AirFlip-Undo: Quick Undo using a Double Crossing In-Air Gesture in Hover Zone

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ABSTRACT
In this work, we use AirFlip to undo text input on mobile touchscreen devices. AirFlip involves a quick double crossing in-air gesture in the boundary surfaces of hover zone of devices that have hover sensing capability. To evaluate the effectiveness of undoing text input with AirFlip, we implemented two QWERTY soft keyboards (AirFlip keyboard and Typical keyboard). With these keyboards, we conducted a user study to investigate the users' workload and to collect subjective opinions. The results show that there is no significant difference in workload between keyboards.

Author Keywords
In-air gesture; hover gesture; touch panel; double crossing gesture; one handed.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation (e.g. HCI): Interaction styles; Input devices and strategies.

INTRODUCTION
Hover sensing capability is available on several smartphones and provides richer interaction. For example, it allows users to unlock a pattern lock without touching the touchscreen of their smartphone. Users can do so securely because fingerprints are not left on the touchscreen. In our previous work, we used this capability to design a quick double crossing in-air gesture for mobile devices, called AirFlip [2]. We have applied AirFlip to rotating a map in map applications and switching tabs in Web browsers. In this paper, we apply AirFlip to undoing text input. In addition, we investigated users' workload and collected subjective opinions on this application as a preliminary user study.

AIRFLIP
AirFlip is a quick double crossing gesture made within the boundary surfaces of the hover zone AirFlip is performed only with the thumb of the hand holding the smartphone. Figure 1 shows how to use AirFlip. Users move their thumb into the hover zone from the side and then move it out of the zone quickly.

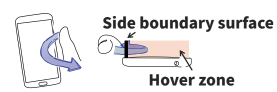

Figure 1. Overview of AirFlip.

While in-air gestures currently available on mobile devices with hover sensing capability require keeping or moving the finger within the hover zone, AirFlip utilizes motion that crosses the boundary surfaces of the hover zone. To avoid conflict with these existing operations, finger movement that satisfies two conditions is recognized as AirFlip: 1) The moving distance of a users' finger in the hover zone is 300 pixels and over; and 2) The hovering time of users' finger in the hover zone is between 350 ms and 1000 ms. In this paper, we apply AirFlip to undoing text input. We call this gesture AirFlip-Undo. Figure 2 shows a use case. Suppose that a user was going to type "just like it says on the can good," but has typed "just like it sdys" (Figure 2a). In this case, she must undo the typing of "sdys" (Figure 2b) and type "says" (Figure 2c). AirFlip-Undo allows her to do this with only five controls, i.e., one AirFlip-Undo and typing "s," "a," "y," and "s," while using the conventional backspace key requires six controls, i.e., pressing the backspace key three times to delete "s," "y," and "d," and typing "a," "y," and "d."

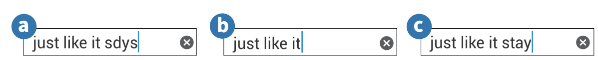

Figure 2. Modifying text input by using AirFlip-Undo. a: Wrong text. b: Undo typing of "sdys." c: Typing correct text.

PRELIMINARY USER STUDY
To evaluate AirFlip-Undo, we conducted a user study to investigate the users' workload and to collect subjective opinions on AirFlip-Undo.

Participants and Apparatus
The participants were eight volunteer university undergraduates/graduates (21-24 years old, $M = 21.75$). Everyone used a smartphone on a daily basis. They had been using mobile devices for 14 to 73 months ($M = 45.25$) The study was conducted on a Galaxy S4 SC-04E (Android 4.2.2, 5-inch screen, 1920 px $\times$ 1080 px resolution). For comparison, we implemented two QWERTY soft keyboards (AirFlip keyboard and

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Typical keyboard). AirFlip-Undo was implemented on only AirFlip keyboard. While the participants' fingers were within the hover zone, AirFlip keyboard vibrated the smartphone to provide feedback. Before the task started, each participant was free to practice with AirFlip keyboard until becaming familiar with AirFlip-Undo.

Task

Each participant used Google Web Search to search phrases that were presented by the experimenter. A trial of the task involved searching a phrase chosen at random from a set of 500 phrases that MacKenzie et al. [4] chose. A session consisted of five trials. Each participant carried out five sessions in succession for each keyboard. In total, the participants conducted 50 trials (5 trials $\times$ 5 sessions $\times$ 2 keyboards). The participants took a break for one minute between sessions. To counterbalance, four participants (P1–P4) used AirFlip keyboard first; the others (P5–P8) used Typical keyboard first. Each time the five sessions were completed, the participants filled out a NASA-TLX [3] questionnaire. We used a Japanese version of NASA-TLX [1] because all participants were Japanese. After the experiment, the participants filled out a questionnaire used to collect opinions on AirFlip-Undo. The experiment took about 70 minutes per participant, including the prior explanation and answering the questionnaires.

Results and Discussion

Figure 3 shows the NASA-TLX score. Table 1 shows the mean of the weights given for the six NASA-TLX scales. Those shown in the table are the averaged results of the eight participants.

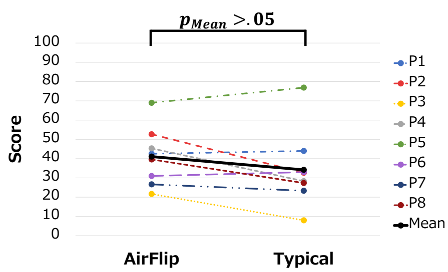

Figure 3. NASA-TLX scores.

	AirFlip keyboard	Typical keyboard	p
Mental Demand (MD)	3.00 (1.12)	3.25 (0.97)	0.56
Physical Demand (PD)	2.38 (1.58)	2.13 (1.27)	0.68
Temporal Demand (TD)	1.88 (1.27)	2.13 (1.76)	0.71
Own Performance (OP)	2.38 (0.99)	2.38 (1.49)	1
Effort (EF)	2.50 (1.94)	2.38 (1.73)	0.78
Frustration (FR)	2.88 (2.09)	2.75 (2.05)	0.84

Table 1. Weights given for six NASA-TLX scales (0–5 scale, low to high). Results in table are averaged results of the eight participants.

According to Table 1, the score of AirFlip keyboard was higher than that of Typical keyboard for three fields: Physical Demand (PD), Effort (EF), and Frustration (FR). Each result is due to the following reasons. First, the PD of AirFlip was higher because the participants were not familiar with AirFlip. Moreover, the participants using AirFlip had to move their thumb outside of the hover zone once, i.e., requiring the participants to move their thumb exaggerated motion, thus it increased the participants' load. Second, the EF of AirFlip was higher because AirFlip is an in-air gesture. The participants using AirFlip had to move their thumb in the hover zone without touching the display. Therefore, the participants had to be careful not to touch the display. Finally, the FR of AirFlip was higher because the vibrational feedback produced by AirFlip was too strong. That is, while a participants' thumb was in the hover zone, AirFlip keyboard kept vibrating the smartphone to provide feedback, frustrating the participants'. In the participants' opinions, P1 and P2 commented, "I was bothered by the smartphone continuing to vibrate." P6 and P8 commented, "I felt my hand was tired." Therefore, it is necessary to redesign the feedback in the future. In comparison, the score of AirFlip was lower than that of Typical for two fields: Mental Demand (MD) and Temporal Demand (TD). The opinions supported this result. P1, P2, and P8 commented, "AirFlip is intuitive." P3, P4, and P5 commented, "AirFlip may be quick." From these opinions, redesigning the feedback would make AirFlip a gesture that can be performed naturally.

While the score of AirFlip keyboard was higher, as shown in Figure 3, there was no significant difference between the two keyboards' workload. In other words, although the AirFlip keyboard was frustrating because of the vibration feedback, using AirFlip to undo typing may be useful for users. As a hint for future improvement, one opinion we got was "I want visual feedback" from P4. Therefore, we plan to design visual feedback as well as redesign haptic feedback.

CONCLUSION

We showed AirFlip-Undo, which uses AirFlip to undo text input on mobile touchscreen devices. The results of our user study showed that there was no significant difference between the workloads with AirFlip keyboard and with Typical keyboard. For future work, we plan to design visual feedback as well as to redesign haptic feedback in order to lower the workload of AirFlip-Undo. Furthermore, we also plan to implement undo–possible applications with AirFlip other than those that use text input.

REFERENCES

1. Haga, S., and Mizugami, N. Japanese version of NASA Task Load Index: Sensitivity of its workload score to difficulty of three different laboratory tasks. *The Japanese journal of ergonomics 32*, 2 (1996), 71–79. (in Japanese).
2. Hakoda, H., Kuribara, T., Shima, K., Shizuki, B., and Tanaka, J. AirFlip: A double crossing in-air gesture using boundary surfaces of hover zone for mobile devices. In *Proceedings of the 17th international conference on Human-computer interaction*, HCII '15 (2015). (to appear).
3. Hart, S. G., and Staveland, L. E. Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. In *Human Mental Workload*, vol. 52. North-Holland, 1988, 139 – 183.
4. MacKenzie, I. S., and Soukoreff, R. W. Phrase sets for evaluating text entry techniques. In *CHI EA '03* (2003), 754–755.