

# First Experiences With a Mobile Information System Supporting Reflective Exploration of Unknown Terrain

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**Abstract:** Supporting people "on the move" introduces a number of constraints that are not present in traditional human-computer interaction settings. In this paper, we describe first experiences with a mobile information device supporting tourists during what we call reflective exploration of areas of interest. The modified mobile game client provides information about the area explored plus information about the tourist's *own* ongoing and past activities. Feedback captured during and immediately after field experiments suggests that participants appreciate that the device offers a range of annotation modalities allowing participants to choose whatever modality fits their current annotation needs. The device's distinct way of visualizing information about past explorative activities also seems to help participants orientate themselves in the unknown terrain and plan next steps of the explorative activity.

## 1 Introduction and Related Work

Using mobile computing technology to support people "on the move" is one of the latest frontiers of technology development and deployment. From a research point of view, it is a challenging area as mobility introduces a number of constraints and difficulties that are not present in traditional human-computer interaction settings featuring, for example, users sitting in front of bulky desktop computers. Examples of technical constraints introduced by mobility include the need for small, lightweight devices, small screens, limited screen resolution, unreliable network connectivity (if available at all), limited battery life, and so on (e.g., [SG05]). More activity-related constraints include the kind of information that is needed in a certain situation and how the information is presented (e.g., [Pe01]).

Industry-oriented research in mobile computing typically has focused on enabling mobile business or mobile work (e.g., [Pi03]). Researchers also have started to look into using mobile technology to support what is often referred to as leisure activities, such as tourists visiting museums (e.g. [Ca05], [Ch04]) and exploring unknown terrain (e.g., [Ch00, BL04]). Work in this area has focused on providing information to guide people

to local attractions and/or provide additional information about artifacts. Researchers also looked into providing information about what other people in an area have been doing during their visits (e.g., [Da02], [LB05], [OI05]).

In this paper, we describe first experiences with a mobile information device supporting reflective exploration of areas by providing information about the area the user is exploring plus information about his or her own ongoing and past activities.

We proceed as follows. First, we describe some of the assumptions guiding our research into the usefulness and usability of mobile devices in the context of leisure activities. Then we describe the technology we used as well as the experimental conditions under which we field-tested the prototype in an area of interest to tourists. Next we provide an analysis of some of the data we collected during the field experiments. The paper closes with a discussion of findings with special consideration of what we call reflective exploration and an outlook on future research.

## **2 Exploring usability and usefulness of mobile devices in the context of leisure activities**

Usability and usefulness are widely considered important dimensions when developing and evaluating mobile devices. When such devices are deployed in work-related contexts there is a good chance that respective devices will be utilized even if users do not appreciate using them. The user acceptance situation is quite different in the context of leisure activities, such as hiking or visiting an area of interest. If users are to use mobile devices at their own discretion then these devices have to provide --or at least promise-- some benefit to the user.

Mobile devices to be used by tourists have emerged as an interesting but challenging research area. Researchers approach the area from a range of inter-related directions. First, considerable effort is being spent on understanding what tourists actually *do* when exploring an area of interest, and if any of the activities observed could be supported by some kind of mobile technology. Often this involves using ethnomethodologically inspired methods to describe and understand respective practices (e.g., [BC03]). A complementary approach, often found in more engineering-oriented research communities, is to explore what is technically feasible and then to see how this could fit into what tourists would use. Often, the value of such technologies and their relevance to practice is unclear as respective practices do not yet exist [Cr04]. It has been argued that the bias towards building systems and a lack of research for understanding design and use limits the development of cumulative knowledge on mobile human computer interaction which in turn inhibits development of the research field as whole [KG03].

In our work we are pursuing what might be called a hybrid approach in that we draw from published research suggesting that tourists do appreciate the additional support that mobile devices can offer (see e.g. the GUIDE project [Ch00]). For our own research we customized an existing mobile learning system which will be described in more detail in the next section. In order to understand whether the functionalities are appreciated by users, we conducted a number of field experiments in Hobart's Battery Point precinct which is a historically significant area that is known to be of interest to tourists and locals alike. We regard the prototype we developed as a technology probe rather than a prototype system that is merely field-tested to verify the functionalities provided. A

technology probe is "a particular type of probe that combine the social science goal of collecting information about the use and the users of technology in a real-world setting, the engineering goal of field-testing the technology, and the design goal of inspiring users and designers to think of new kinds of technologies to support their needs and desires" [Hu05].

There is an ongoing discussion as to whether it is necessary or at least advisable to conduct usability and usefulness tests in authentic environments rather than in simulated environments. Regarding usability evaluations, [Kj04] argue that the added value of conducting usability evaluations in the field is very little and that recreating central aspects of the use context in a laboratory setting enables the identification of the same usability problem list. This is certainly true when narrowly focusing on usability issues but the kind of data we are interested in would be difficult to obtain if we as designers/developers would prescribe as to how subjects should explore an area.

### **3 mExplore: a mobile device supporting reflective exploration of areas of interest**

It is often assumed that tourists explore areas of interest in a goal-directed way e.g. by joining a guided tour or by following routes outlined in their guide books. While this is certainly true for some tourists, anecdotal evidence suggests that others prefer a more browsing oriented approach. Results from ethnographic studies of tourists exploring cities suggest that "destination" may not even refer to a specific location but to loosely specified areas [BL05]. The browsing approach is also supported by guide books but then the book is used more like a resource providing information about objects of interest (buildings, places, etc). The tourist then organizes the specific details as to how the area is explored. Both approaches have their specific strengths and weaknesses. The goal-directed approach is may be more time-efficient and "complete" in the sense that tourists will visit most (if not all) of the objects known to be of interest to tourists. The advantage of the browsing approach is that tourists may encounter more things they had not expected. Typically, tourists will exhibit a combination of both approaches i.e. they pursue whatever strategy suits their needs at a particular point in time.

Most mobile devices supporting tourists while exploring an area of interest tend to focus on what we might call object-driven exploration: guiding the tourist through the area by visualizing his or her current position plus the location of nearby points of interests. We use the term guide to denote "a system closely related to the user's physical location and objects in the user's immediate surroundings" [Kj04]).

The introduction of mobile devices also enabled tracking of tourists exploring an area. Subsequently it has been proposed to use such data to suggest to tourists e.g. most popular routes or routes taken by famous visitors [Da02, LB05].

The device used for conducting this research is a modified version of a mobile game client developed at the University of Zurich for helping first semester students become familiar with the new learning environment (e.g., [SG05]). Apart from providing basic object-related information, the mExplore prototype also supports what we call reflective exploration. By this we mean that mExplore can be used as an information resource helping tourists reflect upon what they experienced so far and then use this information to shape how they might continue exploring the area. A rather simple example of

potential outcome of this reflective process would be using information as to what area had been explored during the past couple of hours to decide to continue the activity in an adjacent area. We are not saying this is not possible using a paper-based guidebook e.g. by making annotations or drawing on a map; rather, we think that a mobile device like mExplore offers additional opportunities which we are exploring through deploying mExplore as a technology probe.

The mExplore system is implemented as a client-server model. The mobile client runs on a Windows Mobile based PDA and uses the Ekahau Positioning Engine to provide location information. The engine requires WiFi coverage in the respective area. WiFi is also used for the communication between the mExplore client running on PDAs carried by tourists and the respective mExplore server.

In what follows we provide some details regarding the different functionalities.



**Figure 1: The mExplore prototype. The left side shows a digital map of the area along with a few representations (six points of interest and three user-created representations) as well as the user's past route within the area of interest. The right side shows an example of a written annotation.**

### **Location information**

mExplore provides a digital map of the area the tourist is exploring. A transparent aura is projected onto the map to indicate the tourist's current location (see Figure 1 left). Similar to ambient displays, the radius of the aura is used to provide information about the inherent inaccuracy of the positioning engine.

### **Past route information**

mExplore collects location data while a tourist is exploring an area of interest. The data is used to visualize, as a thin red line, the tourist's past route (see Figure 1, left).

### **Textual, audio and photo annotations**

"Typical" tourist activities include creating/maintaining representations allowing tourists to reconstruct what they experienced during a journey and also to reflect upon their experiences. Respective activities may include keeping diaries, taking pictures, collecting information brochures, and buying souvenirs. mExplore supports the creation of digital representations by allowing users to capture textual annotations (see Figure 1, right side), verbal annotations and digital pictures. In the context of the Battery Point experiments, taking photos was enabled by supplying a small Canon Digital Ixus camera providing the camera functionality the respective PDA lacked.

mExplore automatically associates digital representations with the location where they were created. Icons projected onto the digital map also indicate the kind of representation created. Clicking on such an icon retrieves the representation. A major difference between these annotations and annotations written into paper-based guide books is that mExplore can generate a personalized "travel diary" (see below).

### **Points of interest**

Similar to other mobile guides, mExplore provides information about nearby points of interest (blue "i" (=information) on the digital map). Clicking on these icons delivers a description of the respective point of interest.

### **Automated generation of a personalized diary**

mExplore can be used to generate a "diary" reflecting the user's activities performed while exploring an area. The diary is created as an HTML page featuring a digital map of the area visited, points of interest, and links to textual, voice and photographic annotations. The map includes a visualization of the actual route taken. The diary can easily be included in a personal web site etc.

## 4 Testing mExplore

Mobile activity took place in the city of Hobart, Australia in the historically significant Battery Point precinct. The location was selected because Battery Point is one of Hobart's prime tourist locations and offers ample opportunities for exploration even for visitors already relatively familiar with the area. Seven out of eight participants (seven males, one female) were in their 20s; one female in her late 30s. All were currently enrolled at the local university and were recruited via an invitation emailed to Hobart-based honours and higher degree research students (the university operates three campuses across the state of Tasmania). Details of the experiment and ethical aspects were discussed prior to the experiments during a recruitment meeting held at the university's Hobart campus.

All participants had been to Battery Point area before and rated their familiarity with the area in average as about medium. Further briefings as well as an introduction to the mobile devices used were held prior to the experiment at a central location in Battery Point. Each participant was told they would have about half an hour they could spend exploring Battery Point. They were also told explicitly that it is up to them as to how they would spend the time, resulting in quite diverse exploration routes.

Because of a lack of WiFi (wireless internet) coverage in the Battery Point area, we implemented a Wizard of Oz approach to location awareness. This means each participant was followed by a "Wizard" using a laptop to update every few seconds, via a WiFi ad-hoc network, the participant's location on his or her PDA such that the participant's PDA would always reflect the participant's current location (see figure 2).



**Figure 2: The first author (right hand), acting as wizard, shadowing a participant (left hand, next to pole) while exploring Signalmaster's Cottage (Battery Point precinct in Hobart, Australia).**

Once participants finished their exploration activity they were asked to provide some verbal feedback and were also requested to fill out forms covering details, such as

general impressions regarding the mobile information system they just used, more specific usability aspects as well as few technical issues. Forms also offered an opportunity for providing free form comments.

Apart from the questionnaires, data collected during the field experiments includes comprehensive location data describing the routes taken by participants, photos and audio recordings taken by participants as well as photos taken by a second wizard shadowing participants. Because of the real world setting and the lack of continuous video recording of participants, monitoring of participants had been incomplete at times.

## **5 Discussion of findings**

Still in the process of analyzing the data collected and generating narratives describing participants' exploration experiences, we would like to focus on a number of findings that stick out already.

### **5.1 The overall impression**

We used a post-experiment questionnaire to find out if participants appreciated the functionalities offered by the mExplore prototype. Participants rated "helpfulness" of the system as 3.75<sup>1</sup> and "fun of using the system" as 3.875<sup>2</sup>. This suggests that participants did appreciate functionalities offered by the prototype.

Generally, feedback regarding mExplore was clearly positive. All participants stated they would like to use such a system when exploring other locations. They rated re-use of the system with 4.125<sup>3</sup>. We also used the SUS test [Br96] to find out about the system's usability in general. The result of 75.94 indicates a high degree of usability. A statement by one of the study participants appears to be representative of the overall impression:

"I liked the software, it was easy & fun to use. I would use it if I was in a new city or especially in a new state / country."

In what follows we will discuss in more detail selected findings regarding the usage of the different annotation functions, the positioning function and the history function.

### **5.2 Usage of the annotation function**

Based on previous experiments with mobile technology (e.g., [SG05]), we expected that the newly introduced audio recording functionality would be used frequently. Participants in previous experiments expressed difficulties using the virtual keyboard provided by the PDA. This hypothesis is partly supported by the data collected during these experiments.

Over the course of the experiment participants generated 54 annotations. The most

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<sup>1</sup> Points on a scale from 1= not at all to 5= very much, N = 8

<sup>2</sup> Points on a scale from 1= not at all to 5= very much, N = 8

<sup>3</sup> Points on a scale from 1= not at all to 5= very much, N = 8

frequently used annotation functionality was taking a picture (27 annotations) followed by the audio recording function (16 annotations) and the text input function (11 annotations).

Offering digital pictures and digital audio recordings input as alternative --and possibly more efficient-- input modalities did not mean participants abandon textual input. Interestingly, one participant used the audio annotation function to augment photos. Every photo taken by this particular participant was accompanied by an additional audio annotation (see Figure 3) describing what is actually shown on the photo as well as the context of taking the picture. Feedback provided in the free form section of the post-experiment questionnaire points towards the motivation for doing so:

"I thought having photos & voice was terrific you could record why you took a photo, very valuable when you return from a holiday and you have all these photos of old buildings and you are not sure where or why you took it"



**Figure 3: Seven photos augmented by additional audio comments**

Comparing audio and textual annotations reveals another unexpected result. The three participants who used audio annotations did not use the textual annotations (except for one single text annotation). In the free form feedback section they explain:

"The sound recording feature was more useful than [sic] the written annotation as you can record your comments a lot quicker. It would be a useful feature if you were in a hurry."

"I would get rid of the annotation in favour of voice messages they're quicker and easier"

"I think the voice recording is better than the annotation. I think on-screen keyboards are too fiddly, especially for people unfamiliar with PDA use."

The point is also supported by the fact that the three participants who used the audio annotation function produced a much higher number of annotations than participants who used the text annotation function. This suggests that the voice recording function is indeed easier and faster to use than text input.

However, interpretation of this result is not as straightforward as it may seem. Participants who used text annotations did not use audio annotations at all. Feedback from one of the audio annotation users as well as from previous, unrelated experiments with similar devices (e.g., [SG05]) suggests that this form of annotation may be difficult to use and may also be inefficient. We believe a verbal comment by one of the



participants (quoted from memory) helps explain this phenomenon:

“I don’t like the voice recording function because I don’t like to hear my own voice”

Anecdotal evidence suggests that quite a few people do not like video or voice recordings of their own. This helps explain as to why a number of participants did not use the audio annotation function even though using it may be much more efficient than textual input.

Overall the data we collected suggests that it is important to offer a range of annotation modalities. Each participant in the experiment used the range of annotation functionalities available in a different way. Participants were able to do so because the mExplore prototype does not constrain usage more than necessary from a technical point of view. We believe this is one of the reasons as to why participants generally liked using mExplore.

### 5.3 The positioning and the history functionality

The positioning function (4.5<sup>4</sup>) was rated best among the functionalities provided by mExplore. Participants also rated the map and the position visualization highly (4.5<sup>5</sup>). The following comment by a participant seems to summarize the general impression:

"Map and location feature probably the most useful part of the system."

The positioning function is closely connected to the visualization of the past route (see figure 1 left for an example of a past route projected, as a thin red line, on the digital map), which was rated as 4.375<sup>6</sup>, i.e., nearly as high as the positioning function itself.

We expected that the novel past route visualization would help participants understand what parts of the area of interest they already explored and what parts they hadn't visited as yet. Both the very high rating of the history function as well as feedback from participants suggest participants appreciated the past route visualization:

"Movement history is also very useful, as you can see where you haven't been yet"

The following comment supports our expectation regarding the usefulness of the history visualization:

"The system could be really cool for people revisiting the site some time in the future- to re see the places they liked, and avoid places they disliked, also allowing them to go on new routes"

An analysis of the routes taken by participants reveals no participant visited an area twice (see Figure 4 for a couple of examples). However, this observation might be due to a number of reasons including moderate familiarity with the area and participants' natural navigation skills.

What we did not expect to find is evidence suggesting that the past route function helped participants orientate themselves (and thus navigate) in a very profound way. In previous experiments with a similar positioning system we observed that people were often stopping at crossroads because they lost their orientation. Participants used to align

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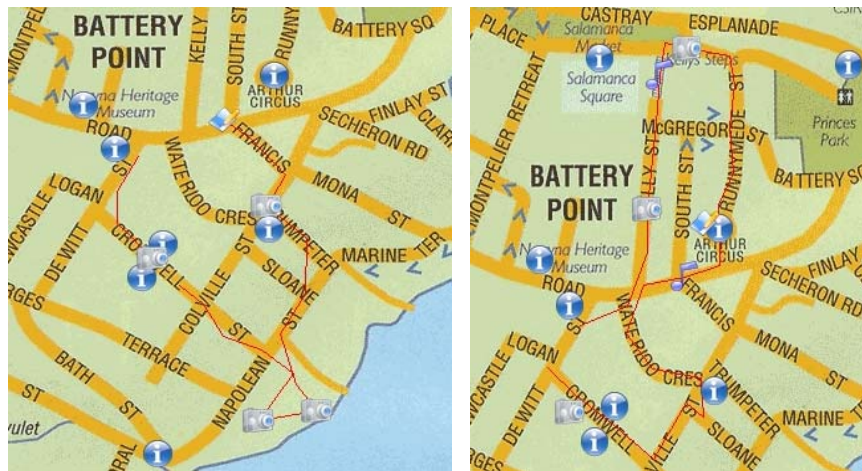
<sup>4</sup> Points on a scale from 1= not at all to 5= very much, N = 8

<sup>5</sup> Points on a scale from 1= not at all to 5= very much, N = 8

<sup>6</sup> Points on a scale from 1= not at all to 5= very much, N = 8

the digital map provided by the PDA and their line of sight to decide where to go next. We did not observe this effect during these "history-enhanced" experiments. Rather, seeing their past route appeared to help participants orientate themselves.

One explanation we came up with is based on the apparent difficulties people have when using traditional or digital maps (e.g., [BL04, BC05]). Generally it is difficult for people to align maps to their current orientation as maps always provide the same orientation (typically North-South), regardless of the user's physical orientation.



**Figure 4: Examples of routes taken by participants 6 (left hand) and 7,8 (right hand). The additional red lines indicate the actual routes taken.**

## 6 Conclusions and future research

Testing the mExplore probe in a realistic, tourism-relevant scenario allowed us to collect valuable data and provided us with valuable insights into ways to support tourists. We are well aware that our data is biased as study participants were not genuine tourists. One of the next steps in this research is therefore to conduct similar experiments with participants we are going to recruit among genuine tourists (negotiations with relevant stakeholders have begun).

We are also exploring different ways to incorporate personalized points of interests. As yet mExplore supports only generic points of interests which means that each user sees the same set of points of interests. Such personalized points of interest are derived from participant profiles which means previous visits to an area will be considered too.

Last but not least we are further exploring the use of visualizations of routes taken during previous visits to an area. This is related to ongoing research looking at ways to support (re-)using route descriptions as publicly shared resources [LB05].

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