mSpace Mobile: Exploring Support for *Mobile* Tasks

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In the following paper we present a formative study comparing two Web application interfaces, mSpace Mobile and Google Local in supporting location discovery tasks on mobile devices while stationary and while on the move. While mSpace Mobile performed well in both stationary and mobile conditions, performance in Google Local dropped significantly. We postulate that mSpace Mobile performed so well because it breaks the paradigm of the page for delivering Web content, thereby enabling new and more powerful interfaces to be used to support mobility.

mSpace Mobile, evaluation, mobility, mobile devices, Performance, Design, Human Factors.
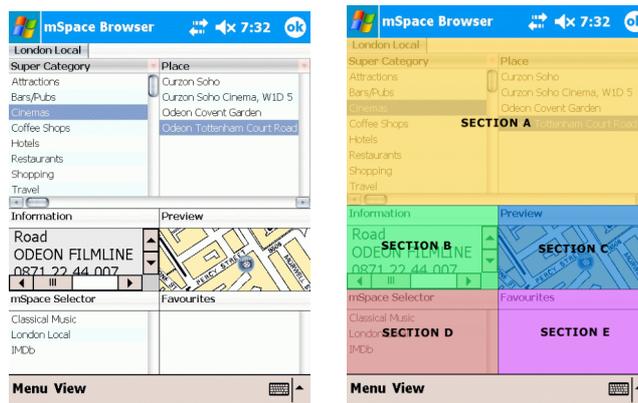
1. INTRODUCTION

FIGURE 1: The mSpace Mobile interface: A – the columnar entity selcetor; B – the information box; C – a context graphic – here, a map; D – an mSpace selector and E – a Finds list.

Increasing ubiquitous connectivity with the Internet for mobile devices (PDAs and smartphones), via cellular networks and wifi-hotspots, means that information services can be accessed while on the move. Subsequently, this should support better informed exploration of a physical area because one can call up information about that location while on that site. This has motivated considerable research into dynamically re-presenting full size web pages more effectively for small screens [1, 2]. This work, however, has been mainly focused on viewing a *single* page (implicitly, while stationary), rather than on carrying out tasks *while mobile* which may require access, back and forth, to *multiple* pages to address even a simple query such as "where is a Japanese restaurant near to a cinema showing this film I wish to see?" In such mobile information foraging activities, the page-as-unit gets in the way of the information the person wishes to access, as people must scan through superfluous-to-task content on numerous pages to assess get at just the data they want.

mSpace Mobile is an approach to support *mobile* Web-based planning and exploration activities on small screen devices that, using new Web protocols, eliminates the page as smallest information unit. This new approach allows us to use more effective UI techniques like focus+context zooming to support rapid exploration of an area of interest. This paper reports on the study we ran to compare mSpace Mobile with current state of the art smartphone/PDA devices for carrying out these exploration and planning activities. The study considered both stationary and mobile performance. In the rest of this paper we describe the related work, mSpace Mobile itself and the formative study. In the discussion of the results, we are able to begin to use these findings to move towards design heuristics to support *mobile* information foraging activities.

2. RELATED WORK

Beyond repackaging Web pages for small screens, visual UI research has looked at support for focus+context type interaction, the exemplar of which has been DateLens [3]. Multimodal research has looked at controlling applications with touch and audio, eliminating video entirely, assuming the video channel is being used of other tasks [4]. Considerable work, such as [5, 6] has looked at custom applications that provide information about a particular place, or to provide guided tours that incorporate location awareness**.** While these devices provide a compelling experience for the user, the context is particularly fixed: that of tourists wanting to be guided to locations of interest. From what we can find, work on effect of mobility on task performance with mobile devices is recent, and has focused primarily on target acquisition [7]. Our interest however has been to begin to look at the effect of interface attributes on ability to support and carry out planning activities – a complete sequence such as finding a cinema and then a restaurant near by it - *while mobile*.

3. MSPACE MOBILE: ZEDPANES

mSpace Mobile (Figure 1), rather than presenting information in a page, represents information as areas of information or domains, where each domain contains a set of associated dimensions. A location domain may have the dimensions Transport, Cuisine, Entertainment, Sites, Clean Public Toilets, and so on, whereas a film domain might have actors, producers, countries, genres. It is beyond the scope of this paper to describe how these dimensions are generated or populated. Suffice it to say that the data is from existing Web resources and uses next-generation Web protocols; an overview of the approach is available at [8].

To facilitate interaction on mobile devices, mSpace uses a combination of a spatial, multicolumn display with a zoomable focus+context interface called ZedPanes as shown in Figure 1. The spatial layout of the multicolumn UI enables a person to select a dimension element like Japanese in the dimension Cuisine. The next column then lists the names of restaurants near the currently selected location as shown in the map pane, and the map reflects the positions of the restaurants in the list. Selecting any element in a dimension (Figure 1, Section A) also brings up information about that element (Figure 1 Section B). For instance, by selecting a particular restaurant, a description of the restaurant, its location, web site and menu if available is rendered. It is therefore easy for people to see the associated contexts of any selection and switch between them rapidly for comparison and contrast. Double tapping an item adds it to a pane for Finds pane (Figure 1 Section E, a feature not used in the study, below). Selecting an item in the Finds pane recovers its associated information. If a person wishes to focus on any particular pane to see it in more detail, ZedPanes enables that pane to be zoomed up two additional levels: focussed (where other panels are reduced) and full screen. In this way people have persistent control over area of interest and can readily switch focus among panes. ZedPanes has been inspired by Bederson's DateLens [3], expanding it such that where DateLens is restricted to zooming on tabular data, like calendars, ZedPanes can support any number of nested hierarchical panes; each pane also has its own three-level zoom. The mSpace multi-paned display foregrounds rapid domain exploration by enabling easy selection and focus on individual elements while maintaining persistent context.

4. STUDY

Our study is mainly a formative exploration of issues that effect carrying out discovery and planning activities with Web-based sources while mobile, and while using a mobile device. Our hypothesis is that the mSpace Mobile interface will perform better than state-of-the-art Web applications designed to support similar planning activities particularly when on the move. For our study we focused specifically on *location-based* discovery and planning tasks. By location-based, we mean activities that take place in a physical location, and by planning we mean building a sequence of related activities, For example finding information such as: cinemas playing a certain movie, then finding times of showings; finding restaurants within a certain distance to that cinema that will be open after the film gets out. This focus on location-as-context let us compare mSpace Mobile with the popular Google Local (http://local.google.co.uk), a Web application with an interface that, like mSpace Mobile, supports discovery of entities like restaurants and cinemas (via keyword search), plots these locations on a zoomable map, lists the finds beside the map, and provides information about an entity when selected, including a link, when available, to that business's site, all in one view. While Google Local has not been optimized for mobile appliances such as phones, it is still useful and usable on a PDA. Our concern with this study, however, is *not* to carry out a head to head competition between mSpace Mobile and Google local, but to use the comparison as a way to tease out specific design attributes that may effect performance under two specific conditions: first, when actually moving and using the device, and second when carrying out a sequence of tasks rather than a single lookup. Sequences of compound queries like the above are natural (and necessary) for carrying out even simple plans: can we have dinner close to the theatre, for instance. By using a sequence rather than a discrete task, we considered we would be better able to explore why either interface performed better or worse in realistic scenarios.

As a context for stepping through a sequence, we built a scenario of an evening out (dinner and a movie), where the participants needed to find appropriate resources to support these activities. There were 6 activities in each scenario. The scenario started with an activity like find cinemas showing a given film "near by" the starting location for the trial. Each following activity built on the previous step. For instance, from the cinema, participants were asked to find restaurants near it that feature a particular cuisine, and then of those, to find ones which also have take-out. Some tasks were completable within the main interface, by which we mean they could be completed without clicking to a remote web page; others required clicking to an external web site linked from the main interface as well as the information available in the main interface itself. Each scenario was balanced to have equivalent steps within the main interface and jumps out to external web sites.

4.1 Method and Apparatus

A 2X2 within-group repeated measures design was used: the two interfaces, mSpace Mobile and Google Local, were tested in two conditions, stationary and mobile. Exposure to each interface was counterbalanced. Stationary trials, however, always preceded mobile trials: we were keen to ensure comfort with the devices in a seated environment before we asked participants to walk about using them. The stationary condition was performed sitting in a chair in a private office. For the in-motion condition, participants carried out their tasks while walking around a sixty-meter indoor course. In order to simulate safely the kind of split attention to both the task and the environment a walker requires in a live environment, participants were asked to navigate both around and between well-marked

objects on the track. An equal number and kind of objects were used for both interfaces, but the course was adjusted for each UI to reduce learning effect. The study included 6 men and 3 women ranging in age from 18 and 45. All participants identified themselves as comfortable with computer technology. Thirty percent of participants regularly used a PDA; all however owned at least one portable devices, such as mobile phones and/or personal stereo. All reported experiences they characterized as "regular" in using these portable devices (making calls, choosing music) while walking with them.

Before beginning, the participants were given training with both mSpace Mobile and Google Local. Each interface was run on the same iPaq hand held PDA and used the same wireless network to access the Web data. The scenario was read aloud to the participants, one activity in the sequence at a time. When the first activity was completed, the next activity would be read out. Participants were given ten minutes to complete the entire scenario, although two extra minutes were allowed for those close to completing the tasks: a pilot study had indicated that six minutes had been the maximum time necessary to complete the entire sequence. We captured the time to complete the full sequence on each interface. We also asked participants to think aloud as they worked. While one investigator read out the sequence for the participant, another investigator recorded observations. Each trial concluded with a semi-structured interview of the participant to solicit further comments about their experience of the interfaces in each condition.

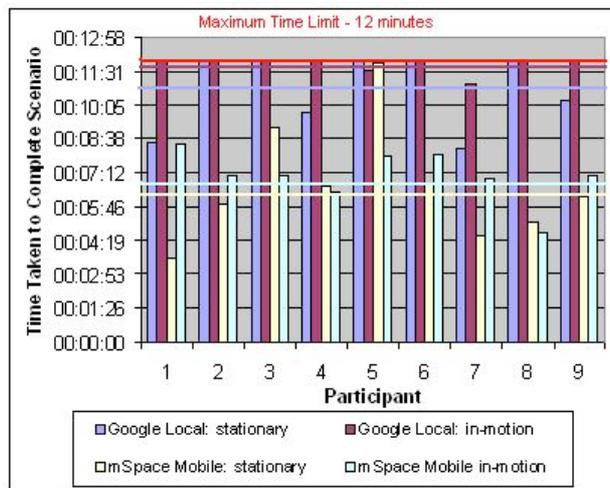## 5. RESULTS

5.1 Quantitative Measures

FIGURE 2: Graph showing the performance times of each participant in the four conditions

Our hypothesis that mSpace Mobile would perform more effectively in each condition was borne out. Figure 2 shows the completion times for each participant in each condition and UI. The lines across the graph show the average completion time for each UI in each condition. mSpace Mobile performed significantly faster (30%, $p<0.0005$, $t=6.5566$) than Google Local in the stationary condition; this increased to almost 40% faster, also significant ($p<0001$, $t=12.2425$), in the in-motion condition. The difference between motion conditions in mSpace Mobile is not significant (6%, $P=0.6279$, $t=0.5040$), whereas the performance drop in Google Local between conditions is greater (10%), but not quite significant ($P=0.0528$, $t=2.2714$). The degree to which mSpace mobile performed better in particular in the mobile condition, however, is a conservative value. Participants were halted after 12 minutes. This stopping value was used for subsequent statistical evaluation. 4 of 9 (44%) in the stationary and 7 of 9 (78%) in the mobile condition with Google Local did not complete the sequence by the 12 minute mark, near double the time needed to complete the sequence in either condition for mSpace mobile.

5.2 Observations
The time required to load external pages requested from within Google Local had an effect on performance in both conditions. Each click in Google Local is a call out to the Web, which can increase interaction time, depending on network performance. In mSpace Mobile information associated with a selection, such as the next column entities, their map locations and information views is transported in smaller chunks and cached: calls to the network are reduced, overall interface response is faster.

While performance time for mSpace Mobile across conditions was largely similar, Google Local's performance dropped significantly from the stationary to the mobile condition. While network performance remained equivalent between conditions, it became apparent from observing participants that scrolling and text entry in Google Local took longer to carry out while mobile than while stationary. Participants commented on this difference themselves during interviews. We also noticed that participants frequently slowed their pace when entering text in Google Local, whereas there was little pace slowing observed with mSpace Mobile. One participant noted that target acquisition was challenging for selecting individual items within the columns of mSpace Mobile, though this did not seem to have a noticeable effect on their performance between the conditions. In cases where participants knew the location of something, they preferred Google Local for its text entry. For this reason, some participants said

they would appreciate a text search box in mSpace Mobile as a complement to the UI. Overall participants said they preferred the direct manipulation of mSpace Mobile, mostly because it requires less focused attention.

6. DISCUSSION

From the above, three conditions emerge which contribute to effective performance when carrying out planning activities with mobile devices, particularly when on the move: quick data transfer, reduced requirement for text entry, and reduced requirement for activities like scrolling that require both acquiring and holding a target – this later point reinforces [7]'s finding for mobile target acquisition. mSpace Mobile's emphasis on single tap selection and expandable panes reduces the need either for scrolling or text entry, contributing to improvement in performance by reducing the number of taps to the interface. While it is possible that walking amplified the scrolling and text entry problems to such an extent as to account for the considerable performance difference between conditions in Google Local, it may be that additional cognitive load factors come into play as a result of the cumulative delays caused to task completion by any one of these factors, reducing performance further. In contrast, the performance of mSpace Mobile remained fairly constant across conditions. This finding suggests that mSpace Mobile's non-page paradigm for presenting Web data, with resulting reduced calls to the network, its largely persistent views of information in a domain, and its focus+context interface may reduce cognitive load and improve performance by improving recognition rather than recall in the interface, particularly when on the move. Further study will be needed to tease out these factors' effects

7. CONCLUSIONS

In this paper we have carried out a formative, exploratory study to consider the effects of being mobile on the ability to carry out sequential tasks like resource discovery and planning activities with mobile devices using the Web. In contrast to typical mobile device Web viewers, we have proposed a non-page based paradigm for exploration of Web information. The approach foregrounds persistent domain overviews from which selections are made. To optimize screen space, the UI for exploration is a focus+context, multi-paned display. We have shown that first, when tested against Google Local, a Web application designed to support the kinds of location discovery tasks we tested, mSpace Mobile performed significantly better in both mobile and stationary conditions. Second we have shown that mobility – in this case walking – has a significant degradation effect on sequential task performance when using a traditional Web page-as-unit model.

These early findings point to interesting directions for designing devices to support network-dependent activities on mobile devices for both stationary and in-motion usability. It seems that, in general, better UI paradigms for access, exploration and planning are enabled when breaking the current page paradigm for delivering network-based content. In terms of design and evaluation heuristics, use-in-motion may be a significant factor for evaluating interaction design effectiveness for mobile devices. Likewise, testing for sequential rather than single task performance seems to be an important criterion for evaluating on-the-move interaction performance. We propose these criteria as to be considered as a part of a potential taxonomy of design criteria for *mobile* devices the community may evolve.

8. ACKNOWLEDGEMENTS

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