International Journal of Child-Computer Interaction 6 (2015) 17–27

Contents lists available at ScienceDirect

International Journal of Child-Computer Interaction

journal homepage: www.elsevier.com/locate/ijcci

Children (and adults) benefit from visual feedback during gesture interaction on mobile touchscreen devices

Lisa Anthony [a,*,1], Quincy Brown [b], Jaye Nias [b], Berthel Tate [b]

[a] University of Florida, Department of CISE, P.O. Box 116120, Gainesville, FL 32611, USA
[b] Bowie State University, Computer Science Department, 14000 Jericho Park Road, Bowie, MD 20715, USA

ARTICLE INFO

Article history:
Received 15 June 2013
Accepted 23 January 2014
Available online 29 January 2016

Keywords:
Gesture interaction
Surface–gestures
Interaction design
Empirical studies
Mobile devices
Child–computer interaction

ABSTRACT

Surface–gesture interaction styles used on mobile touchscreen devices often depend on the platform and application. Some applications show a visual trace of gesture input being made by the user, whereas others do not. Little work has been done examining the usability of visual feedback for surface–gestures, especially for children. In this paper, we extend our previous work on an empirical study conducted with children, teens, and adults to explore characteristics of gesture interaction with and without visual feedback. We analyze 9 simple and 7 complex gesture features to determine whether differences exist between users of different age groups when completing surface–gestures with and without visual feedback. We find that the gestures generated diverge significantly in ways that make them difficult to interpret by some recognizers. For example, users tend to make gestures with fewer strokes in the absence of visual feedback, and tend to make shorter, more compact gestures using straighter lines in the presence of visual feedback. In addition, users prefer to see visual feedback. Based on these findings, we present design recommendations for surface–gesture interfaces for children, teens, and adults on mobile touchscreen devices. We recommend providing visual feedback, especially for children, wherever possible.

1. Introduction

Touch interaction on mobile devices such as smartphones and tablet computers has become one of the most prevalent modes of interaction with technology for many users. These devices all support some form of surface–gesture interaction, but the specific interaction styles used are often dependent on the platform and application (app). While some gestures have emerged as cross-platform standards, such as swipe, pinch-to-zoom, and drag-to-pan, there is still quite a variety of other gestures in use for specific apps. For example, the note-taking and sketching app from FiftyThree, Inc., called Paper,[2] uses a counter-clockwise spiral gesture to "rewind" (e.g., undo) the user's command history. Another example is Realmac Software's Clear[3] list-keeping app, which uses a drag-and-hold gesture to create a new list item. Anthony et al. [1] and Zhai et al. [2] both include summaries of the range of gestures used in research on surface–gesture interaction, some of which are also used in commercial apps. In addition to using a variety of gestures, some applications show a visual trace of gesture input as it is made by the user, such as drawing or tracing games (e.g., Luck-u's Art Penguin[4]), whereas others do not, such as navigation apps (e.g., Ulmon GmbH's City Maps 2Go[5]). Evidence from cognitive and perceptual psychology literature suggests that both children and adults have more difficulty drawing and writing in the absence of visual feedback [3–5]. Young children may benefit even more strongly from the use of visual feedback during interaction because they are still developing the required sensorimotor coordination ability to draw without looking [5]. However, little work has been done to examine the usability of visual feedback for surface–gestures in general, let alone for children or teens.

* Corresponding author.
E-mail addresses: lanthony@cise.ufl.edu (L. Anthony), qbrown@bowiestate.edu (Q. Brown).

[1] This work was done while the first author was affiliated with UMBC, Information Systems, 1000 Hilltop Circle, Baltimore, MD 21250, USA.

[2] https://itunes.apple.com/us/app/paper-by-fiftythree/id506003812.

[3] https://itunes.apple.com/us/app/id493136154.

[4] https://itunes.apple.com/us/app/id449097181.

[5] https://itunes.apple.com/us/app/city-maps-2go/id327783342.

http://dx.doi.org/10.1016/j.ijcci.2016.01.002
2212-8689/

(a) With feedback. (b) Without feedback.

Fig. 1. Examples of gestures (diamond shape) produced with and without visual feedback by one participant (a child, to scale).

In this paper, we extend previously presented results from an empirical study conducted with 41 children, teens, and adults to explore characteristics of gesture interaction with and without visual feedback [6]. We asked questions such as: How well are children, teens, and adults able to enter surface–gestures with and without visual feedback? Does presence or absence of visual feedback affect consistency of the gestures made? If so, is automatic gesture recognition impacted by these changes in consistency? Which mode of gesture input (with or without feedback) do adults, teens, and children prefer?

We find that the gestures generated by users of different ages with and without visual feedback diverge significantly in ways that make them difficult to interpret (Fig. 1). For example, users tend to make gestures with fewer strokes in the absence of visual feedback. They also tend to make shorter, more compact gestures using straighter lines with more efficiency and less wobbling in the presence of visual feedback. In addition, based on our observations, users of all age groups we studied prefer to see visual feedback, although adults are more willing to accept lack of feedback. Based on these findings, we present several design recommendations for new surface–gesture interfaces for children, teens, and adults on mobile touchscreen devices.

The contributions of this work include the following. First, we present an analysis of gesture features that change when visual feedback is present or absent during the interaction, which can be used to design better gesture sets and recognizers for one or both situations. Second, we analyze the actual impact of these feature differences on recognition by current algorithms used in user interaction research. Third, we present design recommendations based on empirical data we collected from children, teens, and adults related to the necessity, utility, and desirability of visual feedback. We go beyond prior presentations of this work [6] by investigating additional features, testing with a new recognizer, and adding to the design recommendations. The results of this work are informative to designers and researchers interested in surface–gesture interaction on mobile devices for users of all ages.

2. Related work

We briefly survey related work on surface–gesture interaction on mobile devices for both children and adults, as well as prior work on usability of interactions with and without visual feedback.

2.1. Surface gestures and mobile devices

Gesture-based interaction on touch-enabled surfaces have been studied extensively in the HCI literature, particularly from a usability perspective [7–15]. Gesture set design [11,15], multitouch gestures [7,9], accessible gestures [10], and differences between pen/stylus and finger gesture input [14] are just some of the areas that have been examined, but none of these studies have included children. From a child–computer interaction perspective, surface–gestures for children especially on mobile devices have generally been neglected. Multitouch gestures for children on tabletops have been explored [8,12,13], but research typically has either included children only, or has not distinguished between adults and children, making the comparisons needed for tailored interaction design difficult. Some work recently has explicitly compared and contrasted surface–gesture interaction design for children and adults [16–18], but has not specifically looked at the question of feedback. As we continue to see an increase in the use of touch-based mobile technologies by children [19], further work in this area is needed.

Related work in pen-based handwriting interactions for children [20], pointing and mouse pathing interactions for children [21–24], and drag-and-drop gestures (with mice or fingers) for children [25–27] have found that children make less stable movements, have difficulty maintaining contact with the screen, and make more input errors overall than do adults. We predict that similar results will hold for other types of surface–gestures performed on mobile touchscreen devices, such as the ones we study in this paper, and we explore this relationship in our own work.

2.2. Usability and visual feedback

Past researchers have examined the use of visual feedback (among other types of feedback) for various modalities such as pointing with a mouse [28], text entry [29], 3D gestures [30], and hand-tracking gestures [31]. In these cases, visual feedback is usually found to be necessary to allow users to understand that their input has had the desired effect. In Clawson et al.'s work [29], however, the visual feedback that was preferred by users during mobile text entry had the side effect of decreasing typing speed, because visible input errors distracted users. Two examples of work that explicitly seeks to reduce reliance on visual feedback are Gustafson's [32] "imaginary interfaces", which uses accelerometer-based gestures on screen-less devices, and Zhao et al.'s [33] *EarPod*, an eyes-free menu selection technique that uses auditory rather than visual feedback. In both cases, the benefit of eyes-free interaction trades off with a new burden on the user to recall required input actions without visual confirmation of their successful interaction.

Very little work has explored the use of visual feedback for touch and gesture interaction. One example is Li's [34] *Gesture-Search* tool, which accepts letter gestures as shortcuts for searching, e.g., to jump to a particular alphabetic section of one's contact list. In that work, users preferred character-based gesture shortcuts for commands due to the mode switch required by text entry on mobile devices. Gesture interaction differs from other modalities in that it can support two types of visual feedback: visual feedback of the actual action being entered (e.g., the trace of a gesture), and visual feedback of the action's effect (e.g., the recognition of a gesture). Work on visual feedback in other modalities can provide design recommendations for the latter type of visual feedback. We are the first to examine the former type.

In addition, none of these studies in any modality has involved child users. Based on child development literature (e.g., [5]), we hypothesize that providing visual feedback will be even more crucial for gesture interaction design for children than for adults since children are still developing the sensorimotor coordination ability required to draw without looking.