the user is very familiar with (thorough audio guides, for example). If in principle the audio file can be automatically generated from a pre-existing text, the results may be of poor quality – a text conceived for being read is different from a text conceived for being listened to. The best solution, in the end, might be to create an "ad-hoc" small audio script from scratch.

The semantic role of some types of text and audio elements is strengthened in mobile context-aware applications.

Explanatory audio, for example, is an ideal way to convey information about the use of the application without demanding too many interactions: it could be used to explain the meaning of the various interaction elements, or to give help if needed. In low-graphic applications, an *orientation text* saying to the user where he is and where he may go can be a surrogate of visual maps, to help the user to understand his current location. In museum applications, textual information about the number of pieces in the different rooms, the estimated time of visit for each room, or the duration of a guided tour. are useful information (while they have a limited interest in stationary museum systems).

Trade-off 2: Images.

On a stationary device, looking at a big, high quality digital picture (e.g., of a painting) can enhance emotions and increase the understanding of the presented object. In contrast, during mobile device fruition, the true emotion and cognitive experience should be provided by the view of the real object. Full screen images of the same object on a mobile device are technically demanding and do not offer any significant added value to on site user experiences.

Trade-off 3: Time-Based Media.

With the exception of audio, time-based resources such as video, animation, and interactive 3D are technically demanding (in terms of bandwidth and processing power) and should be designed having in mind their effective *utility* for the actual situation of use. For example, 3D interactive representations of museum building(s) and rooms can be engaging for the user of a stationary web application, in a context far away from the physical museum. They are probably of no interest for a visitor who is inside the museum and can perceive the physical space and the arrangement of artworks just by looking around. In contrast, 3D virtual reconstructions of an archaeological site can be appealing both on a stationary and a mobile application. On a mobile application they can even amplify the user's emotion of being on-site and improve his understanding of the place. Similarly, a video interview with a painter might be more exciting for the user in front of the painter's work than during a remote stationary fruition, and would justify a temporary distraction from the vision of the painting.

Trade-off 4: User Interaction

In mobile devices, small size and low resolution of (most) displays, and awkward pointing mechanisms, constrain the number, size, and spatial position of interaction elements that are simultaneously presented on the page. In touch screen based devices, for example, interaction elements must be big and very few. Direct pointing tools such as pens on PDAs support a larger number of smaller interaction elements that in principle can be located anywhere on the screen; still, pens are difficult to manage by a user in motion. Applications that rely upon vertical and horizontal scrolling only should limit the number of interaction elements because scrolling is demanding for the user. The use of hardwired buttons only (the solution adopted for example in the MUSE system) has been proved to be very usable but is economically very expensive, and has limited scalability (in order to add or delete an interaction element, the case must be re-designed, and some hardware components must be modified). For similar reasons, data input operations need to be minimized. Mobile devices can be equipped, in principle, with a fully alpha-numeric keyboard, but this creates usability problems while moving around. "Indirect" means for mobile data input, such as a visual keyboard on the screen or handwriting character recognition, require pens, or involve intense scrolling, and cause the same drawbacks above discussed.

Trade-off 5: Navigation Topology

Since information structures may be restructured, navigation paths must change accordingly. For example, if a content piece that fits in a single "page" on a stationary device needs to be split in several "pages" on the mobile (figure 1), these pages must be connected by proper ad hoc navigation links. In addition, the *navigation patterns* [5] that may are appropriate for a stationary application might need to be modified when going mobile. For example, the characteristics of the pointing devices, which support traversal and horizontal scrolling more efficiently than random selection, suggest that *index navigation* (i.e., direct pick-up of an item in a list) should be integrated with (or replaced by) *guided tour navigation* (i.e., back-and-forth sequential scanning).
Furthermore, long lists of links must be split in multiple short lists and links to move from one sub-list to another must be provided. The criteria for grouping information entities and their access links must be tuned on the mobile context. In a mobile application for a large fine arts museum, for example, "visit duration" and "physical vicinity" can be meaningful criteria to collect groups of paintings for on site itinerary (and the corresponding links in itinerary start page). The same criteria are much less relevant for a virtual guided tour on a stationary application. On a mobile device, the collection of "highlights" should collect the "best" painting that are physically exhibited on site at the time of the visit, while the stationary application may focus on the museum best artworks in absolute terms (even if some of them are not on show during a session of application use).
During navigation design, the designer must specify the *access state* under which a composite multimedia object is accessed by effect of link traversing – i.e., the content pieces that are first (dis)played when the link destination object is delivered to the presentation device. The definition of the access state may differ in mobile and stationary applications. For example, when the user has access to a painting object on a stationary museum application, he is typically presented with a combination of text and image(s); audio, video, or 3D elements are usually retrieved by effect of additional user's interactions. In contrast, when a painting object must be shown to the user using the mobile version in front of the real object, the audio should be the first piece of content delivered about the painting (see tradeoff 1).

Trade-off 6: Infrastructure Failure Recovery

Mobile devices can communicate with peers and stationary devices, both locally and remotely, at different degrees of performance and capacity depending on the different network connection modes (GPRS, UMTS, Wireless LAN, Bluetooth). Designers of mobile applications must face the fact that mobile devices typically operate in a highly "dynamic" network environment and the communication infrastructure may have a potential "fragility". A mobile device may connect and disconnect dynamically to (mostly) wireless networks, which in general expose a more unstable behavior in terms of variation of available bandwidth and delay than their wired stationary counterparts. In addition, wireless networks occasionally may not even be available at all for a short period of time (when the device owner is driving through a tunnel, for example). Therefore the system software *and* the user experience should be designed to take into account these technological drawbacks, deciding, for example, what happens to the user when he gets "disconnected". (In the MUSE project, for example, using the "help" button the user can require a new connection when the current one is lost.)

Trade-off 7: Location-Awareness vs. User Control

In a non location-aware application, the user is in control of what is presented on the device: the content is (dis)played in response to user's explicit interactions. In contrast, in a location-aware device, the application can take the control, presenting new information on the screen in response to user's position changes. Different degrees of interplay can be conceived between these two control paradigms, to address different user profiles in different situations of use:
i) *only location aware control is offered* (and, consequently direct user control is excluded). The visitor can "consume" (see, hear, interact with) only the virtual objects proposed by the device, and there is no way to get information that does not directly correspond, at design time, to the current context, although it might be of interest for the user. This solution has advantages for users who are afraid of technology or simply prefer to stay totally passive during the museum visit. The same solution can be frustrating for more pro-active users.
ii) Direct user control and location-aware control are both available, but are *mutually exclusive.* If the user is interested to something related to the object(s) prompted by the device, he can access the desired information, and navigate the surrounding hyperspace, but the location-awareness becomes off and does not interfere with the user navigation. The advantage of this approach w.r.t. the previous one is that the user feels more in control, but the disadvantage is that he must understand "who" is in control at any time (himself or the device) and how to take the control for navigation. The interplay between free, user controlled navigation and application controlled presentation must be carefully designed to avoid usability problems. The interplay can be either under the user control or implicit. In the first case, the user is responsible to turn location awareness off (to navigate) and on. In the second case, the interplay rules are hardwired in the application behavior. For example, the location awareness may become automatically suspended when the user selects links to objects not directly associated to the current location, and may return active and in

control of presentation when the user accesses an information resource "directly" relevant to his current location.

iii) *User control and location-aware control coexist in a synchronous mode.* This means that if the user is interested to something related to the "object(s)" corresponding to his position in the physical space, he can freely navigate the virtual space and access the desired information while the location-awareness behaviour is still active; location awareness takes the control as it detects a change in the user position. For this approach (adopted in Munch-Mobile), location accuracy should not be excessively fine-grained: if the application can intercepts "small" physical movements of the users while he is navigating in the hyperspace, it can also abruptly replace the "current object" the users is exploring on the device, introducing obvious disorientation effects.

Tradeoff 8: Location Awareness and Time-Based Media Behavior

What happens when the mobile applications detects a change in user position *while a time based information item* (e.g. video or audio stream) *associated to his previous position is still playing*? Should the item be played "immediately" replaced by something else, according to the user new position? Or should it be kept playing, and replaced only when it is finished? The choice between these two approaches depends on several aspects, including the location model adopted by the system, the duration of time-based media and their semantic relevance for the on-site user experience. The first approach (i.e., immediate replacement) would be too intrusive for applications adopting a very accurate detection mechanism. For example, the user would be disoriented if the animation he is looking at suddenly disappears because he has turned the device (perhaps unintentionally) towards a different direction. Still, a similar mechanism would be at some degree acceptable in coarse-grained location aware applications. In Munch-mobile for example, a user may accept or even expect a change of the audio stream when accessing a different room (also because by that time the audio stream might be almost over). To improve usability, a solution might be to alert the user about the detection of a position change, and to leave him the decision of continue playing the current object or to replace it.

Tradeoff 9: Interoperability and Cross Channel Workflows

Multi-channel applications must be *interoperable* not only at the technical level, but also in terms of *cross-channel workflows* for the end user. To clarify this concept, let us consider the following scenario. A user at home is using the stationary "version" of a multichannel application for cultural tourism, and wants to decide where to go in the territory during his next cultural trip. He "marks" the specific points of interest, e.g., selecting the museums that he wants to visit and what is more interesting within each museum. He also asks the system to propose the most appropriate itinerary according to his profile, and stores this proposal in a kind of "shopping bag". During the trip, while using the mobile version of the application in the car or inside a museum, he exploits the "customization" carried on at home, and retrieve (or is automatically prompted with) the personal itinerary identified at home. [1] During a museum visit, he uses the palmtop to select the works that have been more impressive for him, also adding short comments and annotations on the fly. They will represent the memory of his visit and points of departure for further investigation later on. At home, he accesses the stationary application and retrieves the list of (annotated) works selected at the museum, to explore the associated multimedia resources made available by the application for an in-depth understanding of these objects. In this scenario, the key issue for the designer is to identify the user requirements for cross-channel workflows, and to define interaction paradigms that make the transition from one device to another smooth and consistent for the user.

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Adaptively Recommending Museum Tours

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ABSTRACT

We believe that a user should be able to *scrutinise* the beliefs a system has about him/her, namely the user model, as well as be able to update that model. A MyMuseum prototype of a scrutable and personalised museum guide has been built to explore ways to visualise how the system adapts to the user and the reasons for the adaptation. As a result of the evaluation, we propose to improve the process of recommending a touring path by using an automatically built dynamic ontology.

Keywords

User modelling, museum, scrutable system, multi-ontology, recommendation

1. INTRODUCTION & BACKGROUND

According to Petrelli [7], most museum visitors welcome some sort of guidance. That is, to some extent they would prefer to receive recommendations regarding what to see, instead of browsing the museums autonomously. Despite this, most of the electronic museum guide prototypes that have been developed so far do not include personalised recommendations concerning the sequence of exhibit(s) to visit. Most of them instead focus on audio-visual augmentation (e.g. [2], [4]), unobtrusive personalisation of information delivery (e.g. [6], [10]), or less user-oriented technicalities (e.g. [8], [3]).

Museum curators and exhibition designers try to arrange artefacts strategically so as to facilitate coherent tours. However, exhibits may be organised in a number of different ways. For example, an archaeology museum may choose to place artefacts with the same origin in the same vicinity (e.g. a mummy may be placed next to an Egyptian sarcophagus). A visitor, on the other hand, may come to the museum to see the wide variety of ancient ceramics. In this case, the visitor will have to look for the ceramics among the other exhibits and might even miss some of them. Since a physical museum can have only one physical layout, it is desirable to be able to tailor a touring path according to the visitor's interests and goals of the visit. While it is neither economical nor feasible to provide each visitor with a human guide, some of the flexibility and personalisation of a one-to-one tour would be a valuable way to enhance the museum experience.

While the concept of personalised information delivery is becoming widespread, the idea of being able to *scrutinise* how the information has been adapted is uncommon. We have been exploring ways to build personalised interfaces that put users in control of the personalisation by giving them control of the machine's model of them (i.e. their individual user models). This means the users should have the right to scrutinise their own user models and update them if they wish to. In addition, we want to support user scrutiny over the personalisation process. This would require a way to visualise the user model, as well as the way it is used.

We have built a MyMuseum prototype of a scrutable museum guide. It provides a mechanism for the user to see how information delivered is adapted to him/her and why. The next section gives an overview of MyMuseum, which is followed by the architecture of this system. In Section 4 we present a user study that we have conducted. And finally, we conclude with some insights derived from this evaluation.

2. SYSTEM OVERVIEW

MyMuseum was intended to 1) build a nomadic museum guide that tailors the presentations to the user's interests and preferences, and at the same time 2) allowing the user to visualise what has been adapted to him/her and why. The testbed we used was the Nicholson Museum[1], the first Australian archeological museum, located at the University of Sydney campus.

Before using the tour guide, the user must be authenticated in order for the system to apply the corresponding user model. In the case of a first-time user, the system asks about the user's goal of visit. Then it initialises the user model by making stereotypical assumptions [9] for the value of each user model component. For example, if a first-time user indicates that the goal of her visit is to learn more about Troy, the system will make inferences that the user wants more detailed descriptions for each artefact about Troy, as well as external references/sources for it.

The following elements are made adaptive in this proto-

[1]The Nicholson Museum: http://www.usyd.edu.au/nicholson/ (accessed on 23 June 2005).

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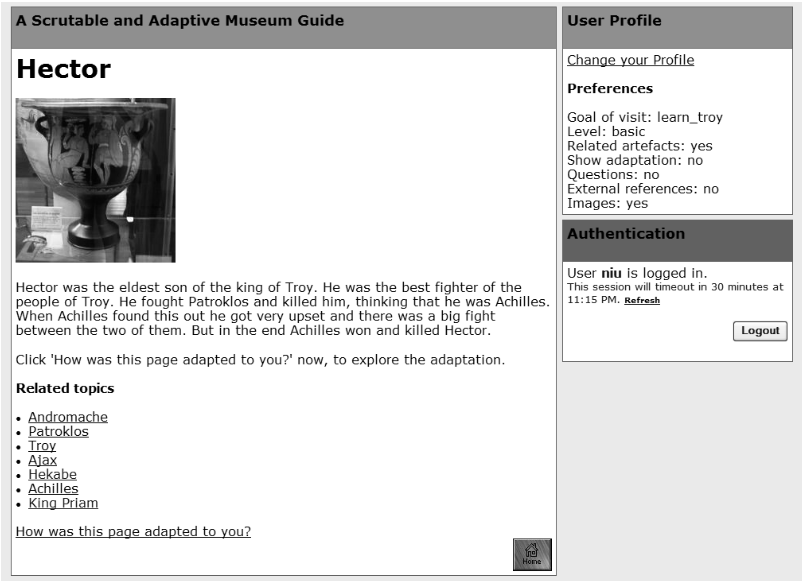

Figure 1: An Example Content Page

type:

- The level of artefact description: basic/advanced.
- Displaying questions for the artefact: yes/no.
- Displaying external links/resources: yes/no.
- Displaying related artefacts: yes/no.
- Displaying image of the artefact: yes/no.
- User's goal of visit: "learn about Troy"/"general museum visit"/none

Figure 1 demonstrates a page of the system that adapts to a user. The main *cell* displays adapted information about an artefact, in this case, a vase about Hector. A name, an image, and a brief description of the artefact, as well as some links to the related artefacts are shown according to the user model. The top right hand cell with the header "User Profile" displays a summary of the user model. This makes it clear that the personalisation is based on the values shown here. The user may click on the "Change your profile" link to update the values, and thereby change the user model.

If the user ever wonders how the system adapts the information delivered to him, he can click on the link that says "How was this page adapted to you?" at the bottom of the page, and a page like Figure 2 will be generated.

Parts that are highlighted with the lighter (yellow) colour were included. In this example, the first few lines were provided because of the user model values. They are the same as the first paragraph in Figure 1. Parts highlighted with the darker (green) colour were excluded. For this user, it was a much longer text, since his user model indicates that he requires a basic level of descriptions delivered to him. By placing the mouse cursor over the highlighted regions, the user may get a brief explanation, as a tooltip, explaining why the system included/excluded that part. Should the user be dissatisfied with the presentation, she can update her profile by clicking the "Change your profile" link.

Figure 2: Scrutinising the Adaptation

3. SYSTEM ARCHITECTURE

This prototype system is based on a Web framework called Cellerator [2]. This simple yet powerful authoring tool integrates well with Personislite, a lightweight version of Personis [5] which manages user models. The Web-based interface, adaptability, and controls for scrutability make it a suitable adaptive hypertext system for building up this prototyping.

[2]http://www.it.usyd.edu.au/~bob/web.cgi?Cellerator

User Modelling

The personalised information delivery is controlled by the user model. The current prototype uses a very simple user model with only seven components. Six of them are listed in Section 2, with one missing being a flag indicating if the user currently logged in is a first-time user. This component is used by the user modelling system to decide whether or not to initiate a new user model for that user. In earlier work [1], we have modelled users by exploring evidence of the duration of time the user has spent viewing or interacting with a particular digital object. In MyMuseum, this will map to the time spent at a museum exhibit. Based on this evidence, the user modelling part of MyMuseum can draw conclusions about user preferences and from this, tailor the delivery of information.

User modelling with Personislite allows adaptive systems to easily manage evidence for user models, and provide mechanisms to handle changes, noise, and other forms of reasoning under uncertainty. It utilises *resolvers* to conclude a value for each user model component based on this evidence. These resolvers are crafted by the system designers with scrutability in mind. For example, the simple point resolver uses the last most reliable piece of evidence to conclude a value. More complex resolvers can make knowledge intensive interpretations of all the evidence for a component (e.g. taking account of the timing of the evidence, the source, and its reliability).

At any time, users should be able to ask the system why an adaptation delivered by the user model was performed, and the system should respond with the interpretation of the evidence that lead to the adaptation. With this in mind, the same resolvers can be accessed by different devices, with the results tailored at the device level to be appropriate to the interface.

Exhibit Ontology

As discussed in Section 2, one of the core tasks of MyMuseum is to recommend a touring path through the museum. Essentially, this involves two tasks: finding artefacts that are similar to one the user has just enjoyed visiting or, in the case that the user does *not* enjoy the current artefact, recommending something that is different on the dimensions that affected the user's assessment with this artefact.

We are currently focusing on the reasons why users enjoyed an exhibit (or conversely, did not enjoy it) that are due to their interest in the aspects that the exhibit presents. This means that we focus on the semantics of the information presented in this exhibit. We are well aware that this is not the only factor in determining user satisfaction and interest. However, it is one crucial factor, especially in the case of museums which are visited by students as part of their formal education programmes.

The approach we are using to tackle this is based upon ontologies. Essentially, an ontology captures the meaning of concepts in terms of the relationships between them. So, for example, Paris is related to Troy because he was a prince of Troy. The core idea we are exploring is that if the user enjoyed an exhibit that was about Troy, they may be likely to also enjoy another exhibit that deals with Paris. To apply this approach, we need an ontology which captures relevant relationships. At one level, the simplest approach is to handcraft a suitable static ontology. This is the approach taken with MyMuseum. However, there are problems with this approach. First, it means that someone has to undertake the laborious task of creating the ontology. Even more serious is the problem that it is probably not possible to define a single static ontology that suites all purposes and all users. In particular, in the museum where we work, there are several major classes of users, including, for example, primary school students visiting as part of their school syllabus, final year school students of ancient history as well as university students in archeology courses. Taking the case of the primary school students, the important relationships between exhibits are defined by the knowledge of those students and the topics in their syllabus, as well as the particular areas their teacher has recently introduced.

To cope with this diversity of needs, we have taken an approach which automatically builds ontologies from existing documents, such as the primary school history syllabus and texts as well as the senior high school syllabus and resources on topics within that syllabus. Essentially, we aim to automatically build a dynamic ontology to drive the recommendation process.

From a theoretical view, this means generating a number of different ontologies from different sources (e.g. a dictionary, a textbook, a Website, etc.) for the exhibits. Depending on the visitor's interests and background indicated in the user model, one or more ontologies may be used to construct a suitable list of recommended artefacts to visit next. The visitor may scrutinise how the system decides the recommended artefacts during the tour, and she/he may update any invalid beliefs the user modelling system holds about her/him.

From the perspective of Personis, each relationship between two exhibits is modelled as a (exhibit model) component. Each component then has a list of evidence that states how the exhibits are related as well as shows the registered sources that reason about the relationship. For example, a component states that Paris is related to Troy. The list of evidence attached to this component is in the format of `<relationship>, <evidence source>, <scrutability support>` that may be:

- princeOf, High school history textbook, (parser1, URI1)
- returnTo, In2Greece[3] online source, (parser2, http://www.in2greece.com/paris.htm)
- princeOf, In2Greece online source, (parser2, http://www.in2greece.com/paris.htm)
- destructorOf, Mythology Website, (MECUREO, URI2)
- sameContinentOf, Geography, (parser3, URI3)

The first word, separated by commas, describes the relationship between the terms (i.e. Paris and Troy). The second set of words specifies the source of this evidence, and the third set is a pair that provides a reference for scrutability control, namely what software has been used to extract this relationship and the original location of the source (e.g. a page number, an URL, a line number, etc.). The original location of the source is used to present explanations of the system reasoning.

As the relationship may be found multiple times in a single source, there could be multiple entries of evidence in the

[3] A Website about Greece that contains Greek mythology (http://www.in2greece.com, accessed 29 June 2005).

component. For example, Paris was a prince of Troy, and he caused the destruction of Troy. It is perceivable that some evidence may be more relevant to the visitor than the other. A high school student, for example, may be more concerned about the relationships of the terms that appear in the textbook than the ones in Mythology Website. Hence, when evaluating the relationship for a particular visitor, each piece of evidence may be assigned different weighting depending on the sources and the visitor's background and interests. In the case of finding a relationship between the prince Paris and the city of Troy, the evidence from Geography of Europe, which would probably mistake Paris as a city, could well be irrelevant. The visitor may scrutinise how the weighting is assigned for each source. If the user wishes, he/she can either change the weighting or update his/her user model.

4. EVALUATION

A small-scale, qualitative evaluation was carried out with seven participants, three women and four men. Two of them were experts in ancient history as they were in the midst of completing their honours thesis in this subject area; the rest of them had relatively limited knowledge of ancient history. None of them had used any sort of interactive museum guide previously, and all had a relatively low understanding of information technology. There were a total of 32 web pages used in this evaluation, with 28 of them being adaptive.

The participants were asked to use the system as if: 1) the system knew where they were looking, 2) the appropriate page(s) automatically appeared, and 3) they were in front of the artefact(s). Participants after they used the system then completed a questionnaire in three sections: awareness of scrutability, quality of information, and user interface.

The participants showed signs of not being used to the idea of scrutinising the adaptation. However, all users indicated that at some point they had examined their own profiles and made some changes in order to understand the difference between each of the settings. Regarding the quality of information presented, all users agreed that the adapted tour furthered their knowledge in the Troy era. Nevertheless, the response to the links and references to additional material suggested that these were mostly suitable for users with more background knowledge and interests. Hence, another level of content adaption seemed to be necessary to delivery better personalised information. In the user interface section of evaluation, the responses suggested some improvements were yet to be done. The main reasons were cluttered text on some pages and the obscure location of the "How was the page adapted to you?" link—at the bottom of the page.

Overall, the participants all found the system useful for a museum visit, although the "wow factor" [3] frequently posed a problem in terms of getting the participants to evaluate the intended usability issues.

5. CONCLUSIONS

A MyMuseum prototype has been built to explore ways to visualise how the system adapts to the user, as well as the reasons for the adaptation. From the evaluation carried out, it was clear that the concept of scrutability was not well perceived. While designing a system with scrutability in mind, we will also need to design it so that it is both user-friendly and easy to perceive the concept.

One insight that was gained from the evaluation is the use of a dynamic ontology to deliver personalised recommendation of a visiting path. We will soon be implementing this onto MyMuseum using Personislite and expect to carry out another user study later this year.

6. ACKNOWLEDGMENTS

We would like to thank Smart Internet Technologies Cooperative Research Centre for funding part of this project.

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Context Awareness in Mobile Cultural Heritage Applications

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ABSTRACT

In this paper, a novel definition of *Context* is presented along with its usage in a Mobile application for Cultural Heritage (CH). The proposed approach is pragmatic and takes care of practical issues that need to be addressed when an implementation has to be built.

Examples are shown of how the context is used for three different purposes: context-aware media retrieval, user orienteering and sensor-driven active contents control.

Keywords

Context Aware Applications, Mobile Systems, Cultural Heritage, Sensors, Multimedia, Human-Computer Interaction.

1. INTRODUCTION

"Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives." [7].

This was Mark Weiser's idea in the far off 1991. Till now, many researches based on this concept have been carried on and different applications, with different aims and in different fields, have been developed.

The definition of context presented in this paper has been used to gain access to CH multimedia contents during a visit to a museum or an archaeological site. The contents are retrieved basing on the context of the visitor; furthermore, the context itself can be used to control the obtained contents. We call this kind of contents, *Active Media.*

The Active Media idea has been tested during a project called MUSE within the National Research Program on Cultural Heritage PARNASO, funded by the Italian Ministry for University and Research. The study of the multi-channel nature of the MUSE project and the user-interface design has been presented in [4]. The MUSE system has been tested in three different and relevant Italian Cultural Sites: a history and art museum in Naples ("La Certosa e Museo di San Martino"), a scientific museum in Florence ("Museo di Storia della Scienza") and the archaeological site of Pompeii [13].

One of the main goals of the project has been to develop a new custom designed mobile multimedia device called Whyre® [13].

This device is equipped with an onboard *sensor platform* that can be used to estimate the direction the device is pointing at, the geographical position, together with the inclination of the device.

2. BACKGROUND AND RELEATED WORKS

Our focus is on CH-related multimedia mobile applications. To be effective such mobile application must be sensitive to the users context and to their environment. Many papers have been published so far that aim to define a notion of context-aware computing. Most of these concepts are well-suited also in our applications domain [10].

The following analysis will review this issue.

According to the computer science perspective, many researchers have proposed their own definition of context and [5], [6] represent an excellent survey of them. We will not discuss in detail all of them; instead, we want to focus on the aspects that are most relevant as a base for our definition.

According to the surveys mentioned above, our application can be categorized as *proximate selection* [2], *presentation of information and services to a user* [1] and *active context awareness* [5]. Our idea of context also includes concepts coming from previous definitions: the *computing context and user context* [2] and the *active nature of context* [5].

This section concludes presenting how our application addresses the different issues presented in [3] concerning the development of mobile guides. Kray and Baus outline five main criteria, including different aspects for each one. The following list, reports the issues that our system addresses:

- **Basic features**
    - Services: information, orienteering, map interaction [4],[11]
    - Positioning: WLAN RF-based indoor system, GPS outdoor system, compass, dead reckoning using user steps count
- **Adaptation capabilities**
    - Technical resources: network failures management [11]
    - Lack of information: "Resource Not Available" notification
    - Lack of position: user driven web-based navigation
- **Interface and user interaction**
    - Language: multi-lingual

   - Evaluation: field tests with real users, questionnaires [13] , [12]
- **Architecture**
   - Type: client-server [11]
   - Interaction: proprietary XML based protocol [4], [11]

3. OUR DEFINITION OF CONTEXT

The current research on CH-related multimedia mobile applications is mostly focused on mixed-reality, or augmented reality applications, requiring high resolution and usually obtrusive tracking systems [8]. Our purpose, in contrast, is to concentrate the attention on unobtrusive, sensory augmented mobile systems.

Our assumption is that a CH site has an inherent hierarchical structure. Therefore the context does not only include the physical position, but also the level of abstraction focused by the user. The following definition of context is used within this application domain:

"Context is defined by a pair of coordinates, named physical and logical coordinates. The physical coordinate represents the current user's position and orientation related to a space model. The logical coordinate represents the current level-of-detail explicitly requested by the user."[11].

The *physical coordinate* is composed by *position*, a component almost common to every definition of context, and *orientation*, this referring to be the current geographical direction the mobile device (user) is pointing at.

The *logical coordinate* totally agrees with the idea that context may also be *explicitly supplied by user*, as stated by Pascoe et al. [9].

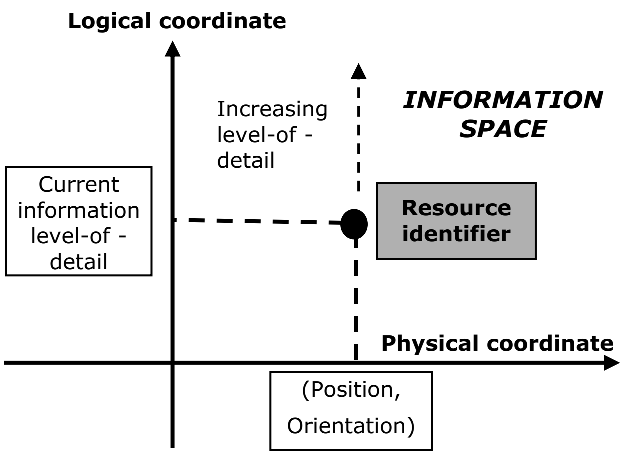

Figure 1 – Context as a Cartesian reference system

The context can be represented using a Cartesian reference system: the horizontal axis represents the physical coordinate, while the vertical axis represents the logical coordinate, as shown in Figure 1.
The information space contains all the resource's identifiers the user can access. Moving in the real world, users access to virtual information related to their position, orientation and information level-of-detail [6].

4. USING THE CONTEXT

Let's consider for example a visit to a museum, by default we can suppose the user to be interested only in gathering information about the halls he is walking through (*e.g.* he is interested in a general description of the hall, instead of the artworks themselves). Referring to figure 2, at this information level-of-detail only the *position* component of the physical coordinate is used.

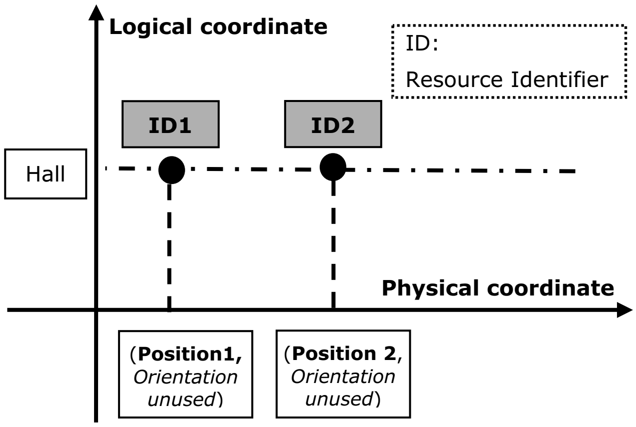

Figure 2 – Using position to access contents

If the visitor finds interesting a particular hall, he can get additional details deepen his knowledge about each single artwork located around himself. Increasing the information level-of-detail - and communicating it to the system (*e.g.* by pressing a key) - the visitor gets access to the artworks he is currently interested in (*e.g.* the painting(s) he is looking at).

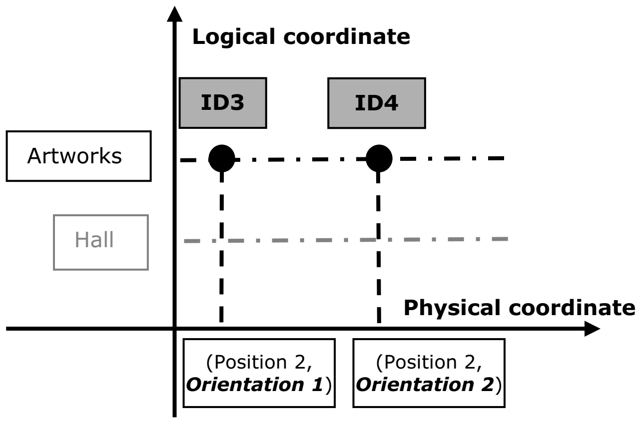

Figure 3 – Using position and orientation to access contents

The next figure represents two generic halls of a museum where the visitor is walking through and it will be used for a better understanding of figure 2 and 3.

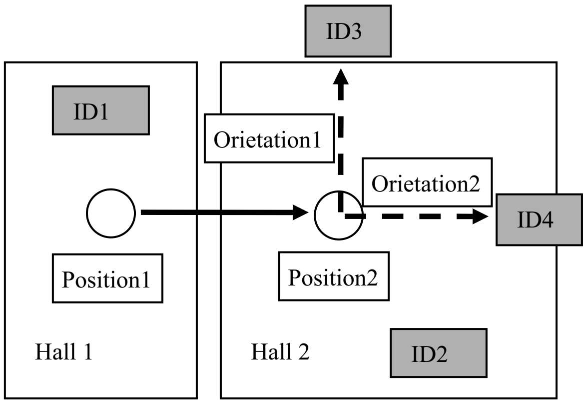

Figure 4 – An example of contents access during a visit

The circle represents the visitor. Basing on the definition of context above presented, the application automatically retrieves the identifier of the resource associated with the current hall (**ID1**). The presentation layer of the application creates a layout by which the user can access all the contents related to that hall (figure 5).

Figure 5 – The application user interface

Moving into a new hall the application automatically retrieves a new identifier (**ID2**). During this process, only the position component of the physical coordinate has been used (figure 2).

When the user wants to learn more about the artworks inside a hall, he can augment the logical coordinate of the context. The new context is used by the application to retrieve the artwork's identifiers (**ID3**, **ID4**) using both the components of the physical coordinate (orientation and position), as shown in figure 3. The presentation layer of the application creates a layout by which the user can access all the contents related to that artwork.

The physical coordinate of the context can also be used for orienteering purposes, feature especially useful in wide open-air sites (*e.g* an archaeological site). The visitor moving around the site can see on a map the place(s) reachable following the way he is walking on, as shown in figure 6 - top. Once the visitor enters inside a building, the application will display on a map the elements close to his position, showing also the relative position of each element (figure 6 – bottom).

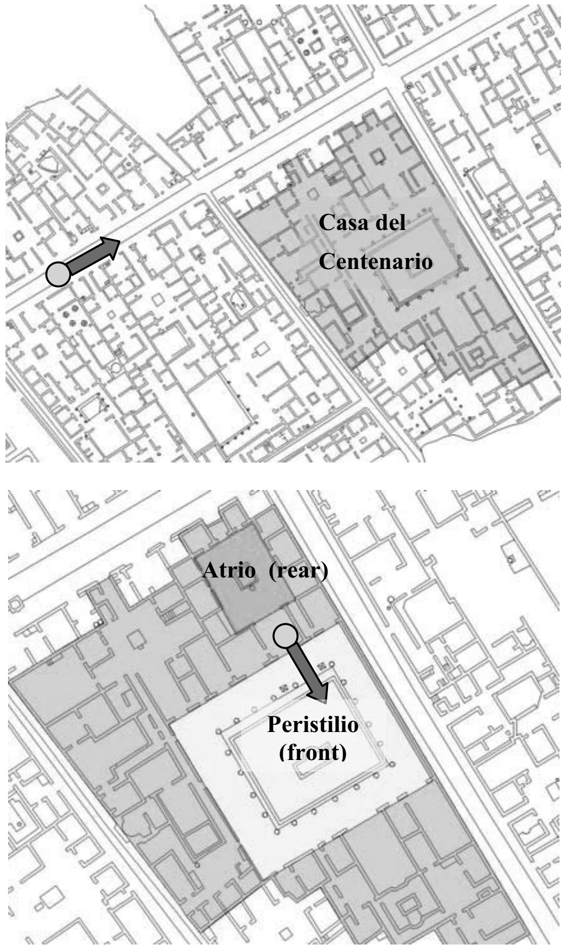

Figure 6 – Orienteering using the context

Both for context aware content access and orienteering purposes, the application has to know the space model. This knowledge, in our system, is supplied by a GIS system [11].

The context can also be used to control multimedia contents in order to obtain a user-friendly interface by which the user controls in real-time the content (e.g. a Quick Time VR® content) not pressing keys, but turning around himself.

In the proposed system, pitch and yaw angles are considered and used to control the view-point. When the user turns around himself, for example, the device shows a reconstructed model of the current field of view according to the orientation (given by the yaw) (see figure 7 –right). The pitch, instead, as shown in figure 7-left, can be used to control the elevation.

Figure 7– Context driven QTVR control

5. CONCLUSIONS

The CH domain is expected to have a tremendous growth in the next few years. Furthermore, research about ubiquitous computing is growing up as well. According to this promising scenario, our research aims to investigate and anticipate the future user expectations in the field of cultural tourism. In order to prove how ubiquitous computing concepts can be applied in the field of cultural tourism, an application has been developed, based on a novel concept of *Context*.

We think that, for being successfully applied in a real application, the context has to be well defined. A context definition was given, suitable for a particular subset of CH applications: mobile context based public presentations, where the mobile device acts as a personal guide to the museums and archaeological sites visitors. However, the focus of the application does not imply that it cannot be adapted to different scenarios inside or outside the CH domain (including, for example, museums of different natures, different archaeological sites and cities).

Some algorithms have been developed for context-based information retrieval and for orienteering purposes and have been tested in three major Italian cultural sites [13] . It was shown how a context-aware system can be used to address the following relevant points:

- Moving the human-machine interaction towards the "zero interface" concept: the device, based on the context, estimates the user's desires and it reacts to satisfy them with the minimum impact on the user's attention;
- Supporting visitor orientation in wide or complex sites;
- Showing multimedia contents in an active and intriguing way, for a better understanding of the cultural aspects.

Clearly, finer the granularity of the physical coordinate, more accurate the selection of the elements the user is interested in will be. Therefore, we are currently investigating how to better estimate the position and orientation of the user using the data supplied by different location systems (*e.g.* GPS and inertial navigation systems).

6. ACKNOWLEDGMENTS

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VR model: courtesy of Sopraintendenza Archeologica di Pompei, Dipartimento di Archeologia dell'Università di Bologna and Ducati Sistemi S.p.A.
We thank *Ducati Sistemi* and particularly Ceo Valerio Gamba and Fabio Sforza for providing Whyre®, the hands-free mobile platform used in the experiments.

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Location and orientation subsystems

Interactive Museum Guide

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ABSTRACT
In this paper, we describe the prototype of an interactive museum guide. It runs on a tablet PC that features a touchscreen, a webcam and a Bluetooth receiver. This guide recognises objects on display in museums based on images of the latter which are taken directly by the visitor. Furthermore, the computer can determine the visitor's location by receiving signals emitted from Bluetooth senders in the museum, so called BTnodes. This information is used to reduce the search space for the extraction of relevant objects. Hence, the recognition accuracy is increased and the search time reduced. Moreover, this information can be used to indicate the user's current location in the museum. The prototype has been demonstrated to visitors of the Swiss National Museum in Zurich.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces - Input devices and strategies; I.2.10 [**Artificial Intelligence**]: Vision and Scene Understanding; I.4.8 [**Image Processing and Computer Vision**]: Scene Analysis - Object recognition

Keywords
Object recognition, Interactive museum guide, Bluetooth

1. INTRODUCTION
Many museums present their exhibits in a rather passive and non-engaging way. The visitor has to scan a booklet in order to find some general information about the object. However, searching for information about object after object is quite tedious and the information found does not always cover the visitor's specific interests. One possibility of making exhibitions more attractive to the visitor is to improve their interaction with the guide. In this paper, we present an interactive museum guide which is able to automatically find and retrieve information about the objects of interest on a laptop-like device. Moreover, it provides further links and references allowing the visitor to browse comfortably on the Internet for an even broader description of the object.

 Smart Environments and Their Applications to Cultural Heritage.
UbiComp 2005, September 11-14, 2005, Tokyo, Japan.

1.1 Related Work
Recently, several approaches and methods have been proposed that allow visitors to interact with an automatic guide in a museum. Kusunoki et al. [7] proposed a system for children that uses a sensing board which can rapidly recognise types and locations of multiple objects. It creates an immersive environment by giving audio-visual feedback to the kids. Other approaches are robots that guide users through museums [4, 10]. However, such robots are difficult to adapt to different environments, and they are not appropriate for individual use. An interesting approach using hand-held devices, like mobile phones, was proposed by [5], but their recognition technique is limited to constant illumination.

1.2 Our Approach
We present an interactive, image-based museum guide that is invariant to changes in lighting, viewpoint, scale (zoom) and rotation. Our method was implemented on a tablet PC using a conventional USB webcam for image acquisition, see Figure 1. This hand-held device allows the visitor to simply take a picture of an object of interest from any position and is provided, almost immediately, with a detailed description of it.

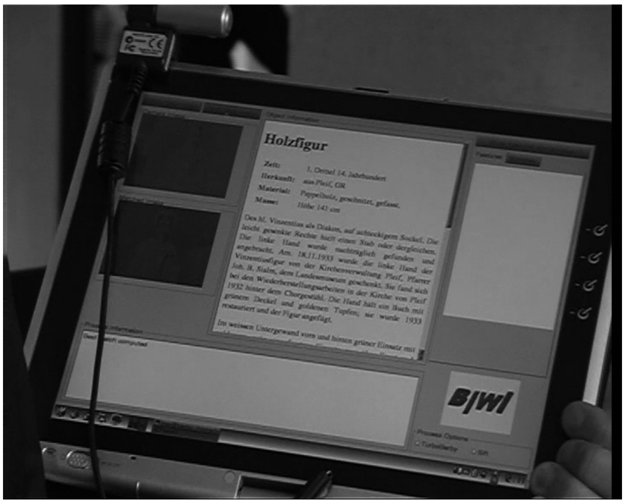

Figure 1: Tablet PC with the USB webcam fixed on the screen. The interface of the object recognition software is operated via a touchscreen.

Furthermore, this device can be extended to display location dependent information on a map, such as the closest emergency exits, the toilets or the direction to the next coffee shop relative to the visitor's position. Our museum guide neither imposes a predefined visiting order, nor the inconvenient task of scanning a vast database.

The museum guide has been shown to the public in the framework of the 150 years anniversary celebration of the Federal Institute of Technology (ETH) in Zurich, Switzerland. It was demonstrated in the Swiss National Museum Zurich. About 250 visitors took part in the demonstration in 20 guided tours of 10-15 persons each. The object descriptions were read by a synthetic computer voice, which enhanced the comfort of the guide.

2. METHOD

Our interactive museum guide contains two different modules. The first is an image-based object-recognition module, and the second consists of an automatic exposition room detector using Bluetooth. The combination of both techniques results in a robust and fast object recognition for large image databases.

2.1 Object Recognition

In order to retrieve the correct object, a database of images has to be established containing images of each object taken from different viewpoints. This fact assures a certain viewpoint independence of the guide and allows it to estimate the approximate direction from which the visitor took the picture. This information can be used as an extension for a more detailed, viewpoint dependent description. An example of a model image set can be seen in Figure 2.

Figure 2: Sample of model images and an input image (lower right image) of an object in the museum. Note the important differences in appearance between the model images and the input image. Also, scale and viewpoint of the input image differs from those of all the model images.

For each image, a set of interest points is computed and described by a scale and rotation invariant descriptor. For that task, we developed a fast SIFT [8] approximation using integral images. Our descriptor has the same number of dimensions (128), but is six times faster than SIFT, detects in average 15% more interest points, and shows similar performance. Due to the space limitation of this paper, it is unfortunately not possible to provide a detailed description of our approach. However, in the following we briefly mention the main difference to the SIFT descriptor.

In order to attain the important difference in speed, we use integral images as defined in [11]. The use of integral images enhances the speed for interest point detection and description. The entry of an integral image $I_\Sigma(\mathbf{x})$ at a location $\mathbf{x} = (x, y)^\top$ represents the sum of all pixels in the base image I of a rectangular region formed by the origin and $\mathbf{x}$.

$$I_\Sigma(\mathbf{x}) = \sum_{i=0}^{i\le x} \sum_{j=0}^{j\le y} I(i, j). \quad (1)$$

Once the integral image computed, it is easy to calculate the sum of the intensities of pixels over any upright, rectangular area.

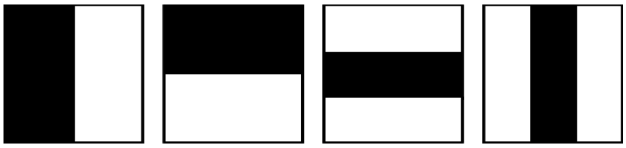

Figure 3: Haar-wavelet like patches approximating the first and second order derivative. The sum of intensities of the pixels lying in the black region is subtracted from the one in the white region

Integral images can be used to very quickly approximate the convolution kernels of the first and second order derivatives. The approximation consists in using Haar-wavelet like patches as illustrated in Figure 3. In this way, important accelerations can be achieved for the detection of Hessian-matrix based interest points as well as the required gradients for the SIFT descriptor.

In order to recognise the correct object from the database, we proceed as follows. The input image, taken by the user, is compared to all model images in the database by matching their respective interest points. The object figured on the model image with the highest number of matches with respect to the input image is chosen as the object the visitor is looking for.

The matching is carried out as follows. An interest point in the input image is compared to an interest point in the model image by calculating the Euclidean distance between their 128-dimensional descriptors. A matching pair is detected, if its distance is closer than 0.6 times the distance of the second nearest neighbour. This is a common robust matching strategy [2, 8, 9].

The average detection time for a database of 130 images of 22 objects is about 10 seconds. The reason for this relatively long recognition time lies in the fact that the feature description vector is high-dimensional. Furthermore, for every recognition step, an average number of 230 descriptor vectors for the input image have to be compared to about 30000 of such vectors in the database. However, the recognition time can be reduced by an order of magnitude by using the Best-Bin-First algorithm [3]. Another approach to get similar results at lower recognition time was proposed by [6], and uses PCA on patches of the gradient image around the interest points. However, both methods suffer of either a loss in quality, or a more time consuming descriptor evaluation. We are currently working on a fast matching alternative using integral images.

2.2 Automatic Room Detection

In every exposition room, one or more Bluetooth senders, also called BTnodes [1], see Figure 4, are positioned.

A BTnode is a versatile, autonomous wireless communication and computing platform based on a Bluetooth radio, a second low-power radio and a micro controller. Every BTnode covers a specific area of the museum and provides it with a localisation signal broadcasted at constant intervals. The signal received by the interactive museum guide is used for two purposes. First, the position of the visitor can be evaluated and displayed on a map. Moreover, as mentioned above, further location-dependent information may be retrieved. Second, as several images of an object are needed in order to robustly recognise it, the number of images in the database increases rapidly depending on the number of objects featured in the museum. This fact slows the object recognition process down drastically. Moreover, as more similar objects may enter the database, the accuracy of the recognition decreases. Classical object recognition methods would be computationally too expensive to get any result in time. To increase the matching speed, the search space is reduced to objects in the area close to the visitor. This area is defined with the signal of a BTnode. Hence, for a faster and more accurate object recognition, only objects situated in this area are considered as candidates.

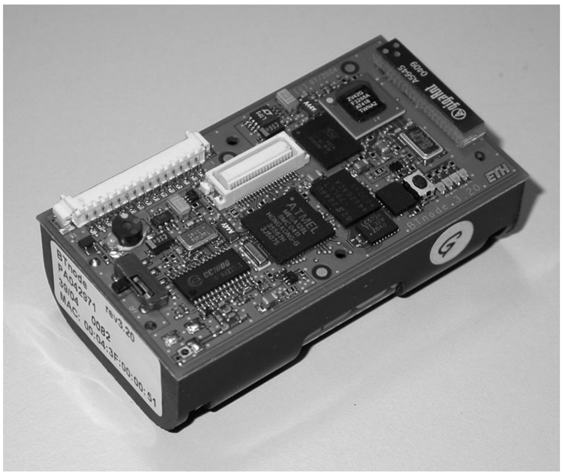

Figure 4: Image of a BTnode. These devices were placed in different exposition rooms of the museum. Each node broadcasts its identification number at regular time intervals.

2.3 Adding New Objects

Adding new objects to the database is easily accomplished. First, a few model images of the object have to be taken from different viewpoints with any kind of camera. The size of the image must be reduced to a conforming size in order to get a reasonable detection time without loosing important details of the object. We chose 320 × 240 pixels. Second, interest points of the model images have to be detected and represented by our scale and rotation invariant descriptor. Finally, the model image names have to be indexed in a table in order to attribute the documentation to the figured object. Additionally, the number of the BTnode, covering the area where the object is located, has to be mentioned in the table.

3. APPLICATION

As soon as the computer receives the signal of a BTnode, it recognises the room in which it is located and selects the part of the database representing the objects in that same room. For the demonstration in the Swiss National Museum, we used only two of such BTnodes (see Figure 5), one in the entrance hall and the other in the first exposition room of the museum. Once the visitor passes the threshold to the entrance hall, the computer receives the signal of the first BTnode and *says* "Welcome to the Landesmuseum[1]". As soon as the visitor enters the exposition room, the computer *says* "Exposition room" and launches automatically the object recognition application. The interface of the latter is shown in Figure 6.

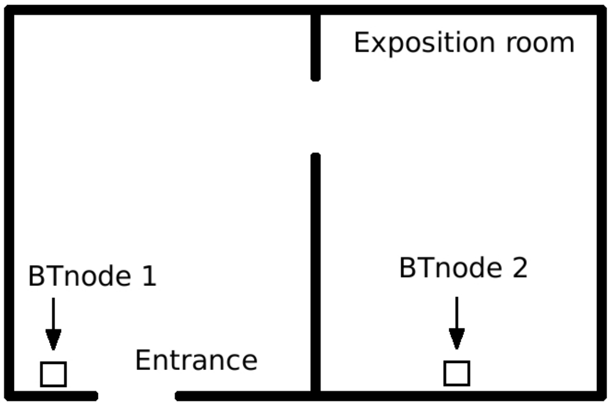

Figure 5: Schematic representation of the BTnode distribution in the museum.

When the user takes a picture of an exhibit, the computer displays, after a short computation time, the requested information in a browser window. Furthermore, the visitor can browse to some more specific information on the Intranet/Internet or to related objects that are currently exposed in the museum (e.g. made by the same artist). Also, the visitor has the option to have the description in the browser to be *read* by the computer via a text-to-speech synthesis engine.

4. RESULTS

Our interactive museum guide has been tested for 22 objects (130 database images) such as wooden statues, paintings, metal and stone items as well as coins and objects enclosed in glass cabinets which produce interfering reflections. The input images were taken from substantially different viewpoints under arbitrary scale (zoom) and rotation. We achieved an object recognition rate of about 80% for about 200 test images taken under various conditions. Furthermore, the recognition rate is affected by conflicts e.g. if two different objects were visible in the same input image.

This performance is quite promising, considering the fact that the interactive guide has to operate in an environment with varying conditions. It is robust to important natural lighting variations, such as different external weather conditions and daytime changes. Moreover, the results are not affected by artificial lighting or even changes in the colour

[1] *Landesmuseum* means "National Museum"

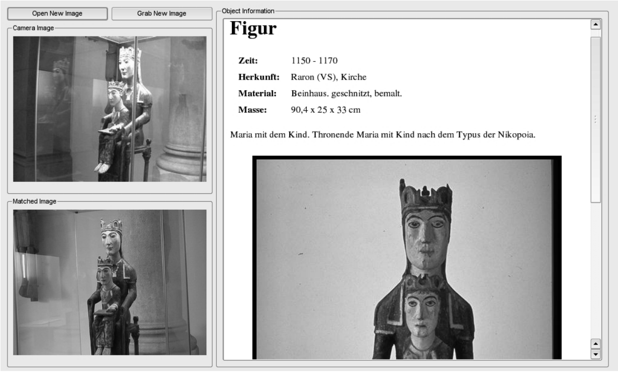

Figure 6: Interface of the object recognition application. On the upper left, the camera input image is located. On the lower left, the matched reference image is displayed. On the right hand side, the browser window can be seen. There, the description of the object, associated to the matched model image, is shown.

of the illuminant. Furthermore, the difference of quality between the reference images in the database and the images taken with the low-quality webcam affect the results only to a limited extent. However, input images with low contrasts are difficult to recognise and mainly these lead therefore often to mis-recognitions.

Note that in contrast to the approach described in [5], we do not use colour information for the object recognition. This is one of the reasons for the above-mentioned recognition robustness under various lighting conditions. We experimentally verified that illumination variations, caused by artificial and natural lighting, lead to low recognition results when colour was used as additional information.

5. CONCLUSION

In this paper we have described the functionality of an interactive museum guide. It allows to robustly recognise museum exhibits under difficult environmental conditions. Furthermore, our guide is robust to changes of the viewing angle as well as rotation and scale. The museum guide is running on a standard low-cost hardware. Moreover, we presented a possibility to improve the accuracy and speed of object recognition by combining image-based object recognition with automatic room detection.

Future work will be focused on developing an even faster algorithm for the matching task. Furthermore, we want to deploy hardware that is better suited for the task at hand. Specifically, we will test cameras which provide images of higher quality and we also attempt to implement our approach onto a smaller portable device.

6. ACKNOWLEDGEMENTS

The authors acknowledge support by the ETH project of versatile computing, the EC Network of Excellence EPOCH and the Swiss NCCR project IM2. We also gratefully acknowledge the crucial support by the Swiss National Museum Zurich.

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Orientation-Aware Handhelds for Panorama-Based Museum Guiding System

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ABSTRACT

This paper presents an intuitive user interface (UI) for visitors in a museum to quickly locate an exhibit through orientation-aware handhelds, which would aid visitors in experiencing fluid visiting. The physical environment is represented as a set of panoramas. The corresponding view of the environment will be automatically displayed on the handheld device, which is equipped with an orientation sensor to align the panorama with the real world. A user can interact with an object within the environment by selecting the corresponding item on the display. Perceiving the same scene on both the handheld and the real world, a user can quickly and accurately select an item by clicking the corresponding item displayed on the handheld. Furthermore, the panorama is augmented with additional information to provide a better understanding of the environment. The simple yet intuitive selection scheme allows users, in the physical environment, to exchange information with the machines. A prototype system has been implemented to demonstrate the usefulness of this UI for museum guide applications. A user study has been conducted to examine its usability and performance.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces

General Terms

Design, Human Factors.

Keywords

User interface, orientation sensor, interactive environment, human-computer interaction, museum guide.

1. INTRODUCTION

Cultural and natural heritage are commonly collected in Museums, historical houses, or art galleries. These exhibition spaces consist of exhibition rooms populated with hundreds of exhibits. While visiting exhibition rooms, visitors roam from exhibit to exhibit, appreciating them and reading information from labels. To facilitate visiting and learning, institutions may present information through electronic guidebooks. In addition, visitors can query electronic guidebooks about advanced information.

When attracted by an exhibit, visitors would like to get more information. However, querying certain exhibits from guidebooks is always a cumbersome task because a visitor needs either to enter the query string or to browse a lengthy list. Although organizing exhibits effectively in hierarchical structure can greatly reduce search time, visitors still have to browse hierarchies. Moreover, the locating effort interrupts the visiting experience.

In this paper, we develop a panorama-based UI to improve the selection scheme, so that visitors can easily and quickly locate an exhibit with minimum user intervention. A panorama-based UI is achieved using a handheld device integrated with an orientation sensor. The orientation-aware handheld determines which direction the user is facing, and then automatically aligns the direction of the panorama with the real world (see Figure 1). The correspondence between the panorama on the handhelds and the physical environment provides an explicit and natural scheme. It also provides the facility to augment the panoramic view with extra information.

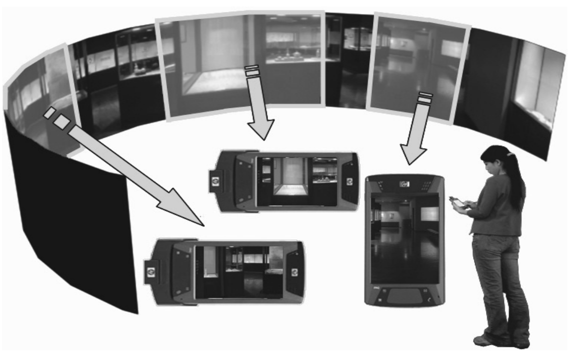


Figure 1. Users See Real World Views in the Handheld

2. Related Work

As a selection scheme, u-Photo [1] allows users to lookup information on devices by taking a photo. u-Photo Tool first recognizes devices in the photo, and then stores them along with contextual information for latter control. In order to find a desired

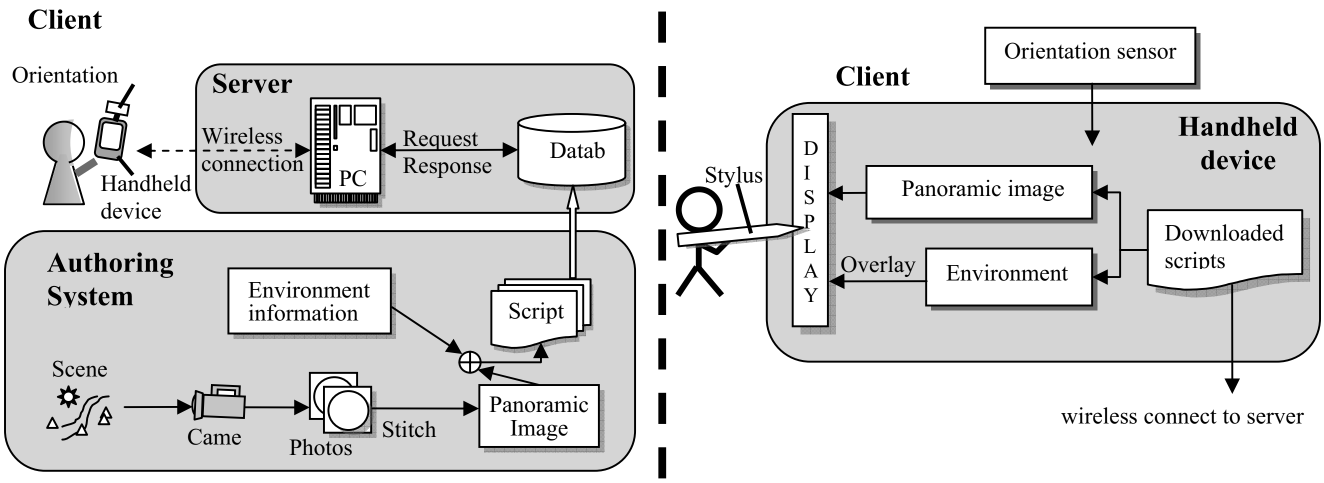


Figure 2. System Architecture

device, users manually browse each u-photo, which turns out to be a time-consuming task when many devices exist in the environment. Woodruff et al. developed Sotto Voce [2], an electronic guidebook, to improve social interaction by enabling visitors to share audio information. Their UI for selecting objects in the environment is similar to ours. However, they use a single photograph for each wall in a room, switching images by pressing a button. In contrast, a panorama is used to present a room and a user perceives the current view by simply turning their body.

There is other research on interacting with the environment. Ringwald [3] attaches a laser pointer to the PDA for users to select and control devices in the environment. Patel et al. present a 2-way selection method [4] to select objects in a physical environment. They integrate a handheld device with a laser pointer. When a tag placed in the environment is triggered by a modulated laser pointer signal, the tag then transfers its ID to the handheld device. Wilson and Pham propose the WorldCursorl [5], an evolution of their previous work on XWand, allowing users to select and interact with physical devices by positioning the cursor on the device and pushing the button on the wand.

3. SCENARIO AND FUNCTIONS

We now present our scenario in a museum, and then describe several functions provided by our system.

Susan enters a crowded exhibition room in the museum. Her PDA automatically downloads the panorama of this room. She looks around and is immediately attracted by a sculpture in the distance. However, she has trouble making her way to the sculpture due to the crowds. Susan holds her PDA, and the panorama displayed on the PDA is automatically aligned with Susan's orientation. She easily identifies the sculpture in the panorama and taps it with a stylus. A detailed description of the sculpture appears on the screen.

We can summarize the functions provided by our system. First, our system provides an intuitive way to choose objects by clicking on them in the panorama. A panorama is a 360-degree viewing image. We install the orientation sensor on the handheld. While the user operates the handheld, we constantly update the partial view of the panorama on the handheld, according to the user's orientation. Figure 3 shows the workflow. A user sees the same scenes in the handhelds as in the physical environment; it is easy to recognize the object even if the object is obscured by others.

Second, additional information can be superimposed on the panorama. For example, the exhibits in the panorama are labeled for easy reading. The panorama may be annotated with private information, which is unsuitable in the physical environments.

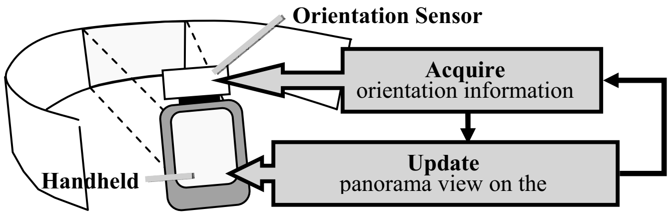


Figure 3. Workflow of the Client

4. SYSTEM DESIGN

Figure 2 illustrates the system architecture. Our system comprises three parts: client, server and authoring system. The authoring system works offline in advance to generate panoramic images, and to edit environment-related information. The server and client work in real-time to interact with users.

In the authoring system, we use a script to describe a scene in physical world. Each scene has its portrait script, which combines its panoramic image and environment information. These scripts are then saved in the database indexed by scene ID.

The server, which contains a computer and a database, is responsible for responding to clients' requests. The connection between server and client use a wireless technique. Clients request from server the scene-related scripts with scene IDs. Then, the server retrieves them from the database using the scene ID as the index.

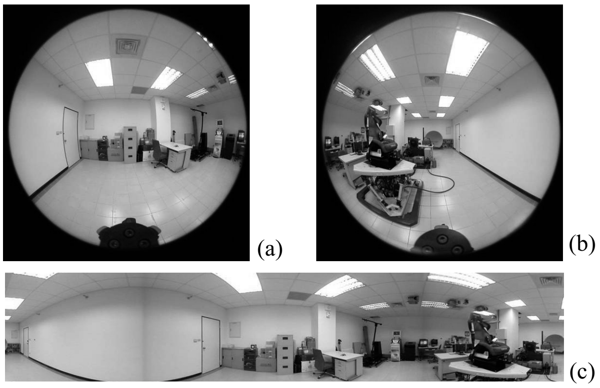


Figure 4. Creating a Panoramic Image from Fisheye Images
(a) The fisheye image taken from front side, (b) back side, and (c) the panoramic image created by Panoweaver from two taken fisheye images.

5. SYSTEM IMPLEMENTATION

To confirm the performance of our proposed system, we build an experiment in our lab (see section 6) and an application in the National Museum of History. The following is the detailed implementation of our system.

5.1 Authoring System

A panorama is an extremely wide-view image created by capturing a series of images at a fixed point. Constructing a full 360-degree panoramic image usually requires stitching ten to fifteen shots. This would take time and may cause bad stitching results because of changes of lighting and movement of people.

A fisheye lens has an extremely wide angle of view, as much as 180 degrees. With a fisheye camera, as shown in Figure 4, we only take two photos of the scene, one for the front side and one for the back side. Constructing a panoramic image with at least two fisheye shots can significantly reduce the workload. Some commercial software, such as Panoweaver [6] and IPIX [7], provide powerful functions, which can provide users easy and automatic stitching in order to create panoramas.

To display the real scene on a handheld device, we do not need high-resolution panoramic images for the device's small–size screen. In our approach, the panoramic image is used mainly as an intuitive interface for users to contact information in a physical environment, not for virtual exhibition. Therefore, we acquire panoramic images, in our current implementation, from fisheye images captured by Nikon coolpix 5000 plus FC-E8 Fisheye Converter lens. We then use Panoweaver to stitch panoramic image from the fisheye images.

5.2 Client and Server

To acquire the orientation information, we use an iPAQ hx4700 connected to TruePoint orientation sensor released from PointReserch. It is a true 3-axis digital compass module, which can achieve 0.1 degree in resolution and 1 degree in accuracy. Figure 5 shows our client prototype. The server is IBM ThinkCentre A50 series, which is used to serve multiple clients in our deployment.

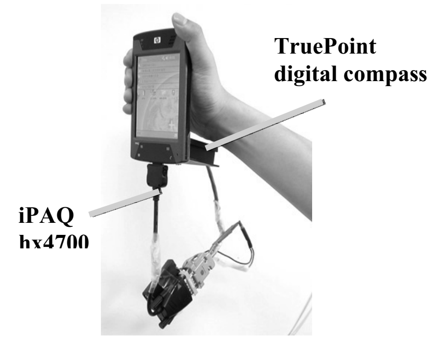


Figure 5. Client Prototype.

6. EXPERIMENTS

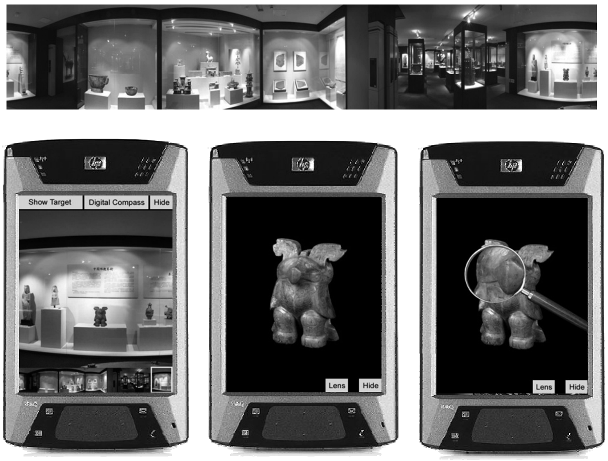
6.1 An application in Museum Guide System

We developed an application in National Museum of History. On deploying the museum guide system, we superimpose the exhibition room information on the panorama, i.e., the exhibit labels, doorway indicators, etc.. We also generate object movies for part of exhibits. Users can select the exhibits when they navigate the panorama. After selecting an exhibit, users can see detailed descriptions of it or virtually manipulate the object movie of the exhibit. Our system also provides a magnifying glass which helps users view the details of the exhibit. (see Figure 6).

6.2 Experiment setting

In order to display a user's view of the physical environment on the handheld, we use panorama technique [8] to reconstruct a physical environment. The panorama is the most popular image-based approach for its photo-realistic view effect and for its ease of acquisition. It is widely applied to applications which require the exploration of real or imaginary scenes. However, if a user stands at a location not exactly where the panorama was shot, the user will perceive a slightly inconsistent view with the real world. Therefore, we conducted a user study with 35 volunteers, ranging from 15 to 60, to examine two hypotheses: (1) the panorama-based UI decreases seek time and (2) the inconsistency between the image and the user's view can be compensated for by the human visual system. There are 19 males and 16 females. 4 participants are familiar with using the PDA, 12 participants used a PDA occasionally and 19 participants never used it before. The experiment includes: four sessions, a questionnaire and an interview. In each session, participants are instructed to finish ten randomly assigned selection tasks. Time and correctness are logged. In session Ⅰ, Ⅲ, Ⅳ, participants use panorama UI in distance 0, 1 and 2 meters away from the shooting point respectively.

Designing how to assign the participants selection tasks in the experiment, we considered various simulating conditions similar to those a visitor encounters in the museum. We first observed visitors' behaviors when they use the electronic guidebook. We found that, while visiting with the guidebook, visitors are first attracted by the exhibits in front of their eyes. Then they use the electronic guidebook to find out information about the exhibit. Interestingly, while they use the electronic guidebook, their orientation is often roughly facing the exhibit. This pattern



(b) (c) (d)

Figure 6. Experiment in Museum
(a) The panoramic image at the National Museum of History,
(b) navigating in the museum using the panorama,
(c) after selecting an exhibit for manipulation, and
(d) a magnifying glass showing details of the exhibit.

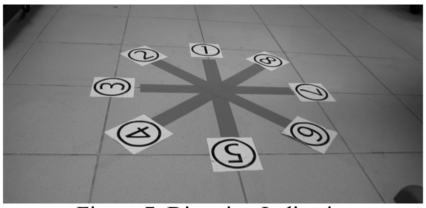


Figure 7. Direction Indications

convinces us that the orientation-aware panorama-base user interface can provide visitors with a fluid experience. Therefore, we add this pattern into the selection tasks. Each task, we assign a target item by notifying its direction (N, NE, E, SE, S, SW, W or NW) followed by shining a laser point on the item. Participants recognize the target and pick it out in the panorama. As Figure 7 shows, we attach indicators at each test point so that participants can quickly turn to the correct direction while receiving a direction indication. In session Ⅱ, participants use a list-based GUI. When using list GUI as the selection scheme in guidebook, visitors look for target by browsing all exhibits on the list. The same occurs in this session, and we assign target item by simply noting its name in each task.

The results show that the average seek time for session Ⅰ and for session Ⅱ are 65.5 sec and 88.0 sec, respectively. That is, the panorama-based UI performs 25% better than list-based GUI in average seek time. Also, the error rate for session Ⅰ is 5.7%, which is better than that for session Ⅱ, which is 9.4%. That is because, in Session I with the help of orientation information, users perform a local search on the panorama. In contrast, in Session Ⅱ, users locate an item by globally searching all items on the list. Our experiment shows that the average seek time for session Ⅲ and for session Ⅳ are 66.5 sec and 69.4 sec, respectively. This implies that the seek time does not increase when the location deviation occurs up to 2 meters away from shot point. Accordingly we concluded that such inconsistency does not affect the selection process due to human's excellent vision system.

Other findings in the questionnaire and interview include: (1) most participants operate our interface well with merely 5 minutes of training, including explanation of the UI and practicing, (2) all but two say they can visually utilize relative position among items to turn their body and quickly find the target, and (3) participants also believe that familiarity with the environment helps speed the selection process.

7. CONCLUSION

We proposed a simple yet intuitive UI for visitors in the museum to quickly locate an exhibit. As a selection scheme, the novel UI utilizes augmented panorama to display the surroundings. With the help of an orientation sensor, the panorama can be aligned automatically with the real world. Perceiving the same scene both on the handheld and in the real world, users can select target items quickly and accurately. We have presented our system design in detail and tested the system in sample environments, including our research laboratory and a science museum. A user study has been conducted to examine its performance and usability.

8. ACKNOWLEDGMENTS

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Orientation tracking exploiting ubiTrack*

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ABSTRACT
In this paper, we propose the orientation tracking method exploiting ubiTrack developed by GIST. Location information is already used in various applications, and orientation information is also important to provide the appropriate services according to different situations. In order to recognize orientation we attach two IR receiver modules to ubiTrack receiver. We can obtain the orientation information of both a resident and a device by calculating locations of two IR receiver modules. The proposed method can be widely exploited for LBSs which require the orientation information.

Keywords
Ubiquitous computing, Location tracking, Orientation tracking, Device

1. INTRODUCTION
Ubiquitous computing environments can provide context-aware services according to various contexts which can be obtained form several sensors. Among various kinds of context information, location information is important to provide a variety of services from different locations. Many research organizations have studied about location tracking technologies. Especially the outdoor orientation tracking technologies have been already applied in many applications. For example, GPS and CDMA are used in several services. Recently, many researchers are conducting researches on indoor location tracking techniques. This trend implies that orientation information is required in order to provide more appropriate services to a user according to the different situation.

There are several indoor location tracking systems, such as the ubiSense [1], Active Badge [2], and ubiTrack [3]. They can track the orientation as well as location by subtracting current locations from previous locations. However, they cannot track orientation when orientation is dynamically changed in the same place. In addition, they cannot obtain the orientation in the right direction when a user steps backward.

In this paper, we propose reliable orientation tracking method exploiting ubiTrack. We use two IR receiver modules in order to get orientation while classic ubiTrack uses one IR receiver module. Each IR receiver module has an individual ID of right and left. So it can be aware of orientation of a user and a device by calculating locations of two IR receiver modules. By using the proposed method, we can obtain not just one-dimensional location as a point but two-dimensional location as a line, the physical length of a device, and orientation.

This paper is organized as follows. In chapter 2, we explain the motivation of the proposed method. Chapter 3 covers the orientation tracking method. In chapter 4, we will show the accuracy and performance through several experiments. Finally, in chapter 5, the summary and future works are presented.

2. MOTIVATION
Figure 1 shows the motivation of the proposed method. Classic location tracking systems cannot track changes of orientation in same position. When he exists in the annotation service area about exhibits, a visitor is provided multiple services as well as services about exhibits which he does not face on.

The environment provides specific services with consideration of a user's attention by comparing orientation of a user and an exhibit. In other words, the user is provided the service about the exhibit which he faces on. As shown in figure 1, visitor 1 is provided with services of

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an exhibit 1 because he watches the exhibit 1. The visitor 2 who watches an exhibit 2 is provided with the annotation service of exhibit 2 rather than the service of exhibit 1, even though he is technically in the service area of exhibit 1. Because the environment recognizes that he faces on exhibit 2 by his location and orientation from ubiTrack.

If ubiTrack couples the outdoor location tracking system, such as GPS, we expect that it can be used inside or outside of historical building or exhibition.

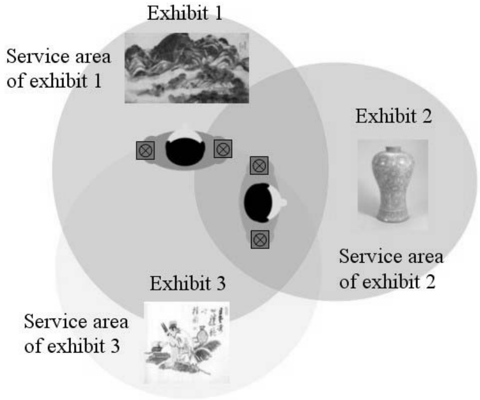


Figure 1. Motivation of proposed method

3. ORIENTATION TRACKING

We propose the orientation tracking method exploiting ubiTrack. In order to obtain the orientation of both a user and a device we attach two IR receiver modules to classic ubiTrack. Two IR receiver modules have individual IDs, such as right and left. Proposed method can obtain orientation of both a user and a device by calculating the different locations of two IR receiver modules. Proposed method can track the two dimensional location, length of a device, and orientation by using two IR receiver modules.

3.1 System architecture

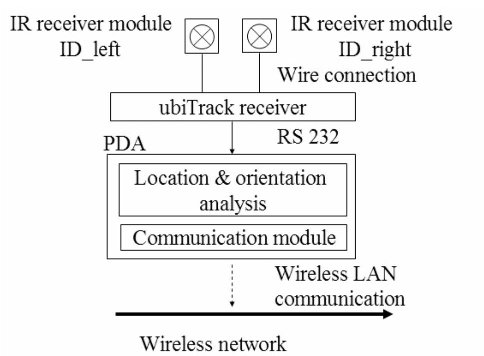


Figure 2 diagram of ubiTrack receiver

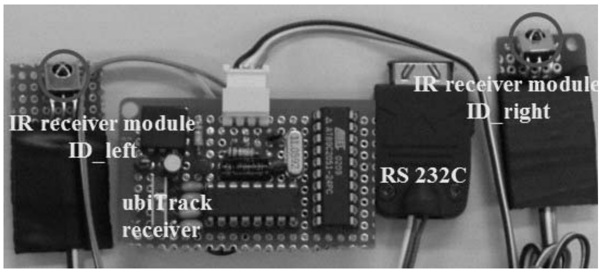


Figure 3 ubiTrack receiver

Figure 2 shows the diagram of ubiTrack receiver. Two IR receiver modules receive the individual IDs from IR transmitters attached on the ceiling. Two IR receiver modules have individual IDs of ID_right and ID_left. IDs received from two IR receiver modules are distinguished with each other in ubiTrack receiver. UbiTrack receiver transfers IDs to the PDA of both a user and a device. UbiTrack receiver connects with PDA through the serial communication (RS232C). In the PDA, location and orientation analysis part calculates the physical location and orientation from distinguished IDs according to the locations of two IR receiver modules. Then the communication module transfers the location and the orientation information to the wireless network by wireless LAN communication (IEEE 802.11b).

3.2 Orientation tracking method

We use two IR receiver modules in order to obtain the orientation. Two receiver modules have individual IDs of ID_right and ID_left. Two IR receiver modules recognize the orientation of a device using the each location information of two IR receiver modules. Figure 4 shows the method of the orientation tracking. Six circles represent IR sensing areas generated by IR transmitters attached on the ceiling. We attach two IR receiver modules to the each side end of a device which we want to know the location and the orientation. The device's location is presented as the center point (x, y) between two IR receiver modules. 'ℓ' is the physical length of the device measured by proposed method,

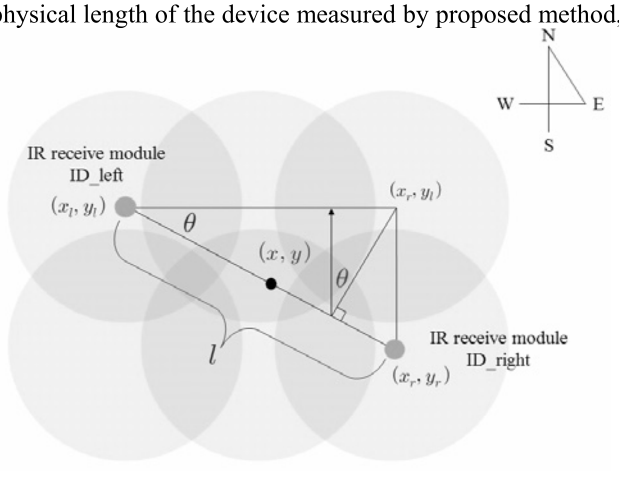


Figure 4 orientation tracking method

Location	$(x, y) = (\frac{x_l + x_r}{2}, \frac{y_l + y_r}{2})$
Length	$l = \sqrt{(x_l - x_r)^2 + (y_l - y_r)^2}$
Orientation	$\theta = \cos^{-1} \frac{\lvert x_l - x_r \rvert}{\sqrt{(x_l - x_r)^2 + (y_l - y_r)^2}}$

Table 1 computation of location, length, and orientation

which is the distance between two IR receiver modules as shown table 1. The proposed method can recognize not one- dimensional location such as a point but two-dimensional location such as a line. It is more practical than conventional systems which can obtain only one-dimensional location such as a point. Then, it can obtain the orientation (θ) using each location of two IR receiver modules. If left and upside point is (0, 0), θ is an angle between the north direction and the forward direction of a device. Thus, if the forward direction of a device is headed north, orientation of this device is 0 degree. Table 1 shows the equation calculating location, the length, and the orientation of both a user and a device.

4. EXPERIMENT

We made various experiments in order to know the reliability of the proposed method. We measured the location and orientation of a resident in ubiHome which is smart environment developed in GIST [4]. We attached two IR receiver modules on the shoulders of a resident. While changing angle of his orientation from 0° to 360° per 30°, we measured the location and orientation as shown in figure 5. In order to increase the reliability we collected the 100 samples

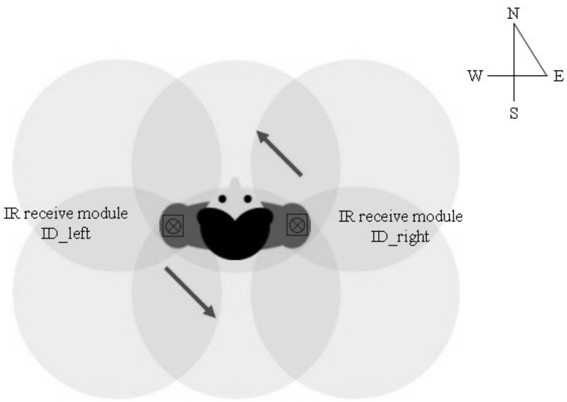
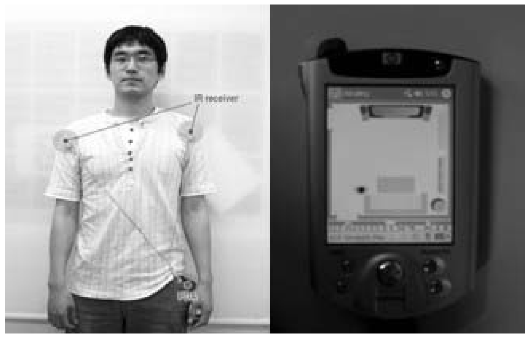


Figure 5 measurement method of a sofa's orientation



(a) a resident who attached receiver (b) PDA display

Figure 6 experimental set-up

Figure 7 ubiTrack transmitters

in each angle. Figure 6 shows the experimental set up. Figure 6 (a) shows a resident who attached the receiver on the shoulders. Figure 6 (b) is the PDA which shows the map and the resident's location.

Figure 8 and 9 show the results of this experiment. Figure 8 shows the measured location of a resident, whereas the practical location of the resident is (140, 130). Figure 9 shows a resident's orientation in each 30° degree sections and shows that all errors exist within 30°. In this experiment we can see that ubiTrack recognizes eight directions. It is enough to apply this technique to ubiHome to find the attention of multiple residents by using several ubiTracks.

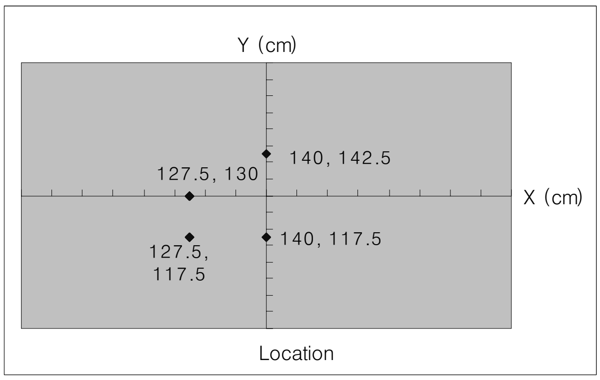


Figure 8 Location of a resident

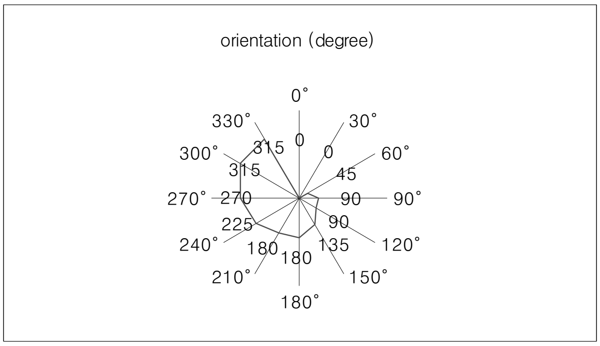


Figure 9 Orientation of a resident

Figure 10 shows the cause of errors. Although the locations of two IR receiver modules are different, if they exist in the same sensing area, two IR receiver modules are aware of the same location, because ubiTrack uses the proximity method for location tracking [5]. For example in figure 9, there are two IR receiver modules, a and b. Their locations are physically different, but they exist in the same IR sensing area. Thus, the locations of both a and b are recognized as c. This is the reason why there are errors in location tracking using the proximity method. By using location with these built-in errors, there also exist errors in length and orientation.

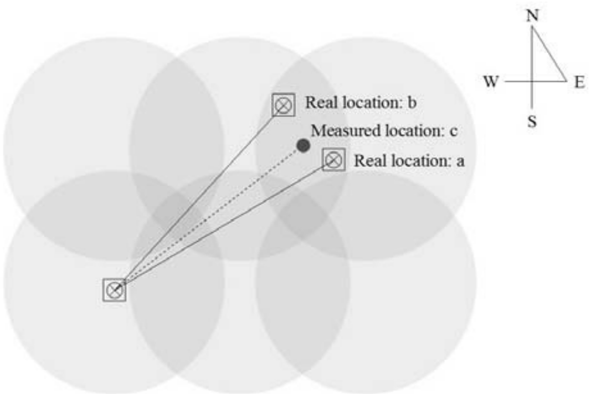


Figure 10 cause of error

5. CONCLUSION & FUTURE WORK

We proposed the orientation tracking method exploiting ubiTrack. The proposed method attaches two IR receiver modules to classic ubiTrack which is infrared-based location tracking system. By using two IR receiver modules, the proposed method can obtain the location, which is not

For high accuracy, IR sensing area should be more accurate and dense than current state because ubiTrack used the proximity method.

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Ambient intelligence for outdoor cultural experiences

eRuv: A Street History in Semacode

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ABSTRACT

eRuv: A Street History in Semacode is a digital graffiti project installed along the route of the former 3rd Avenue elevated train line throughout lower Manhattan. The Third Avenue train line, which stood until 1955, was more than just a critical means of transport for New Yorkers; it was part of an important religious boundary called an eruv for the immigrant Polish Chasidic Jewish community on the old Lower East Side in the first half of the 20th century. The train has since been dismantled and most of the Chasidic Jews have moved away, so what was once in part both a physical and symbolic enclosure is now purely imaginary, a psychic boundary that intersects present-day communities in Lower Manhattan. With camera phones, New Yorkers can tap in to this history, accessing web content linked through semacodes installed along the avenue that once sat below the train line. In this way, the former eruv is reconstructed and mapped back onto the space of the city.

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Categories and Subject Descriptors

J.5 [**Computer Applications**]: Arts and Humanities

General Terms

Design, Experimentation.

Keywords

Eruv, semacode, Judaism, psychogeography, public space, street art, graffiti, mobile Internet, Manhattan, New York City, Lower East Side.

1. The Eruv: An Introduction

An eruv (pronounced ey-roov) is a religious boundary that is erected around orthodox Jewish communites throughout the world. An eruv usually consists of a series of poles connected by galvanized steel wire that circumscribe an urban neighborhood. They often incorporate existing municipal infrastructure such as utility poles and electrical wires, so long as they are used in accordance with the lengthy and complex set of kosher architectural laws set forth in the Talmud, a sacred text written by a series of Rabbinic sages around 500 CE.

The construction of eruvin (or eruvim, plural for eruv) stems from the observation of the Sabbath, the weekly sacred day of rest (Friday sundown to Saturday sundown) that includes a prohibition against carrying objects outside of one's home, or private domain. The actual Biblical declaration of this law occurs in the Old Testament which states briefly but very specifically that the transferral of objects between public and private domains is a form of work and hence a violation of the Sabbath. The reason Jews construct eruvin is that according to most Rabbinic authorities, the shared public space within an eruv is considered the private domain of the community [1]. In this way, observant Jews can carry their keys or prayer books on the Sabbath while acting in accordance with sacred principles. According to Webster's New World Hebrew-English Dictionary, an eruv is a "religious legal fiction drawing a symbolic fence around a town or parts thereof so that the encompassed area may be regarded as one's own yard."

2. Is Manhattan an Eruv?

Natural topographic boundaries such as rivers, cliffs and ravines can also form one or more legitimate sides of an eruv. For this reason, it is possible from a number of Talmudic perspectives to consider the island of Manhattan a natural eruv. This has been debated over the centuries-long course of Jewish habitation on the island [3]. At one point, before the dismantling of the old Third Avenue commuter train line in 1955, the elevated tracks, which transected the island from end to end, formed the western side of an eruv used by the immigrant Polish Chasidic community, so that only the eastern portion of the island of Manhattan was used as their eruv [1]. Presently, the Fifth Avenue Synaoguge on the Upper East Side maintains a pole and wire-based eruv that encompasses all of Central Park. Some rabbis agree that that these are legitimate eruvin while others disagree; there is no consistent agreement across Jewish communities and their rabbis. In fact, many of the most observant religious Jews won't accept any eruv because they see it as an expedient of the sacred laws of the Sabbath, a workaround that was never mentioned in the Old Testament. What complicates matters is that the laws pertaining to eruvin depend upon an intepretation of laws written for an ancient architectural context, at a time when urban space was organized differently and constructed out of different materials.

3. The Third Avenue Elevated Train Line

In 1946 alone, the Third Avenue elevated train line carried as many as 86 million passengers in New York City. Its last service came on May 12, 1955 at 6:00 pm [5]. The iron platform, which ran across the island, from the South Ferry at the southern tip of Manhattan all the way to the north where Harlem meets the East River, was a public structure that was adopted by a group of ultra-orthodox religious Jews and given symbolic meaning. These Jews of Polish extraction, like countless other European immigrants at the time, had settled on the Lower East Side of Manhattan. In 1907, the prominent Rabbi Yehoshua Siegel, who had himself immigrated from Poland and was considered one of the greatest Jewish authorities of his time, published a religious treatise entitled “Eruv V’Hotzaah” which, among other things, established that it was acceptable for Jews to carry on the East Side of Manhattan by determining that the boundary formed by the East River and the Third Avenue elevated train line constituted a valid eruv. This Jewish ruling was quickly disregarded by other Rabbis and was rejected en masse by the Lithuanian Jewish community also on the Lower East Side at the time [1].

4. The eRuv Semacodes

A semacode is a printed binary array that contains an encoded URL. (See section 5.) The semacodes for this project were printed in black and white with an inkjet printer onto sheets of adhesive matte photo paper. They were then coated with a protective matte spray finish to waterproof for outdoor use. Each semacode was roughly four by four inches in size. They were installed in clusters at six different locations along the length of The Bowery and Third Avenue, two continuous streets that together formed the route of the former Third Avenue elevated train line in Lower Manhattan. While the semacodes at each of the six location clusters were identical, there were 15 stickers within each cluster, for a total of 90 stickers. They were installed on public property such as utility poles, kiosks, and garbage bins without municipal permission and positioned in such way as to maximize visibility to pedestrians.

Figure 1. The Bowery Savings Bank beneath the Third Avenue elevated train line circa 1900. (Photo courtesy of the Library of Congress.)

The semacodes contained links to web pages featuring an historic photo of the former train line at the same location as the cluster some 50-100 years earlier. There were a total of six photos, one for each location. Each of the selected photos includes an image of the former train line in addition to a landmark building that is still standing, so that the users could easily identify the area. While the cluster locations are heavily trafficked by pedestrians, it is safe to assume that the vast majority of them did not have semacode-enabled cameraphones. For this reason, a text URL for a project description site was written in fine print at the bottom of the sticker for those users who were curious about the semacodes but could not actually use them. It is reasonable to assume, given the current installed base of semacode readers, that more people experienced the concept of *eRuv* from the project description site than through the actual semacode technology.

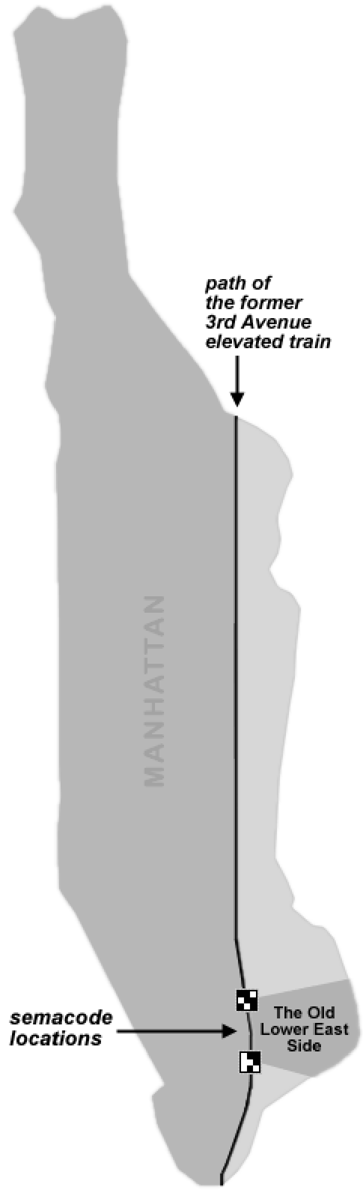

Figure 2. The route of the former Third Avenue elevated train line in Manhattan. The East Side, in pink, is the portion of Manhattan that was established as an eruv by Rabbi Yehoshua Siegel in 1907. The semacodes are installed in clusters along the eruv line, the path of the former train. They were located around the western boundary of the old Lower East Side, where most of the observant religious Jews lived at the time of the elevated train, from Chatham Square on the south to 14th street on the north.

5. About Semacode Technology

Semacode is a visual protocol for interfacing between the Internet and physical space. Using a binary array (like consumer product barcodes, but two-dimensional) one can encode a URL on a piece of paper. Devices such as cameraphones can then "import" that code and, with a software interpreter, use it to link to a URL. These semacodes can then be printed on stickers and installed anywhere in public or private space. What this means from a user scenario perspective is that the cameraphone user must 1) find the semacode, 2) take a photo of it, being sure to have the semacode take up the full contents of the frame, and 3) open it in the semacode reader installed on the phone. The URL will, of course, be useless to the user if the cameraphone is not also web-enabled. This, in most cases, means that the user is paying an additional monthly fee for Internet service.

Semacode readers are not available for all cameraphone platforms. They are currently only available for Java-based phones and Series 60 Smartphones. Generally, this software does not come pre-installed by device manufacturers, so users must download and install the appropriate reader from Semacode.org, which features a comprehensive list of compatible cameraphones.

From a project production standpoint, artists and developers can easily produce semacodes using the Tagger SDK, also available for free at Semacode.org. It comes in the form of a Java applet that can be integrated into standard HTML. In order to use it, an artist or developer must only type in a URL, which is then immediately converted into a semacode image.

Figure 3. A semacode for http://www.dziga.com/eruv created using the free Java applet available at Semacode.org.

The semacode taggers and readers are also available for servers. This allows users to send a text URL via SMS and receive its respective semacode via MMS or email. This is useful for more technically complex applications that allow users with non-semacode-enabled cameraphones to send photos of semacodes via MMS or email to a remote server for interpretation. The server would then send back the appropriate URL.

6. Related Work

The following is a review of other existing projects that use new technologies for linking historical and/or user-generated content to public space.

6.1 FRAG on the Main

A project of the Boulevard Saint-Laurent Development Society and artists Pierre Allard and Annie Roy, *FRAG on the Main* is a cultural history project installed along Boulevard Saint-Laurent, otherwise known as “The Main,” which was once the primary boundary between Anglopohone and Francophone Montreal. Like an eruv, this boundary was more psychogeographic than physical in nature. The project now reemphasizes the historical significance of the street by posting large placards that include historic photos and written histories along its length. While the placards are not associated with supplementary Internet content, each of the installation sites are assigned barcodes which are included prominently on the placards.

Figure 4. A sample *FRAG on the Main* barcode.

6.2 Yellow Arrow

Yellow Arrow bills itself as “the first global public art project.” *Yellow Arrow* is based upon the distribution of thousands of yellow stickers, each with a unique ID such as “yw51eb.” The stickers cost 50 cents (US) plus shipping and handling. When an individual wants to tag something in physical space, he or she installs the arrow and uses SMS to send the sticker ID along with a personalized message to the *Yellow Arrow* phone number for that country. Other users can retrieve the message associated with the arrow by sending an SMS containing the sticker ID to the same phone number. Users can then send a comment back to the originator of that arrow. *Yellow Arrow* also provides functionality on the website called *My Arrows* which allows users to monitor and attach photos and maps to a larger collection of arrows.

6.3 Grafedia

Grafedia, by artist John Geraci, takes *Yellow Arrow* a step further by eliminating the need for coded stickers that require centralized distribution. It achieves this by promoting a social protocol derived from the hypertext standard on the Web. The idea is as follows: Underlined blue writing on the street indicates that a user can send an email or SMS to the address formed by the text of the graffiti concatenated with “@grafedia.net.” In order to set up an original *Grafedia* tag, a user must tag the space with writing in the appropriate *Grafedia* style and upload an image associated with that word to the grafedia.net website.

7. ACKNOWLEDGMENTS

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The history information disclosure system by a cellular phone

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1. INTRODUCTION

Ruins do not exist in a place by chance, they have an inevitable reason for existing in their place. The archaeology and history of Japan have many new discoveries and results by research over a very long period.

However, the field of study is finely divided with each special field of study having many remarkable results, but few instances exist of synthetic research looking at broader histories, such as the history of an area and the features of a time. The research of the area of Japanese ancient times and Japanese medieval times or a city by Koichi Mori, Yoshihiko Amino, Ishii Susumu, etc. is one of a few of the examples [1] [2].

Original historical study is the interpretation synthesizing various areas of research of archaeology or history of an area or the whole time. It cannot be said that the situation of revolving the present history is not necessarily enough. Furthermore, as a result of subdividing an area of research, the results are hard to return to the community at large. As for research, being returned to community at large has a great importance. This is also the problem of the present historical study.

The research presented here synthesizes the fruits of work of old Japanese archaeology and history based on the present condition of such Japanese archaeology and history, and is a trial for returning the result to community at large.

Therefore, in Doshisha University, the following two methods are considered and preparation is advanced now. (1) The method for interpreting three stages at the time of discovering a historical inheritance (ruins/remains), and (2) the historical inheritance (ruins) itself. The three stages at the time of discovery are as following. (i) Acquisition of information about the ruins/remains. (ii) Sharing of this information. (iii) Practical use of this information. Two methods for interpreting an historical inheritance (ruins) are as follows. (1) Restoration of a historical scene. (2) Quantification of the historical information for analyzing the optimal arrangement. Here, (i)-(iii) is considered.

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2. TIME MACHINE NAVIGATION SYSTEM

In order to study the synthetic history of Japanese ancient and medieval times, we need to go back to the time in question and look at the scenery that people of the time were looking at. Then, we can perform historical study with presence for the first time. For this reason, the great historian adheres to the details of the background of an occurrence. Enumeration of an external or isolated occurrence cannot explain the actual conditions.

Therefore, ruins are studied, the results are returned to society, and in order to utilize them for historical education,, we must reconstruct the past scene based on the information which discussed us. But we must know that that is not a real scene but a virtual scene.

We have so far performed various trials. The typical examples are creation of a model or an illustration, maintenance of a ruins park, CG exhibition in a museum, etc. The most ideal form for providing full presence in a historical experience is maintenance of a park in which the ruins are persevered or restored. However, there are very few examples that can be presented as such a park. Now, almost all ruins are lost or are buried in the earth again. Many ruins or historical inheritances are no longer accessible when we want to see them. This is because many ruins and historical inheritances have overlapped with, and so replaced by, our present living space. As a result, CG in a model, an illustration, or a museum has become a standard approach to their presentation.

However, the most effective method for practicing full presence historical experiences is that of reviving the ancient remains in the present place.

For example, the place where Emperor Kammu built DAIGOKUDENN, the central political facilities when HEAINNKYOU started is now immediately north of the crossing of the present SENNBONNMARUTAMATI. However, when the place is visited now, all that is visible is the scenery of an ordinary modern crossing. If various other features of the Heian period are revived, an Emperor's Administrative Office Building would appear nearby. From what kind of elaborate CG seen in a museum might we achieve such presence? The restoration CG of HEAINNKYUU and DAIGOKUDENN is not in its current context, and seeing these at the crossing of SENNBONN-MARUTAMATI has the greater, more immediate, meaning.

Then, as a trial for realizing these ancient features in the same present place, a history display system is under development, offering information (project 8 by a "Keihanna intellectual cluster" creation enterprise "time machine navigation system") delivered by cellular phone and GPS.

The experiment conducted so far is as follows. (1) The base which is used is a CG creation of the Satsuma Domain mansion of the last stage of the Edo period which is now in the Idegawa campus of Doshisha University. This is the creation of the descriptive video of the Time machine-navi. (2) Creation of CG of the Ashikaga general mansion (HANANOGOSHO) of the Muromachi period located on the Doshisha University Muromachi campus. With the mobile personal computer which carries GPS and an autogiro, the picture is united and displayed according to the movement of a user. The experiment which combined the above. (3) digital-guide-experiment for Osaka Castle Park using the cellular phone and GPS.

3. CG of the Satsuma Domain mansion of the Edo period last stage, and research of description video creation of a "time machine navigation system"

The Satsuma Domain mansion was located on what is now the Idegawa campus of Doshisha University in the Edo period last stage. The Satsuma and Choshu alliance, in which there was a great transformation to modern Japanese society, was connected with this place. It can be said that modernization of Japan began from here. However, only the crossing of KARASUMAIMADEGAWA and the building of Doshisha University appear in this place today.

So, this research examined the following point. The historical information required for (1) Satsuma Domain mansion CG creation. (2) Display of the CG and the historical explanation of the Satsuma Domain mansion on the screen of a cellular phone. Takamori Saigo who is the hero of (3) Satsuma and Choshu alliance walks and appears here. (4) What kind of effect does such combination produce?

3.1 Creation of CG

The position and form of the Satsuma Domain mansion are drawn on the pictorial map of the Edo period last stage. Therefore, the dimensions were determined based on these historical records.

We can know from historical description that the Satsuma Domain mansion was the one temple originally. Therefore, the expression of the building of the Satsuma Domain mansion created the general temple of the same time to reference.

As for Takamori Saigo, his photograph does not survive. Therefore, the most common portrait was used to reference him.

3.2 Scenario

Two persons who came from Tokyo come Kyoto of the Edo period last stage to "Karasuma now Idegawa." He is disappointed at what "anything does not have for" one person. The other person takes out the portable electrification talk. If the lens of a cellular phone is turned to Doshisha University, the "Satsuma Domain" mansion will appear on a screen and the image will move to it according to person's motion. Moreover, the explanatory note chapter about the "Satsuma Domain" mansion is displayed. Furthermore, the figure of "Takamori Saigo" who goes to the "Satsuma Domain" mansion is expressed as an animation. Two persons go to the Doshisha University campus of the remains of the "Satsuma Domain" mansion so that it may be invited by "Takamori Saigo."

Fig.1 Package model of Time machine navigation system

Fig.2 Navigation with "Takamori Saigo"

3.3 Result
It turned out well that it is effective in making the historical experience intelligible by allowing the lost history inheritance to coexist with the present scenery using a cellular phone.

3.4 Problem
As for older historical study, the scene and scenery were seldom considered. Therefore, there are very few historical records which can be consulted in order to restore the Satsuma Domain mansion and the image of Takamori Saigo. Therefore, it turned out that it is very difficult to create sincere CG. However it can offer an image which is full of presence, if the contents are not faithful to a historical fact, it will not become the right history inheritance in practical use.

A thing called a real history expression is the point which old historical study made the weakest. This is a big subject for the present holistic historical study. Furthermore, since expansion and the reduction of a digital image are free, unlike the restoration model and restoration illustration which have so far been performed, expressing correctly the details is called for. However, in old historical study, there was also little such data and it became a big problem. The pictorial data which the opportunity treated as historical records until now had need to be positively utilized.

Moreover, in order to reproduce it as a scene, not only each building and person but the expression of a scene which summarized the fixed area is required. However, everydayness, a feeling of a life, etc. in which the existence of man is given only by material space, laying out each building only in combination is not obtained. Moreover, an ornament unrelated to a historical fact will make the wrong scene. The necessity of building the detailed database of historical information anew was felt.

4. The experiment of the HANANOGOSHO inspection by the mobile personal computer with GPS and autogiro
The experiment of the HANANOGOSHO" inspection by the mobile personal computer of GPS and autogiro loading

The Muromachi campus of Doshisha University is the presumed ground of HANANOGOSHO which the general of the Muromachi period used as his mansion. From this place emanated the politics, the Japanese economy, and Japanese culture of the Muromachi period. It is the place which played the same role as Kasumigaseki in present-day Tokyo. However, in the place KANNBAIKANN of a private house and Doshisha University is built now, and the former general's mansion cannot be imagined.

So, the following experiments were conducted in this research. CG of HANANOGOSHO was created. The information on this place is provided. It is perused with the personal computer to which GPS and an autogiro were attached. The user walks along KANNBAIKANN presumed by HANANOGOSHO. An effect which is walking along HANANOGOSHO in CG is investigated.

4.1 Creation of CG
The position of HANANOGOSHO, referred to as HANANO-GOSHO is drawn on a national treasure, and UESUGIHONN-RAKUTYUURAKUGAIZU with the present KANNBAIKANN and its area on the south.

The building of HANANOGOSHO created to reference HANANOGOSHO currently drawn on RAKUTYUU-RAKUGAIZU.

Fig.3 GPS positioning with autogiro in HANANOGOSHO

4.2 Directions

4.2.1 Applying CG to the present place
The site of HANANOGOSHO is referring to RAKUTYUU-RAKUGAIZU, and it turns out that it is surrounded a KAMIDATIURI passage, a KARASUMA passage, and as MUROMACHI.

4.2.2 The user walks along HANANOGOSHO.
From the ground, HANANOGOSHO CG created in three dimensions considers it as a viewpoint, rotates 360 degrees, and can be perused to a height of 1.5m now. By GPS, from the point by which positioning was carried out, the position which stands for itself is reflected in CG, and the experimenter with a mobile computer looks at the reproduced HANANOGOSHO through the screen of a mobile computer. Furthermore, with an autogiro, if an experimenter changes direction, the view of HANANOGOSHO on the screen will follow their movement.

4.3 Result
The lost buildings reappear in the place and the historical inheritance is interlocked with the motion of a visitor. The presence which has not been experienced until now was obtained.

4.4 Problem
It was realized that the historical information required for CG work was insufficient in the case of the Satsuma Domain mansion. This experiment referred to the available pictorial data RAKUTYUURAKUGAIZU. About a building or scenery, more history information than the Satsuma Domain mansion was able to be acquired. However, a detailed expression left many

subjects. Immediately, it is necessary to build the detailed database of synthetic historical information.

6. Conclusion

The place in which the people of ancient and medieval times lived, their lives, and society were not special. There were no our present life and present change fundamentally. People of those days were also living an "optimal" life and "common" in each area.

An important question is what kind of thing the “optimal” was. The historical research in each area which is full of presence is helping to explain this rationally. Until now, it was divided into elements, such as "politics", a "system", "religion", and "economy", and each special field of study has been explained separately.

However, a historical normal state of being is a different whole sense of values. It is not a set of each explanation. City research is also the research which was conscious of the medieval times when the ancient study in which Mr. Koichi Mori took the lead, and Mr. Yoshihiko Amino and Mr. Ishii Susumu have advanced it. The rational fusion of a different sense of values is the target of the historical study which should be aimed at from now on.

It is expected by the theory of the optimal arrangement based on suitable quantification as the most promising method of attaining this target that research on the ruins to which archaeology attaches importance most at that point is scene restoration by GIS.

Since priority is given to known superior information, the research into ruins and remains which archaeology has so far performed has been premised on the data obtained by excavation. However, excavation is performed regardless of the existence of ruins in many cases. The data obtained by excavation is only part of the data required in order to restore the history of the area. Although the research of ruins performed now is superior data, it is only a restrictive hypothesis by the data collected by chance for historical restoration of the area.

From the first, history is a proposal and an argument. There is no problem in all explanation of historical study being hypotheses. However, if based on old research, the range of the data to examine is extended and it is time to try the analysis of all data required in order to explain history. The work which examines the same data from various directions is fundamental. However, the trial which produces new data and examines the whole including the related data containing is also required.

The social structure of an area is due to be restored in broad view and in micro. The methods of acquisition, information sharing, and practical use of the ruins information which Doshisha University has recommended by including all the ruins information in a GIS database, enabling the prediction of undiscovered ruins.

Archaeology is learning which describes history based on ruins. However, finally man must be described. The viewpoint of a human being with a feeling of actual existence is required. Archaeological research may be absorbed in artifact and object research and may forget the human research which is its original purpose. man should be studied from the substantial data -- there are many examples which started as research into the material data and have been finished with research into the material data. We have to check anew that archaeology is one field of historical study, and that the purpose is research into human history.

Furthermore, we must be careful of the prejudices of the living human being who is not model-like and is not abstract. He is not the human being who is anywhere. It is the prejudice by the human being who was present in the place, and the human being who was alive at the time.

7. REFERENCES

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