Just Point and Click? Using Handhelds to Interact with Paper Maps.

Derek Reilly, Michael Welsman-Dinelle, Colin Bate, Kori Inkpen
Faculty of Computer Science
Dalhousie University, NS, Canada
+1-902-229-1612
{reilly, michalw, bate, inkpen}@cs.dal.ca

ABSTRACT
We present preliminary results from two studies examining the selection techniques suitable for paper maps using handheld computers or cellphones as interaction devices. An informal mockup exploration indicated a strong tendency toward point-and-click style interaction when participants were asked to envision how a range of queries might be expressed. A subsequent study involving a functional prototype and a short training session showed that participants were receptive to other interaction styles, including tracing paths, circling regions, constraining queries with paper menus, and selecting multiple non-adjacent map icons. The contrasting results underline the importance of using a range of design evaluation techniques when developing applications involving handheld devices as interactors.

Categories and Subject Descriptors
H5.2. [**Information interfaces and presentation (e.g., HCI)]**: User Interfaces – *prototyping.*

General Terms
Design, Experimentation, Human Factors.

Keywords
Mixed Media Interfaces, Universal Interactors, Geographic Maps.

1. INTRODUCTION
Paper maps are promising physical artifacts to interact with digitally. As information resources with distinct regions, paths, and icons, they promote the expression of spatial and topical queries via selection operations [1]. For example, information about a given map icon might be retrieved by pointing a device at the icon and clicking a button. Such interactions are a common feature of electronic map interfaces, however it is not at all clear that a successful technique for electronic maps will translate to paper maps.

Interaction with paper maps was one facet of the Chameleon project [2], wherein a handheld computer was used as a virtual overlay or lens over a static paper map. Combining electronic resources with paper maps is also explored by McGee and Cohen [3]. Interactive paper technology including Anoto [4] and DataGlyph [5] have also been used to produce interactive maps.

Our focus is on ad-hoc interaction with paper map resources when mobile, using either personal maps or public kiosks. We envision that the interaction device under such circumstances would be a personal device such as a smartphone.

This scenario presents a number of potential benefits, including:

- Permitting the continued use of standard paper maps as navigation tools, while introducing the electronic device as a dynamic, interactive information resource.
- Allowing users to build and use survey knowledge, which is harder to achieve using maps on small screens.
- Allowing users to take the results of their interactions with them on their mobile device.

2. MOTIVATION
The work presented in this paper follows from a prior study in which participants retrieved pages from mobile city guides by holding a handheld over places of interest on a paper map and clicking a button (figure 1). Results were promising for the technique, especially during tasks which required a close correspondence between the map information and the guide resources (e.g. spatially-oriented tasks) [6].

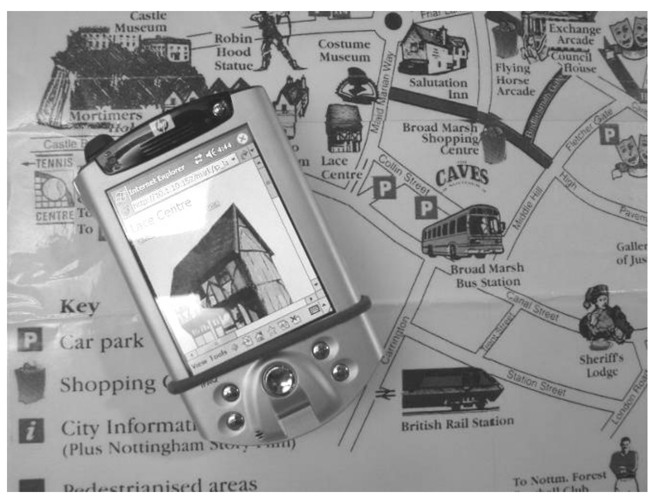

Figure 1: Initial prototype, showing Nottingham paper map and attraction detail on PDA

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The prototype used in the first study permitted point and click interaction only, by associating information to single points on the maps. We have since developed a prototype that permits a wider range of interactions with a map using a handheld computer. In this paper we present initial results concerning the effectiveness of various techniques when interacting with static paper maps.

For example, the current prototype permits selecting paths. The technique is illustrated in the following example, which expresses a request for a street directory:

1. point the PDA at one end of a street (on the paper map)
2. press a button on the PDA to begin the selection
3. drag the PDA across the length of the street (on the paper map)
4. release the PDA button to complete the request.

Additional supported interaction styles include circling map regions, selecting multiple non-adjacent map items, and interacting with "paper controls" on the map itself. In the next section we discuss the results of a lo-fi prototype evaluation.

3. MOCKUP EVALUATION

We conducted an informal study involving seven participants in which we explored potential techniques for interacting with paper maps, to gather design ideas for prototype development.

Participants were given either a cellphone or a PDA, and told that the device could be used to interact directly with maps, much like a pointer or stylus. We alternated between devices to mitigate the impact of form factor, screen size, buttons, etc. on the participants' expectations. The exercise was entirely make-believe: the device was turned off, and participants envisioned and demonstrated how they would use the device to answer certain questions. They were free to imagine any kind of software support on the device, and to assign functions to map icons.

Participants were asked how they would expect to complete several fact-finding tasks. Each task involved one of three paper maps: a schematic subway map, an illustrative tourist map, or a street map. Tasks ranged from executing targeted queries (e.g. get bus lines and frequency between two points on a map), to gathering a range of detail (e.g. get tourist information pertaining to a map region). Participants described and demonstrated their expected interactions, which were recorded for later review.

3.1 Observations

As might be expected, there were a variety of expected approaches to the tasks provided. We categorized each by the style of interaction between the device and the map, and the nature of expected software support. Observations are summarized below.

3.1.1 Trend toward Point-and-Click interaction

Selecting by pointing at a map location with the handheld and clicking a button on the device was by far the most common interaction envisioned by the participants. This interaction was predominant when tasks involved individual map items such as attraction icons, but was also used to express queries for travel time between points (select each endpoint), queries related to streets (select street name), and queries pertaining to larger regions (select name of region). Other interaction techniques were envisioned as well, however point and click was predominant. Other techniques included circling regions, tracing paths, and hovering over/scanning areas.

3.1.2 Amount of interaction with the handheld device

On several occasions a participant would indicate that they didn't expect map interaction itself to be able to provide the information required for a particular task. For example, one participant made a distinction between "typical" queries, which would be supported primarily via direct interaction with the map, and atypical ones, which would require some additional interaction with the handheld. Interactions described with the handheld device included selecting a category of information prior to interacting with the map, following step-by-step instructions given on the handheld while interacting with the map, and drilling down to specific details after selecting items on the map.

4. IMPLEMENTATION

A functional prototype was developed, permitting use of a handheld computer to directly interact with paper maps in various ways. We focused our prototype on the action of selecting map items, as this is a critical aspect of many expected interactions. Techniques were inspired by our previous work and the results of the informal study just described. They are outlined in table 1.

Table 1: Interaction techniques supported by the prototype.

Technique	*Description*
Click-select	*Click handheld button when device is over item to select it (point and click).*
Path-select	*Click handheld button at starting point, drag along path, release button to select entire path.*
Multi-select	*As with click-select, but using a different button, to select multiple non-adjacent items.*
Lasso-select	*As with path-select, but with same end and starting point. Points inside circle are selected.*
Menu-select	*First select an information category using a paper menu (see figure 4), then interact with the map using one of the previous techniques.*

While the make-believe session suggested that point-and-click could be the dominant or sole technique for interacting with paper maps (at least for the range of maps and tasks used), we decided to include a range of interaction capabilities in our prototype. This is because several individuals suggested the use of other interaction techniques for one or more tasks, the other techniques might more effectively express certain information needs, and because we felt that a functional prototype might alter receptivity to other interaction styles.

Our prototype was developed as a simple client-server application. An RFID (Radio Frequency Identification) reader was attached to the back of an iPaq handheld computer, such that regions on the map were selected by holding the handheld face up over the region. RFID reads were sent to a server, which logged RFID reads and communicated RFID tag ids to client software on the handheld. The client software combined RFID read information with button presses to generate the higher level selection events described in table 1. These events were sent back to the server for logging, and determined the audio and visual feedback presented on the handheld (see figure 2). For example, the start of a path selection would cause an orange trail to be left as the selection progressed; once the button was released the path would then turn red and a particular sound would play.

Figure 2: Interacting with the Nottingham map. Map-style feedback indicates the map icon the user is currently over.

Beyond selection feedback, no further information was provided to the user relevant to specific queries. That is, an information system was not created as part of this prototype: the implementation ended at selection. The prototype was also limited in selection *granularity* by the size of the RFID tags. A grid of 40x40mm squares was used for one map, and another had RFID "hotspots" corresponding to prominent map icons. As a result, only coarse approximations of selected regions or items were captured by the prototype.

Despite this limitation, we consider RFID to have some benefits for portability. It allows a paper map to be held at any angle, to not be completely planar, and to be used in any lighting condition.

5. EXPERIMENT

Our formal experiment is briefly described here. A full discussion of the experimental design is available separately [7].

5.1 Design

The study employed a repeated measures design, involving 12 participants. The main experimental factor was the type of visual feedback presented on the handheld during interaction with a paper map (figure 3).

In this paper, we focus on the use and evaluation of the interaction techniques supported by the prototype, and do not directly consider the effect of specific feedback styles. Because two types of feedback were used, the impact of the type of visual feedback during selection operations was mitigated.

Two map scenarios were used under each feedback condition. One scenario involved an illustrative tourist map of Nottingham, England (figure 2), and the other a larger street map of Halifax, Canada (figure 4). Participants were not familiar with either city. For each map scenario, participants were first given a series of short training tasks designed to demonstrate the various selection techniques. These tasks were not explicitly suggestive of how specific information queries might be posed. Instead, they were direct instructions for accomplishing selection tasks, e.g. "click and hold the button over Sherwood Forest, follow streets to Nottingham Castle, and release the button".

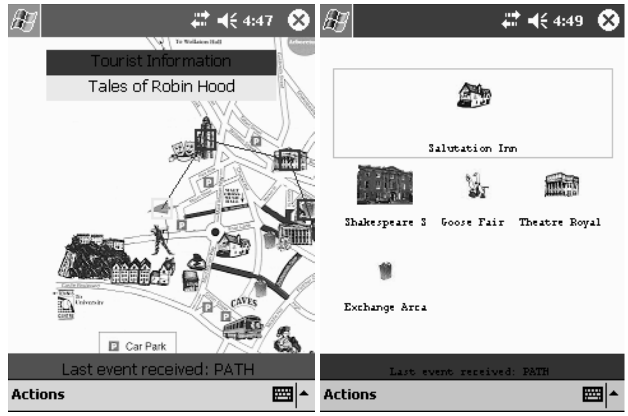

Figure 3: Feedback styles presented on the PDA during interaction with the Nottingham map. On the left is the map-style feedback, indicating that a path has been selected for a query constrained as "tourist information". On the right is an example of "butterfly net" feedback, showing the list of items selected so far, and the current item the PDA is over.

Figure 4: Interacting with the Halifax map. On the right the user sets a query category by selecting a menu icon.

The second set of tasks were more open-ended. Each task could be accomplished using more than one selection technique, however each was most efficiently completed (in our estimation) using a particular technique. For example, one task asked how the participant would retrieve a list of coffee shops in a pedestrianised area. The expected interaction was to select "food and entertainment" on the paper menu, then to "lasso-select" (circle) the region on the map. Participants completed either four or five such tasks (as time permitted) for each of the two maps under each feedback condition, for a minimum total of 16 unique tasks attempted per participant. A think-aloud protocol was used when these tasks were being completed. Task, map, and feedback condition orders were counterbalanced.

5.2 Measurement

The software logged time taken per task and the interactions registered by the handheld while the task was being performed. For each task, an observer recorded on a coding sheet the final interaction as described by the user as well as a description of overall style (e.g. speed, precision, fluidity).

Participants completed questionnaires asking them to rate interactions for given maps, and evaluate the visual feedback provided to them. Most questions were on a five-point Likert scale. A post-session interview asked several questions intended to garner impressions of the prototype, ideas for improvement, and their overall experience. Prior to the interview participants completed similar tasks with an electronic map presented on a touch-sensitive wall-display, to use as a counterpoint when discussing the prototype.

6. RESULTS

Overall, the interactions recorded stand in contrast with those imagined by participants during the mockup evaluation. The full range of interaction styles were used; there was no observed preference for point and click.

For the majority of tasks, there was strong consistency across participants in the interaction techniques chosen. For the most part these techniques were as expected for the tasks (see table 2).

Table 2: Number of trials completed per interaction technique, and the percentage completed using the expected technique.

Technique Expected	Total number of tasks (trials)	Percentage of trials as expected
Path-select	8 (92 trials)	87%
Lasso-select	4 (46 trials)	70%
Multi-select	8 (74 trials)	64%
Click-select	0 (0 trials)	n/a

A number of tasks engendered a variety of approaches, however. For example, certain tasks that were expected to be completed via multi-select were often completed as either paths or as several click-select operations. When the map icons to be selected were relatively close to each other and could be connected by drawing an arc (path) through them, approximately one third of participants chose the path interaction.

None of the tasks given to participants highly favoured a "click-select" (point and click) interaction, however the click-select technique was introduced in the training sessions. We did this to evaluate the strength of the tendency toward point and click observed in the mockup study. Only 9% of all task trials were completed using a click-select approach.

Each map included an iconic paper menu allowing participants to constrain queries according to information category. The menus were used in this way by all participants. In fact, there were no cases where participants felt that they could not answer a question given the tools provided. However, some menu categories overlapped and there was no unanimity in the category chosen for most tasks. For example, "tourist information" and "accommodations" were chosen with equal frequency when participants were asked how they would find a hotel listing.

7. DISCUSSION

Providing a functional prototype and some basic training led participants to quite fluidly interact with the paper map using the path, lasso, and multi-select techniques. This preliminary finding from our study illustrates that freeform design sessions with users can be problematic when the application is novel. Point and click interaction is an important technique when retrieving information from static resources like paper maps, however maps do permit other types of interactions, as shown in our study.

Unlike the mockup evaluation, no participants said that a task could not be completed using the prototype. We attribute this in part to the availability of paper menu items, and to the training sessions. However the nature of the tasks themselves, as they favoured completion using given techniques, also played a role in this. Only a subset of the tasks given in the mockup evaluation were also given in the second study. As such, we cannot conclude that the functional prototype impacted the participants' impressions of what was possible in all cases.

Our prototype did provide valuable insight into receptivity to interaction techniques. However, as a functional approximation the prototype is limited in terms of granularity. This means coarseness in the detail captured during selection operations, as belied by the visual feedback.

Additionally, the prototype only supports the selection operations themselves, and does not respond to operations by retrieving information according to the expressed query. Therefore, participants could not use the prototype to validate that their interactions would successfully express the query they intended to formulate. Participants were instead told to interact as they would expect to, and assume that the system would correctly interpret the interaction. We cannot use our current prototype as is to determine what kind of self-correcting behaviour might emerge through use over time.

The coarse visual feedback and the absence of a success indicator had a definite impact on several participants. As a result, questionnaire and interview responses are not interpreted as an evaluation of the interaction techniques as part of a functioning system. Future work will evaluate the techniques in the context of a working information system, and with finer granularity in both capture and feedback.

8. ACKNOWLEDGMENTS

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