
Visualizing User Interactions on Mobile Multi-Touch Devices to Identify Accessibility Issues

Susumu Harada

IBM Research - Tokyo
NBF Toyosu Canal Front
5-6-52 Toyosu, Koto-ku
Tokyo 135-8511 Japan
haradas@jp.ibm.com

Daisuke Sato

IBM Research - Tokyo
NBF Toyosu Canal Front
5-6-52 Toyosu, Koto-ku
Tokyo 135-8511 Japan
dsato@jp.ibm.com

Hironobu Takagi

IBM Research - Tokyo
NBF Toyosu Canal Front
5-6-52 Toyosu, Koto-ku
Tokyo 135-8511 Japan
takagih@jp.ibm.com

Chieko Asakawa

IBM Research - Tokyo
NBF Toyosu Canal Front
5-6-52 Toyosu, Koto-ku
Tokyo 135-8511 Japan
chie@jp.ibm.com

Abstract

We present several methods for visualizing user interaction behaviors on mobile multi-touch devices such as smartphones and tablets. Our method enables one to quickly make sense of the raw multi-touch interaction log data from mobile applications, and to identify noteworthy patterns and potential accessibility issues in interaction behavior. In particular, we report on the usage of our visualization methods in the context of our on-going user study assessing elderly users' interaction behaviors on such devices.

Author Keywords

Visualization; Mobile; Multi-touch; Smartphone; Tablet.

ACM Classification Keywords

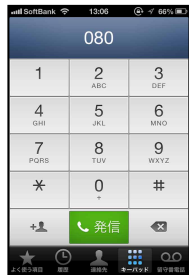
H.5.0 [Information Interfaces and Presentation]:
General.

Introduction

Over the past several years, mobile multi-touch devices such as smartphones and tablets have been rapidly proliferating. While the multi-touch interfaces enable intuitive direct-manipulation interaction that mimic real-world metaphors, they also introduce a number of potential challenges, such as non-intuitive multi-finger

Copyright is held by the author/owner(s).

CHI'13 Mobile Accessibility Workshop, April 28, 2013, Paris, France.



Phone



Address Book



Map

Figure 1: Screenshots of the three application interfaces in our user study test application that mimic actual applications while capturing detailed interaction logs.

gestures, unexpected sensitivity of the touch surface, and a conceptual model that differ significantly from traditional desktop computers and other preceding technologies. These could be especially problematic for elderly users whose senses may not be as acute.

There have been works seeking to measure and analyze low-level interaction metrics on mobile touch-screen devices as participants performed various controlled tasks [3, 4, 7, 8]. While these studies provide concrete data, much of them have focused on aggregating primitive metrics such as task completion times and error rates, which do not always capture higher-level interaction issues that users may experience in realistic usage scenarios.

To better understand such higher-level interaction issues which users may encounter as they interact with mobile multi-touch devices, we present a number of visualization methods for low-level interaction logs that enable identification of noteworthy patterns and potential breakdowns in interaction behavior. We report on the usage of these visualizations in the context of our on-going user study assessing elderly users' interaction with realistic applications on such devices.

Related Work

There have been numerous works on visualization methods for analyzing user interactions on graphical user interfaces, but little have focused on visualization of interaction on touch-screen devices, especially multi-touch devices. Arroyo, Selker, and Wei [1] presented a tool for assessing webpage usability by visualizing mouse movement tracks of page visitors. Gray, Badre, and Guzdial [2] presented a "contextual" visualization of users' key and mouse interactions focusing on

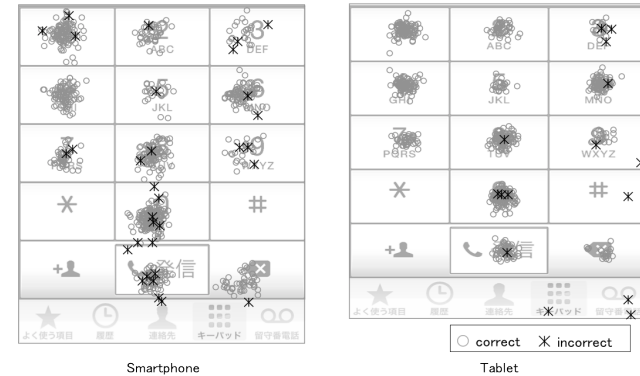


Figure 2: Tap position visualization showing correct and incorrect touches in the Phone task on smartphone and tablet across all participants.

interactions around specific GUI components. There have also been active work in visualizing eye-tracking data [5, 6]. The main difference between these visualization methods and our proposed methods is that the former are targeted at single-point interactions (such as mouse or eye movement) whereas our method considers multi-touch interactions, as well as gesture events such as swipe, two-finger pinch, etc.

User Study Background

We first provide a simple summary of our ongoing user study to which we have applied our visualization methods, so that we may describe those methods within the concrete context of the intermediate results from the study. In our user study, elderly participants perform realistic tasks on our logging application whose interface mimics those of actual applications on mobile multi-touch devices. Our goal is to observe interaction patterns and accessibility issues that may arise during realistic usage that may not be captured under highly controlled and simplified experimental tasks.



Figure 3: Flicks and taps sequence visualization of all gestures within a representative Address Book task trial across three participants. Each stroke represents finger movement on the screen. Rows that were tapped, including both correct and incorrect selections, are shown filled.

Our participants performed tasks on three application interfaces: Phone, Address Book, and Map (Figure 1). On the Phone interface, the task is to dial various phone numbers. The primary gesture used here is single-finger tap. On the Address Book interface, the task is to locate and select a particular name among the alphabetically sorted list, each time starting at a random list position. The primary gestures used are single-finger flick, drag, and tap. On the Map interface, the task is to locate a particular region, starting each trial with the same view of Tokyo Bay and ending each trial with the target region filling up the screen. The primary gestures used are single-finger flick, drag, and double-tap, and two-finger pinch-in, pinch-out, and single-tap. The tasks were performed on both a smartphone (Apple iPhone) and a tablet (Apple iPad).

Visualization Methods

We present a set of visualization methods for the interaction types embodied by the three task interfaces.

Tap position visualization

Figure 2 shows the tap position visualization that render the tap positions across all participants in the Phone task. Correct tap positions are shown as circles, and incorrect tap positions are shown as asterisks. It is readily apparent that there were more miss-taps on the smartphone, and that especially troublesome were miss-taps on the “dial” button. Furthermore, the miss-taps on the lower-right corner on the tablet confirm the unintentional touches by the bottom of the palm that were observed during actual sessions.

Flicks and taps overlay visualization

Figure 3 shows the visualization for showing the positions of all taps and drags for each of the four participants across all trials within the Address Book

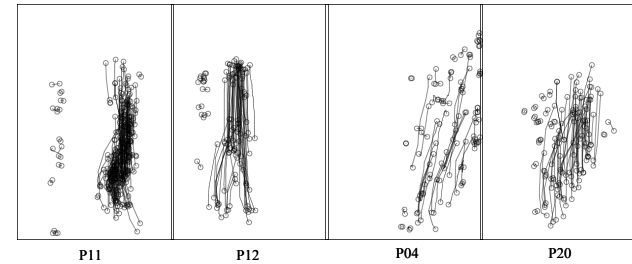


Figure 4: Flicks and taps overlay visualization of all gestures within a particular Scroll task trial across four participants. Blue circles represent taps, and red circles and lines represent drags.

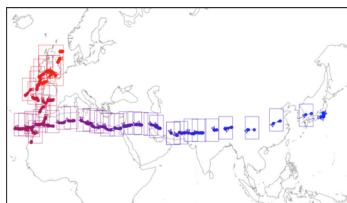
task. It can be seen that P11 and P12 both tended to tap on the left side of the screen when making selections, whereas P4 and P20 tended to tap near the middle or the right of the screen. Particularly problematic was P4’s tap locations, which sometimes happened to land on the index bar widget on the right edge of the screen, leading to inadvertent jumps to some point on the list instead of a row being selected.

Flicks and taps sequence visualization

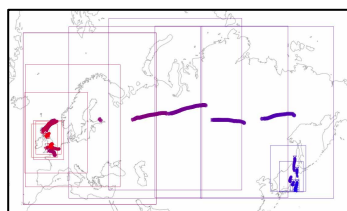
Figure 4 shows the flick and tap sequence visualization of three participants’ gestures during a particular trial of the Address Book task. The visualization shows that P11 and P14 used extremely short strokes for flicking, only moving the tip of the finger to perform the gesture, in contrast to P18 who exhibited a much longer and smoother flicking stroke. As a result, P11 and P14 experienced several miss-selections on non-target rows, as indicated by multiple filled rows.

Pan and zoom visualization

Figure 5 shows the pan and zoom visualization for a particular Map task trial for two participants. The



P15 (Novice)



P23 (Experienced)

Figure 5: Pan and zoom visualization showing all interactions within a particular trial of the Map task for two users. The rectangles represent the map region (and thus the zoom level) that the user was viewing at each point in the interaction. The strokes represent finger movements on the screen. The temporal sequence is represented from blue to red.

visualization shows that the novice participant (top figure) stayed at the same zoom level from the start, relying mostly on panning gestures to navigate her way across the globe to find the target (England, in this case). The experienced participant (bottom figure) on the other hand, can be seen first zooming out to a world-level, panning a few times to find Europe, and then zooming in on England in just a few gestures.

Zoom level transition visualization

Figure 6 shows a graph visualization of the zoom level transitions over time throughout a particular Map task trial for a specific participant. While this participant quickly zoomed out at the beginning of the task to get to the “world”-level view, for some reason, he continued to repeatedly perform pinch-in gestures as if attempting to zoom out even further, as indicated by the dotted circle regions on the graph. This was likely due to the fact that the map widget does not provide any visual cue to indicate that no further zooming out is possible (unlike the Address Book interface, which “bounces” the list back if one attempts to scroll past either end of the list).

Conclusion

We presented a number of visualization methods for graphically representing multi-touch event logs of users performing various realistic tasks on smartphones and tablets. The visualizations provide an intuitive representation for what a particular user was doing during each of the task trials, and reveal various interaction behaviors and patterns. While the visualizations presented here have been for a few specific application interfaces, we are working to generalize them to be usable in visualizing multi-touch interactions in a wider variety of interfaces.

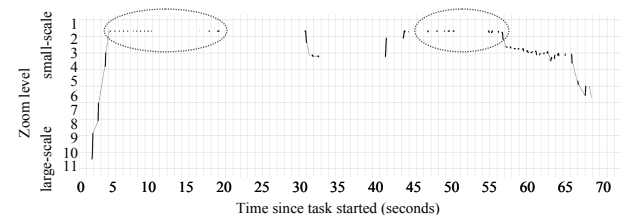


Figure 6: Zoom level transition visualization for a Map task trial. Vertical axis represents the map zoom level (“small-scale” = zoomed out). Thick lines indicate gesture was being executed. Dotted circles highlight attempts to zoom out further than the smallest scale.

References

- [1] Arroyo, E. et al. Usability tool for analysis of web designs using mouse tracks. *Ext. Abstracts CHI 2006*, ACM Press (2006), 484–489.
- [2] Gray, M. et al. Visualizing usability log data. *Proc. INFVIS 1996*, IEEE Press (1996), 93 –98, 130.
- [3] Kobayashi, M. et al. Elderly user evaluation of mobile touchscreen interactions. *Proc. INTERACT 2011*, Springer-Verlag (2011), 83–99.
- [4] Nicolau, H. and Jorge, J. Elderly text-entry performance on touchscreens. *Proc. ASSETS 2012*, ACM (2012), 127–134.
- [5] Rähkä, K.-J. et al. Static visualization of temporal eye-tracking data. *Proc. INTERACT 2005*, Springer Berlin Heidelberg (2005), 946–949.
- [6] Ramloll, R. et al. Gaze data visualization tools: opportunities and challenges. *Proc. IV 2004*, IEEE (2004), 173 – 180.
- [7] Wacharamanotham, C. et al. Evaluating swabbing: A touchscreen input method for elderly users with tremor. *Proc. CHI 2011*, ACM (2011), 623–626.
- [8] Ziefle, M. and Bay, S. How older adults meet complexity: Aging effects on the usability of different mobile phones. *Behaviour & Information Technology*. 24, 5 (2005), 375–389.