Single-Handed HandMark Menus: Rapid Command Selection on Tablets

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Abstract
Although rapid command selection is important for touch devices, only a few techniques allow accelerated selection while still providing a large command set. HandMark menus [3] propose the use of the hands as landmarks for fast memory-based selection. However, the original HandMark menus for tables rely on bimanual operation - not suitable for tablets, and earlier studies provided only limited evidence for the value of hand-based landmarks as a reference frame for spatial memory. We introduce adapted HandMark menus that can be operated with one hand (while the other hand holds the tablet); the new version changes bimanual selection operations into sequential actions with one hand. Three studies of these HandMark menus showed that using the hand as a landmark significantly improved performance and allowed fast spatial memory development, even with one-handed use. Our work extends HandMark menus and shows that they are an effective selection method for tablets, and provides new evidence about the value of the hands as a spatial landmark for interaction.

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

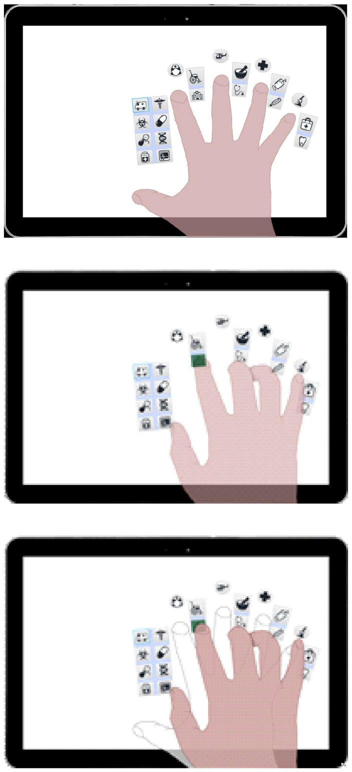

Figure 1. HandMark-Finger selection technique: (top) menu invocation, (middle) item selection after visual search, and (bottom) rapid selection with two sequential actions – one to invoke the menu, and another to select an item.

ACM Classification Keywords

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

Introduction

Similar to traditional WIMP systems, fast command selection is also important for touch devices, but techniques that allow quick operation for experts (e.g., shortcuts, hotkeys) are uncommon on touch interfaces. One promising approach to providing a higher performance ceiling for experts involves the use of spatial location memory (e.g., [1, 2, 3]) – once users learn command locations in a spatially-stable interface, they can make quick selections based on memory rather than visual search.

Landmarks provide anchors for people's spatial memory when they move from novice to expert command selections – for example, people can remember items at the corners of a grid better than they remember items in the middle. A few touch-based selection techniques have considered landmarks and spatial memory as mechanisms for improving performance. For example, the FastTap technique [1] lets people make selections using a multi-touch tap on a grid of items; the structure of the grid provides an external reference frame for remembering command locations (e.g., "top left"). The limited structure and size of the grid, however, means that FastTap provides only a few landmarks, and cannot accommodate a large number of commands (only 20 items in a 4x5 grid [1]).

A more recent technique uses a rich source of landmarks on a touch interface – the user's hands – to assist the development of spatial learning and to increase the number of available commands. *HandMark menus* are a bi-manual technique that takes advantage of the user's knowledge of their own hand, and uses the hand as a reference frame (i.e., a landmark) for locating commands [3]. In these techniques, one hand is used as the anchor for the menu, and the other hand is used to perform rapid selection of an item.

However, there are several limitations to previous work on the HandMark approach. First, the techniques require bi-manual operation, which is feasible for tabletop systems but inappropriate for tablet use in mobile settings (where one hand is needed to hold the device). Second, previous studies did not strongly focus on the spatial learning that takes place with HandMark menus – they compared HandMark menus only to toolbars at the edge of a table, rather than pop-up menus that are invoked at the user's work location. Therefore, it is still unclear whether HandMarks are fast because of the hand landmarks, or because of other factors such as the simple proximity of the commands.

We address these limitations by presenting two new versions of HandMark menus (Figures 1 and 2) that work in a single-handed fashion, and are therefore appropriate for settings where a touch tablet is held in one hand and manipulated with the other. We then report on studies that we conducted to understand spatial learning performance and the value of the hand as a landmark with the one-handed versions of the technique. Our results show that both types of HandMark menus work well in single-hand operation, both allow quick development of spatial memory, and both are strongly preferred by participants.

Our work makes two main contributions. First, our adaptation of bimanual HandMark menus provide two

Design Goals: The goal was to build a spatial memory-based interaction technique that will accelerate the command selection process. It should be feasible for one-handed mobile tablet use: menu can be operated with the dominant hand while the non-dominant hand holds the tablet. In addition, it should support large number of commands.

Menu Capacity and Layout: *HM-Finger* uses the spaces around the hand (top of fingers) and between fingers to display **20** items. *HM-Multi* uses a spatially-stable 4x5 grid to show **80** items (**4 tabs**, and **20** items in each tab) in the space between thumb and index finger.

Chunking Actions: HM uses chunking of two sequential steps (*menu invocation* and *item selection*), rather than a bimanual parallel action. It works as double clicking for expert users.

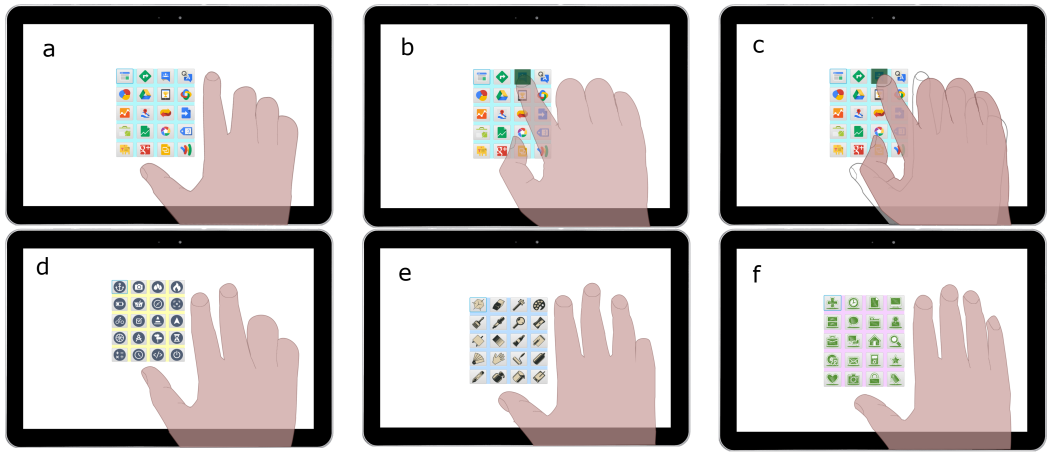

Figure 2. HandMark-Multi selection technique: (a) invoking the 1st item set by placing index and thumb in 'L' shape posture, (b) item selection after visual search, (c) rapid selection with two sequential actions – menu invocation, and item selection, and (d-f) invoking 2nd, 3rd, and 4th item sets with specific finger combinations respectively.

selection techniques for mobile tablets that are fast and that have high capacity. Second, our studies provide new evidence that using the hand as a landmark is feasible and effective for the development of spatial-memory based selection techniques, even with one-handed use.

Design 1: HandMark-Finger for Tablets

Similar to the original version of HM-Finger for tables [3], our version of HM-Finger for tablets provides modal access to a set of commands (Figure 1). The need to hold a tablet with one hand requires to deviate from the bimanual technique and enable command selection using one hand only. In our adapted technique, commands can be displayed by touching down all the fingers of one hand in any order, spreading the hand to provide space between the fingers. The user can rotate and move the menu in any direction by moving their fingers. Unlike the earlier technique, however, command selection is carried out by lifting the fingers from the screen and touching the desired item with any finger. Command icons remain displayed until a selection is made (or until the menu is dismissed by touching on another part of the tablet).

Design 2: HandMark-Multi for Tablets

We also adapted the earlier HM-Multi technique for use on tablets. HM-Multi uses a similar command selection mechanism as HM-Finger, but differs in the placement and number of commands. There are four sets of commands, invoked by placing a specific number of fingers (in addition to the index finger and thumb) on the screen in an L-shaped posture (Figure 2). The menu follows the user's hand as it rotates or moves. HM-Multi uses a spatially-stable 4x5 grid to show commands in the space between thumb and index.

Demo Task: An icon appears on the middle of the screen after pressing *start* button. The user then needs to invoke the HM menus and select the item with any finger of the right hand.

Three Studies: *Study 1* was conducted to understand the performance of the two single-handed HM menus. *Study 2* explored the value of hands as landmarks for both HMs. *Study 3* analyzed the interference of item associations between two applications.

Demonstration Setup

The demonstration setup consists of two versions of the single-handed HM menus, which were implemented for a Microsoft Surface Pro 4, with a 12.3-inch multi-touch 2736 x 1824 screen, and running Windows 10. The interfaces were written in JavaFx. The demo consists of a series of tasks, each involving serial touch actions for both HM menus.

Discussion & Future Work

After the implementation, we conducted three studies with 19 participants on both HM techniques. Our studies clearly revealed that our adapted HandMark menus can be used effectively for single-handed interactions on tablets, and they support rapid spatial memory development. The main results from the studies are:

- Study 1 showed that both HM-Finger and HM-Multi allowed rapid selections.
- Study 2 showed that using hands as landmarks improved performance: HM-Finger and HM-Multi outperformed a non-landmarked technique, and were strongly preferred by participants.
- Studies 2 and 3 showed that overlapping targets are not a main source of errors, but that location memory can degrade because of time or because of interference.

Despite the limitations of single-handed use, our adapted HM menus for tablets performed similarly to the original HM menus for tables. Therefore, we believe that interaction designers, as well as people interested in spatial-memory-based rapid selections in HCI can benefit from this demonstration.

In future work, we will continue the development of the HandMark approach, and will test the technique in real-world settings and compare it to other memory-based selection methods. We are also interested in comparing HandMark menus to systems that introduce artificial landmarks on the display surface, and in potentially combining the two approaches. Finally, we will run studies that focus on issues of decay and interference in memory-based methods, to better understand how techniques like HMs can be deployed in the real world.

Acknowledgements

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