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USING OVERVIEW STYLE TABLES ON SMALL DEVICES

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Abstract

Users increasingly expect access to data from a wide range of devices, both wired and wireless. The long term goal of our research is to inform the design of applications that support data access by providing reasonably seamless migration of data among internet-compatible devices with minimal loss of effectiveness and efficiency.

In this paper we focus on design issues related to the use of tables of data on small mobile devices. In particular we are concerned with tables presented in an overview or focus + context style to maintain the consistency of their structure on all devices to support users who have already used the data on larger devices. We report on the results of two user studies related to two techniques, cascade and auto column expansion, that support the use of tables in such a display. We show that for a range of tasks from simple lookup to complex comparisons, both techniques provide benefit to the users.

Keywords: Overview, PDA, small screen, handheld device, Focus + Context, Tables.

1 INTRODUCTION

In this paper, as part of a larger project, we concentrate on usability issues related to the use of tables on a PDA, especially where the user may have used or may use the same table on a larger device or who are collaborating with someone who is using the same table on a large screen. Earlier research has shown that the choice of information model for data that is accessed on different screen devices may result in increases in both errors and frustration. Reorganization of previously seen data increases the user’s cognitive overhead as they need to consciously or unconsciously remap their model of the data and this may lead to increases in errors both in the location and the comprehension of data (Albers & Kim 2000). We propose that users benefit from a consistent mental model supported by an overview of the table that is independent, at some level, of the size of the physical device, to facilitate switching between devices with minimal content and comprehension loss. There may be tradeoffs, however, between the maintenance of a consistent mental model and ease of use on individual devices. The current study examines the influence of design decisions on the performance of users for interaction with tables on a PDA.

In this paper we report on an ongoing series of user studies focused on design decisions related to accessing data in tables that are reduced in size for presentation on PDA sized devices, where the structure of the tables remain consistent. The focus of this set of studies is to understand the effects of subtle design decisions on the ability of users to complete a range of tasks from simple lookups to more complex comparisons on small devices.
2 RELATED WORK

The context of mobile usability has an impact on human interaction design. Kim et al. (2002) conclude that the user contexts for Mobile Internet use have an impact on mobile usability factors. Dix et al. (2000) reported that explicitly considering the impact of the context in informing the design of different interaction techniques was necessary and Kakihara and Sorensen (2002) found that the spatial, temporal and contextual aspects of mobility in human interaction were fundamental consideration in design.

Design characteristics have been shown to effect performance for tasks on small screens: Resiel and Shneiderman (1987) showed that the smaller screen size slows down the reading time; the study by Jones et al. (1999) found that the smaller screen size impedes search task performance; Duchnicky and Kolers (1983), however, showed that even for very small displays of only a few lines of text, the ability of the user to read and understand information was not adversely affected; a study of task performance on tables using small screens (Watters et al 2003) confirmed that for both simple and complex tasks the allocation of screen space for context information improved efficiency and effectiveness, where the context included title and column headings plus relative position within the table.

Tables remain a difficult issue for accessibility on small screens because the inherently two-dimensional structure and the reliance on spatial layout are essential components of the semantics (Pontelli et al 2002). A prime concern in this research is the accurate and contextual representation of information embedded in tables. The contextual component of tables, such as title and column headings, has been shown to have a significant effect on both effectiveness and efficiency of complex task for users on small screens (Albers & Kim 2000).

Using a small screen device to view a table designed for use on a PC is like trying to use a small window to read the newspaper: users can only ever see a small part of the text. The challenge is to balance a need for context with a need to display as much data as possible on the screen by tailoring the data presentation and/or navigation functionalities to minimize negative performance effects on both efficiency and effectiveness.

Although there are many ways to display a table of data on a small screen, there are three main models for the migration and display of tables designed for larger screens to small screen versions: Default View, Linear View, and Overview (MacKay 2003, Watters & MacKay 2004). The Default View is the most simplistic and requires little manipulation by either the server or the device and found in many commercial systems, such as NetFront v3.0 (ACCESS CO., LTD) and ThunderHawk (Bitstream Inc.). Tables are simply displayed on the small screen as though it is a big screened device, like the desktop or laptop. The user scrolls both vertically and horizontally to manage the view of the table. Because the header of columns and rows are not locked on the screen, it is very easy for users to get lost. Browsers designed for the small screen, like often provide Default Views of web pages including tables on small devices.

The Linear View, used by OceanLake’s mScope (2001) and AvantGo (2002) for example, decomposes the table either into a sequence of rows or a sequence of columns and the user scrolls vertically through the resultant set of lists. The difficulty for the user with this kind of reconstructed table is the increase in cognitive overhead needed to maintain the context of the column headers and making it harder to complete tasks that require access to multiple rows.

The Overview attempts to provide a high level view of the table in its entirety by reducing one or more features, such as font size, column width, or row width. This view has its root in Focus + Context (Rao & Cart 1994, Gutwin & Fedak 2004) designs, which have been used with success on regular size screens. Focus + Context designs present a consistent overview of the entire data set, which may be too small to be legible, accompanied by functionality that allows the user to focus on parts of the data within the context of the overall view.
Figure 1. Default View. Linear View. Overview.

In the first study of this project, reported elsewhere in detail (Watters et al 2005), we compared effectiveness, efficiency and preference for the three table views: Default View, Linear View, and Overview on mobile devices. This study identified the overview technique as the most robust view for users on small screens over a variety of tasks from simple lookup to complex comparisons.

In this paper we report a continuing series of studies examining features in the context of Overview tables including: cascade expansion of cells, column expansion, search, and landmarking.

3 PROTOTYPE

We developed a prototype table application for our experiments, written in C#, which is executable on Pocket PC device, Dell Axim X30. Although intended for numeric data, the design features, particularly column expansion, in the Pocket Excel provide a useful starting point for functions that can be applied to tables of text or mixed data types on small devices.

The basic features mimic features found in the Pocket PC version of Excel.

The main interface of our prototype is shown in Figure 1 (Overview) and includes two parts. The upper part is the functional area and the lower part is for the data display. The table columns are ellipsed to fit the width of the small screen and the rows are compressed to fit the length of the screen, as much as possible. At the same time, the font size of the data in the new table is reduced and zoom-in and zoom-out functionalities are provided for users to vary the font size. The user can expand individual columns and rows, expand individual cells using tool-tip style cell expansion, and create Sub-tables, as shown in Figure 2.

Figure 2. Subtable Feature.

Figure 3. Sample table with 2 columns and 1 row expanded.
Column or Row Expansion. The user can use the stylus to adjust column widths or row heights to read the entire content of each cell in that row or column, as shown in Figure 3.

Cascade. The Cascade mode automatically expands cells sequentially down a column or across a row by a single click on the header of a row or column. The full content of each cell of the row or column is displayed in a popup overlay one by one from the first to the last. This feature lets users scan a row or a column to get a general sense of the information or to locate a particular value with a single stylus action. Figure 4 shows a row cascade, a column cascade, and when the cascade moves outside the range of cells on the screen, the popup stays at end of the row or column with a different background color.

![Figure 4. Row cascade; Column cascade; Cascade cell outside the screen.](image)

Landmarks allow users to highlight cells of interest by changing the background color of the cell to facilitate refining and comparison tasks. This feature addresses issues of short term memory exacerbated by the space constraints of the table on a small screen.

Search, common in most application, has been designed for direct cell value look up. When users specify a search string, all of the cells with the content are highlighted.

4 STUDY ONE: CASCADE VS COLUMN EXPANSION

In study one (Zhang et al 2006), we compared the efficiency, effectiveness, and user preference for Column Expansion and for Cascade for a set of lookup and comparison tasks on the PDA. We focus on column expansion because of the inherent difficulty with the Overview model of scanning across one or more rows, which may require a series of column expansions to find the required data and for more complex tasks may require multiple columns to be expanded simultaneously.

Effectiveness is measured by how accurate the user is, in this case, the number of correctly completed tasks; efficiency is measured by the time taken to complete the task (using a stop watch to record the lapsed time); preference is measured in a post-experiment questionnaire. While users may expect that it may take longer to find information on a smaller display, they, nonetheless, expect accuracy in the results.

The experiment was designed as a mixed factorial experiment with independent variables, Column/Row Expansion method and order of tasks. Two task types were defined to represent a range of table oriented tasks, from simple lookups to more complex comparison tasks. Task T1-3, simple lookup tasks, required the user to locate a cell in the table. The complex tasks T4,5 involved both lookup and comparisons, that is, users need to locate and scan one row of the original table to identify the minimum/maximum value.

A total of ten subjects completed the study, which provides adequate statistical power in a repeated measure design. The students were all graduate students in either Computer Science or Management with average age of twenty-six and an average of four years working since undergraduate degree. Each
subject completed two blocks of five tasks, one block per method, using a working prototype on a working PDA in a within-subject design. The subjects were randomly assigned to one of two groups. One group completed the first block of tasks using the Cascade method and the second block of tasks using the Column Expansion method while the other group did the blocks in the opposite order. Five minutes were allocated for introduction and practice at the beginning of each block so that the subjects were familiar and comfortable with each method. The experimenter was rehearsed to be consistent with all users to reduce the possibility of experimenter effect (Rosenthal 1976).

Results. Overall both methods resulted in accuracy levels of about 85% correct. The users performed more accurately, i.e., got more correct answers, using the Cascade method for the complex tasks, T4 and T5, than with the Column Expansion method.

Participants performed better using the Cascade method than for the Column Expansion for the more complex tasks, T4 and T5. This difference was significant (F=4.519, p=0.049, η2= 0.220). We attribute this difference to the cumbersomeness of expanding the columns one by one in order to make comparisons of the cells within a row.

After the study, the participants reported on their preferences using a short questionnaire. The mean across all users was slightly in favor of the Cascade method. Participant preference for the Cascade method was summarized in the following categories: general preference, ease of use, quicker to find the required information, easier to use while the user stays still, and easier while the user is walking or distracted. The internal consistency of this scale had a Cronbach alpha of 0.773.

From this study we conclude that for complex tasks, the Cascade method was more accurate and more efficient and that the users preferred it to the more common Column Expansion method on the small screen. The Cascade method does not affect the current view of the Overview table. That is, if the user has expanded one or more columns they are not disturbed. This provides a type of low commitment on the part of the user. The Cascade method also provides benefit when the further expansion of columns is not possible without the truncation of cells because the screen is simply not wide enough. Clearly, the Cascade method will not replace column expansion for certain tasks. We saw that users quickly saw benefit in combining the methods for complex tasks. Consequently, we expect that users will expect to continue to be able to use column expansion techniques were appropriate for individual tasks.

5 STUDY TWO: COLUMN EXPANSION

Although the combination of column expansion and cascade methods provides benefit to users in many cases where values from one column were required to complete a task using another column, in other complex tasks, namely those requiring paired values, the users preferred to use column expansion alone for side by side display. The use of column expansion to provide full access to cell data in such tables on small devices, although useful, may be problematic for users for a variety of reasons including difficulties in using the stylus to expand small columns.

In study two we compared two column expansion techniques: a single click auto column expansion (ACE) and the more typical drag column expansion (DCE). The Auto column expansion feature allows the user to click on any column header to increase the width automatically to fit the widest entry in that column. This has appeal because of the difficulties of handling the stylus for drag-and-drop executions within the confines of the table column header on the small screen, where a few pixels may cover an entire column in the overview. The Drag column expansion technique requires the user to drag the edge of the column header in or out but provides finer grained control over the resultant size of the column, which may be important in optimizing the use of screen space.

In this study we used three levels of task complexity based on a range of table-oriented tasks, from simple lookups, moderate min/max lookups, to more complex comparison tasks. In order to test for effects of data type and table length should cover different table style, we used two tables in two
lengths. One table was largely textual in nature and the other largely numeric. Each table had a short version that fit on the PDA screen without needing any vertical scrolling and a long version that required vertical scrolling to access all of the rows of data. The experiment was designed as a mixed factorial experiment with independent variables; expansion method (within subjects), task complexity (within subjects), and order of expansion methods (between subjects).

The sixteen participants were all graduate students in either Computer Science or Management with average age of twenty-six and an average of four years working since undergraduate degree, none of whom claimed to be experienced PDA users. Each participant completed four blocks of six tasks each, one block per method with one short table sample, using a working prototype on a working PDA (HP running Windows Pocket PC). In this case, we eliminated the effect of the table scrolling. Two additional blocks of six tasks using two long table samples were provided in the second part to measure the effect of the scrolling for longer tables.

The participants were randomly assigned to one of two groups. One group completed the first block of tasks using the ACE method and the second block of tasks using the DCE method while the other group did the methods in the opposite order. Five minutes were allocated for introduction and practice of the methods at the beginning of each block so that the participants were familiar and comfortable with each method. The experimenter was rehearsed to be consistent with all users. This procedure eliminated the possibility of experimenter effect (Rosenthal 1976).

Results. The ACE method was significantly better than the DCE method on the short table samples (p=0.01) and significantly better as well for the long table samples (p=0.05) with accuracy rates between 80 and 100%.

There was a significant difference in efficiency between ACE and DCE on short tables for the simple lookup tasks (F=15.83, p=0.000, η²=0.203) and complex tasks (F=9.27, p=0.003, η²= 0.130), but not for the moderate tasks (F=1.84, p=0.180, η²= 0.029). The overall time needed to complete the simple tasks decreased with each additional simple or moderate task but this practice effect was not found for the complex tasks. There was also a significant difference on the long tables between ACE and DCE on the simple tasks (F=12.51, p=0.001, η²= 0.294) and complex tasks (F=15.91, p=0.000, η²= 0.347), but no significant difference for moderate tasks (F=1.41, p=0.245, η²= 0.045).

The considerable time taken for Task 5 using the DCE method on the long tables causes us to speculate that some locations near the borders on a longer table may be more difficult for users to manipulate column headers effectively with the stylus. A subsequent study would be needed to identify which areas of large tables lead to such navigational difficulties.

After the study, the participants reported their preferences using a short questionnaire across the following categories: general preference, quicker to find the required information, ease of use, ease of learning, more often got the right answer, easier to use while the user stays still, and easier while the user is walking or distracted. The internal consistency of this scale was high and all of the participants preferred the ACE method over the DCE method.

The results of study two provide support for the automatic ACE method which was shown to be effective, efficient and preferred by the users for tables on small screens. The ACE method has the obvious advantage of needing to successfully target fewer clicks with the stylus to get the desired effect, which may account for its overall preference. For the moderately complex tasks, users needed to scan a single column using short term memory to hold one value while finding the target value. We surmise that the difference in time required to initially expand the column is overwhelmed in the total time required to complete the task after the column has been expanded. With the complex tasks, the user needed to expand two columns simultaneously to complete the tasks. These results indicate, however, that the ACE method always performed at least as well as the manual DCE method for tasks on small overview tables. Given that the software overhead is not a factor, there is little reason not to provide the users with both options although designers could consider using ACE as the default function and let users then choose to use manual refinement where appropriate.
6 ONGOING STUDIES: LANDMARK AND SEARCH

Landmarks. According to research by Norman and Shneiderman (1988, 1998), reducing short-term memory load is a key factor for interface design. Making things visible is a way to solve this problem. Because of the screen limitation of mobile devices, it is hard to avoid using horizontal and vertical scroll bars for table browsing, navigation or operation. Consequently it is very easy for users to forget the cell content in the course of more complex comparison tasks when columns have been collapsed and they cannot see the entire contents.

Landmarking is a method which lets users mark cells of interest by tapping on that cell to effect a change in the background color of the cell. The cells retain the landmark colour even when the column has been collapsed and individual cell contents can easily be viewed using a tool-tips style popup. Our preliminary work with users indicates that this feature may be useful especially for comparison style tasks. We are currently engaged in a formal user study of this feature using the prototype system.

Search. When users have some ideas about what they are looking for, it is not reasonable to leave them to browse the whole table to get the information they need. It is time consuming and frustrating. String search features are widely used in most applications and are familiar to most users. The research on the usefulness of search functions on small screens is however divided. In a study by Jones et al (1999) search was found to be useful but in a study by Watters et al (2003) search was found to decrease accuracy in all tasks performed on tables on small screens.

This study will combine landmark feature with string search to evaluate the string search feature compared to the combination across a range of tasks and using both numeric and textual data in realistic settings.

7 CONCLUSIONS

The current results of our research in progress on features for overview tables on small screens indicate that users can accomplish relatively complex table oriented tasks on a small screened device. This supports our vision of users exploiting consistent views of data tables across multiple devices.

Even though we had a small N for study one, we were able to reach significant support for the Cascade function of scanning columns for complex tasks. Within the limitations of this study, we suggest that users would benefit from both methods of accessing tables on small screens. For simple tasks, little difference was detected but as the task became more complex, an advantage was found for the scanning potential of the Cascade method. One of the limitations to this study was the lingering effect of practice on efficiency and a future study would include a more regulated and extended period of practice to dampen this effect.

In this second repeated measures study, we were able to show significant benefit for an automatic column expansion feature for both simple and complex tasks using overview tables on a small screen, for both short and longer tables. In the case of moderately complex tasks no difference was found. The participants preferred the automatic column expansion method overall. We suggest that users would benefit from both methods of column expansion for tables on small screens. Users may benefit from using the automatic expansion technique to initially explore a new table and benefit from manual Column Expansion on particular tasks, especially in the manipulation of simultaneous access to multiple columns.

We are currently exploring the value of landmarking and string search features in this context. Upon completion of those two final studies, we anticipate embarking on a longitudinal trial on a broad range of user tasks in the users context of full feature sets. Other usability factors, such as safety, learnability and memorability, will be examined in future work.
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