Use of Landmarks to Design Large and Efficient Command Interfaces

Md. Sami Uddin
Department of Computer Science
University of Saskatchewan
Saskatoon, SK S7N 5C9, Canada
sami.uddin@usask.ca

Abstract
Rapid command selection is a priority for the user interface designers. Spatial memory is an effective way to improve the selection performance, since it allows users to make quick selection decisions from the memory rather than relying on the slow visual search. Spatial learning in the real world leverages landmarks available in the environment, but user interfaces often lack in visual landmarks.

ISS '16 Companion, November 06-09, 2016, Niagara Falls, ON, Canada
ACM 978-1-4503-4530-9/16/11.
http://dx.doi.org/10.1145/3009939.3009942

As a result, when the number of commands increases, remembering locations and efficient command selection become difficult.
To improve the efficiency of memory-based user interfaces, I am investigating the use of landmarks in different spatially-stable interfaces. With a series of exemplar interfaces, I am trying to exploit the interface and human factors related to users' spatial knowledge. I along with my colleagues developed a new memory-based technique – HandMark menu that uses the hands and fingers as landmarks, and helps users to remember commands placed between and around them. My current research investigates the use of both natural and artificial landmarks in spatial interfaces, and their effects in rapid spatial memory development.

Author Keywords
Command selection; landmarks; expertise; spatial memory.

ACM Classification Keywords
H.5.2. Information interfaces (e.g., HCI): User Interfaces.

Introduction
The most common way of menu organization in modern user interfaces is the hierarchical control that uses tab or ribbon based toolbars to orient the menu items.

However, this visual-inspection depended command selection slows down the performance of expert users [3]. Spatial memory-based selections are an alternative way to improve the efficiency [7,9,14] that allow the users to become experts by rehearsing the similar novice selection process. For example, by flattening the traditional command hierarchy, CommandMaps [14] help users to develop spatial memory of the commands, where an individual command is assigned to a unique spatial location in the display. Although these methods improve user performance, the lack of reference points in a large interface often makes the command revisitation task challenging.

The goal of this Ph.D. is to understand the effect of landmarks in spatial memory development, and investigate their use in the computer interfaces by designing new interfaces with landmarks to support rapid and accurate spatial memory development.

Background and Related Work

Spatial memory is a powerful way to enable expertise in any user interface. Expert users can leverage their spatial knowledge of items to decide about the rapid selection, instead of resorting to slow visual search [4]. Earlier research showed that the spatial memory lasts a long time [5] and can support a large number of commands. For example, the Data Mountain [13] performed significantly fast in retrieving 100 web pages compared to standard bookmarking. Grid-based menus such as ListMap [6], CommandMaps [14], and Square Menus [1] showed spatial memory's performance benefits with a large number of commands over the visual search-based hierarchical menu organizations.

In real life, landmarks are easily distinguishable objects that can orient its surrounding with reference to it [12]. Few landmarks are always available in user interfaces such as the device's corners. Several techniques have already utilized these landmarks to organized the menus and toolbars to develop spatial memory of the commands and improve command selection [7,10,15]. These natural landmarks, however, become unfit in large interfaces with many items in the middle region.

In the absence of natural landmarks, artificially created objects or colors can act as landmarks that provide spatial memory development. Many studies have implicitly used landmarks in the interface to enable better revisitation facility: Footprints Scrollbar [2] uses color, visual ID [11] uses shapes, and Edit Wear and Read Wear [8] uses marks to understand activity. However, the explicit use of landmarks in interfaces and their effects in spatial memory is less explored.

Research Status

I primarily identify myself as an HCI researcher, and my interest lies strongly in the human factors in interaction design. My research focuses on the design and evaluation of new interfaces that rely on spatial memory to improve interactions, and also allow users to develop expertise. I have been working in this area for the last two years which began with the Masters' program at the Computer Science department in University of Saskatchewan, Saskatoon, Canada, and now I am continuing my research in the same field as a Ph.D. student under the supervision of Dr. Carl Gutwin. So far my research has produced a full paper publication in CHI 2016: "HandMark Menus: Rapid Command Selection and Large Command Sets on Multi-Touch Displays" [18], and another full paper in ISS

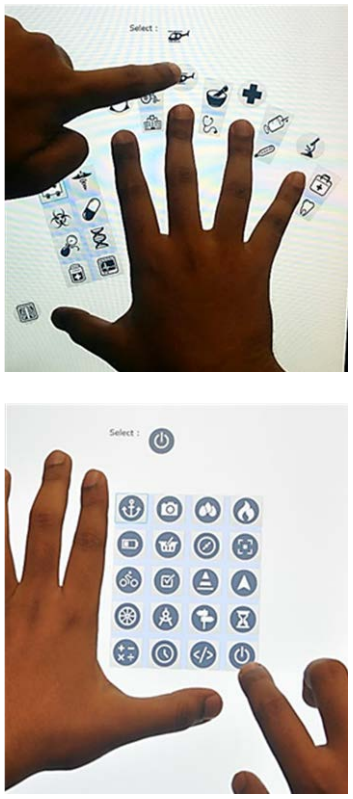

Figure 1. Bimanual HandMark Menus selection techniques for tabletops: (top) HM-Finger - for small number of commands, and (bottom) HM-Multi - for large number of commands. Parallel operations of menu invocation with one hand, and selection with another.

2016: “Rapid Command Selection on Multi-Touch Tablets with Single-Handed HandMark Menus” [17]. I have also worked on a paper, currently unpublished, that investigates the effect of landmarks in spatially-stable interfaces. Besides these, I have explored the visualization comprehension skills by tracking eye, which was published at SCAM 2015: “On the Comprehension of Code Clone Visualizations: A Controlled Study using Eye Tracking” [16].

From the Doctoral Symposium, I hope to receive feedback on the general direction of my dissertation. So far, my research has explored the value of landmarks in spatial interfaces–I would, therefore, like to have experts’ opinion on my research to use both natural and artificial landmarks in interfaces as well as insight into projects that are most interesting and direction for future development.

Research Goals

There are two main goals of my Ph.D.: *understanding the effect of landmarks in spatial memory*, and *designing interfaces with landmarks to support rapid spatial memory development*. I am working in parallel toward achieving the two goals.

To accomplish the first goal, I have explored (or are intending to explore) the use of artificial landmarks in different sizes of command set, and the ways in which users perform in these interfaces. I plan to accomplish the second goal by designing new interfaces based on these results.

The following sections describe the work that has been already completed in these areas.

HandMark Menus (CHI 2016)

At CHI 2016, we introduced a new command selection technique called HandMark Menus [18] for tabletops, in fact, we have created two variants of HMs: HM-Finger, and HM-Multi (Figure 1). HMs display commands around and between the fingers of both hands, allowing users to remember commands with reference to their own hands and fingers. HandMark menus, bimanual in nature, provide rapid command selections, where the menu invocation and command selection operations can be performed with one hand in parallel.

We performed two experiments with the two variants of HMs evaluating the performance of HMs against two equal standard tabbed widgets. We found that the small version – HM-Finger was significantly faster at all stages than tab menu, and the large version – HM-Multi, though it was slow at the beginning, it performed equally with tabs when users gained experience with the method. Our studies showed that our hands can work as strong landmarks in user interfaces, and improve user performance.

Single-Handed HandMark Menus (ISS 2016)

In order to design HandMark Menus for smaller devices such as tablets, we had to deviate from the bimanual nature of HMs, as one hand is always required to hold the tablet. As such, we have created the single-handed HandMark menu for tablets [17] which was accepted to ISS 2016 (Figure 2). In the two versions of the new variant, the menu invocation and command selection operations can be executed as two sequential chunked actions with only one hand.

We carried out three studies with our single-handed HMs, and the first study showed that similar to original

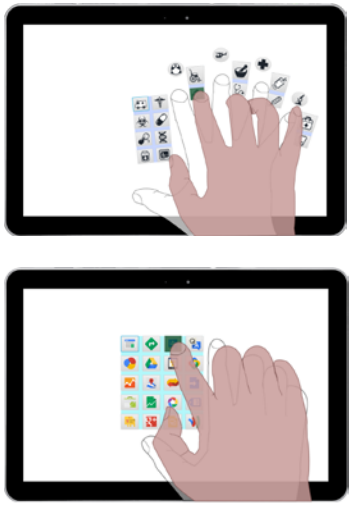

Figure 2. Single-Handed HandMark Menus selection techniques for tablets: (top) HM-Finger, and (bottom) HM-Multi. Sequential chunked operations of menu invocation and selection with the same hand.

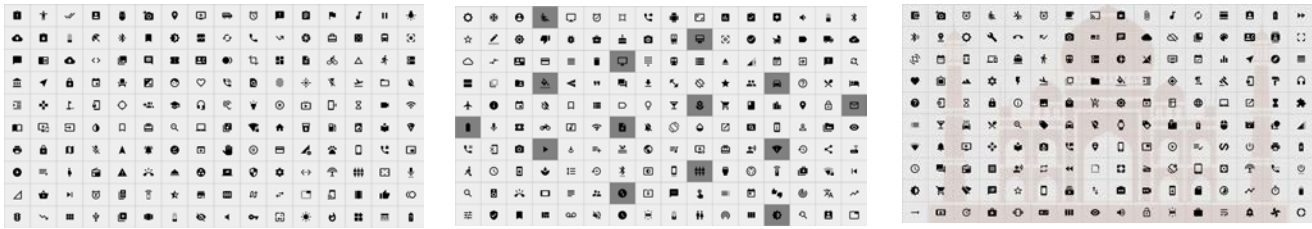

Figure 3. Use of artificial landmarks in spatially-stable interfaces: (left) standard grids, (middle) anchor points with grid, and (right) image as the background of grid.

versions, the adapted menus were also supported rapid development of spatial memory, while improving the selection performance. We investigated the value of hands as landmarks in our second study, and it showed that performance significantly improved because of using hands as a reference frame. The third study showed overlapping targets are not the main cause of errors in memory-based interfaces. Our studies showed HandMarks can work well in one-handed fashion for tablets, and new evidence of hands as landmarks to support spatial learning.

Use of Artificial Landmarks

Spatially-stable command selection technique – CommandMaps [14] demonstrated the power of spatial memory, allowing rapid command selection from memory in a flat menu showing all commands at once. However, lack of sufficient referencing points in the vast middle area often makes the spatial memory less effective. In a paper, currently unpublished, we have explored the idea of improving spatial memory development by introducing artificial landmarks in interfaces similar to the CommandMaps. We have created three grid-based interfaces which follow the flattening menu hierarchy principle: standard 2D grids, grids with few grey colored anchoring points, and an image of Taj Mahal as the background of the grid (Figure 3). By three separate studies with these artificial landmarks, we tried to understand the effects of landmarks in different sizes of command set: small, medium and large.

Our studies showed that for small grids, artificial landmarks had little impact on performance, while the simple anchors significantly improved selection performance for the medium and large grids compared to the weak-landmarked grid only version. Simple anchor marks were also faster and less error-prone than the visually rich-landmarked image interface.

Future Work

Over the course of next few years, I plan to pursue a number of projects on the topic of spatial memory and landmarks. So far, I have figured out two. First, I am planning to perform a comprehensive survey of landmarks and spatial memory literature in HCI. Second, I plan to design new memory-depended interfaces with both natural and artificial landmarks to improve the spatial memory development and user expertise.

Acknowledgement

My research works were supported by NSERC. Also, I thank my supervisor Dr. Carl Gutwin for his support and valuable guidance throughout my research.

References

[1] Ahlström, D., Cockburn, A., Gutwin, C., and Irani, P. Why it's quick to be square: modelling new and existing hierarchical menu designs. *Proc. CHI 2010*, ACM Press (2010), 1371–1380.

[2] Alexander, J., Cockburn, A., Fitchett, S., Gutwin, C., and Greenberg, S. Revisiting read wear: analysis, design, and evaluation of a footprints scrollbar. *Proc. CHI 2009*, ACM Press (2009), 1665–1674.

[3] Cockburn, A. and Gutwin, C. A Predictive Model of Human Performance with Scrolling and Hierarchical Lists. *Human-Computer Interaction* 24, 3 (2009), 273–314.

[4] Cockburn, A., Gutwin, C., and Greenberg, S. A predictive model of menu performance. *Proc. CHI 2007*, ACM Press (2007), 627–636.

[5] Czerwinski, M. and Robertson, G. The Contribution of Thumbnail Image, Mouse-over Text and Spatial Location Memory to Web Page Retrieval in 3D. *Proc. INTERACT 1999*, IOS Press (1999), 163–170.

[6] Gutwin, C. and Cockburn, A. Improving list revisitation with ListMaps. *Proc. AVI 2006*, ACM Press (2006), 396–403.

[7] Gutwin, C., Cockburn, A., Scarr, J., Malacria, S., and Olson, S.C. Faster command selection on tablets with FastTap. *Proc. CHI 2014*, ACM Press (2014), 2617–2626.

[8] Hill, W.C., Hollan, J.D., Wroblewski, D., and McCandless, T. Edit wear and read wear. *Proc. CHI 1992*, ACM Press (1992), 3–9.

[9] Kurtenbach, G. and Buxton, W. User learning and performance with marking menus. *Proc. CHI 1994*, ACM Press (1994), 258–264.

[10] Lafreniere, B., Gutwin, C., Cockburn, A., and Grossman, T. Faster Command Selection on Touchscreen Watches. *Proc. CHI 2016*, ACM Press (2016), 4663–4674.

[11] Lewis, J.P., Rosenholtz, R., Fong, N., and Neumann, U. VisualIDs: automatic distinctive icons for desktop interfaces. ACM Transactions on Graphics 23, 3 (2004), 416–423.

[12] Lynch, K. The image of the city. MIT Press, 1960.

[13] Robertson, G., Czerwinski, M., Larson, K., Robbins, D.C., Thiel, D., and van Dantzich, M. Data mountain: using spatial memory for document management. *Proc. UIST 1998*, ACM Press (1998), 153–162.

[14] Scarr, J., Cockburn, A., Gutwin, C., and Bunt, A. Improving command selection with CommandMaps. *Proc. CHI 2012*, ACM Press (2012), 257–266.

[15] Schramm, K., Gutwin, C., and Cockburn, A. Supporting Transitions to Expertise in Hidden Toolbars. *Proc. CHI 2016*, ACM Press (2016), 4687–4698.

[16] Uddin, M.S., Gaur, V., Gutwin, C., and Roy, C.K. On the comprehension of code clone visualizations: A controlled study using eye tracking. *Proc. SCAM 2015*, IEEE (2015), 161–170.

[17] Uddin, M.S. and Gutwin, C. Rapid Command Selection on Multi-Touch Tablets with Single-Handed HandMark Menus. *Proc. ISS 2016*, ACM Press (2016).

[18] Uddin, M.S., Gutwin, C., and Lafreniere, B. HandMark Menus: Rapid Command Selection and Large Command Sets on Multi-Touch Displays. *Proc. CHI 2016*, ACM Press (2016), 5836–5848.