DoubleFlip: A Motion Gesture Delimiter for Mobile Interaction

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Figure 1: Illustration of the DoubleFlip gesture.

ABSTRACT
In order to use motion gestures with mobile devices it is imperative that the device be able to distinguish between input motion and everyday motion. In this abstract we present DoubleFlip, a unique motion gesture designed to act as an input delimiter for mobile motion gestures. We demonstrate that the DoubleFlip gesture is extremely resistant to false positive conditions, while still achieving high recognition accuracy. Since DoubleFlip is easy to perform and less likely to be accidentally invoked, it provides an always-active input event for mobile interaction.

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General Terms: Human Factors

Keywords: Motion gestures, sensors, mobile interaction.

INTRODUCTION
A major technical barrier for adopting motion-gesture based interaction is the need for high recognition rates with low false positive conditions. This obstacle limits the potential of good interaction design since many proposed physical motions (i.e. flipping [2] and tilting [2,3,5,8,10]) are indistinguishable from everyday motions. Hence, these gestures suffer from the inherent difficulty that they generate a large number of false positives.

While modeless interaction for motion gestures is ideal, it is not practical for general interaction situations. The dilemma that we encounter here is the same for other types of interactions, i.e., inking versus gesturing in pen-based user interfaces [4,6,9]. Previous work has often relied on hardware buttons [2,8,10] or the use of additional sensors in order to determine the context of use [3,5]. Although successful, these mode-switching techniques either require a designer to use interaction context (which is often hard to infer) or a user to switch input modalities (i.e., from motion input to pressing or touching a button).

We designed DoubleFlip to tackle the challenge of separating gestural input from normal motion. DoubleFlip is a unique motion gesture that acts as a delimiter for other motion gestures, and hence, separates normal mobile phone motion from a user's intended input. In addition, the gesture gives users the control to activate motion gestures without any hardware modifications to existing devices. The gesture is quick to perform and can be performed in a limited amount of physical space.

As part of this work, we implemented a recognizer for the DoubleFlip gesture. Based on a collection of over 2,100 hours of motion data captured from the phones of ninety-nine volunteers, we found that our DoubleFlip recognizer is extremely resistant to false positives — on average less than one false positive every 8 hours of phone use. Thus, the DoubleFlip gesture and recognizer can be used as a building block for other systems to provide motion-gesture interactions.

DESIGING DOUBLEFLIP
We set out to create a delimiter that is not dependent on a touchscreen or hardware buttons, but instead, uses the commonly available sensors in today's smartphones. Therefore, we decided that the delimiter should be a motion gesture that meets the following requirements. First, the gesture should be resistant to false positives against the ambient motion. Second, the screen must be visible after completing the gesture to allow the user to interact with the screen. Third, the physical space required to perform the gesture should be limited so that the gesture can be performed in a crowded space. Finally, the gesture should be

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distinct enough from any gestures that a user/developer might want to incorporate into an application.

As shown in Figure 1, the DoubleFlip delimiter is performed by quickly rotating the wrist such that the phone's display is facing away from the user, then back to the original position with the display facing the user.

The design of DoubleFlip makes it resilient to false positives. Since users commonly interact with the front of the device during normal use (due to the location of the display), it is unlikely that the DoubleFlip gesture will be accidently triggered. The need to flip the phone back to trigger a DoubleFlip ensures that the display is facing the user upon completion, which addresses our second design requirement — keeping the screen visible to the user after DoubleFlip.

DoubleFlip is easy and quick to perform. Since the gesture can be carried out with the simple rotation of the wrist and no movement in the arm, the gesture requires no more physical space than holding the phone for normal use.

EVALUATION OF DOUBLEFLIP

To be a successful delimiter, the recognizer needs to have a low false positive rate and a high true positive rate. To evaluate DoubleFlip, we designed a recognizer using Dynamic Time Warping [7], which was implemented in Java using the Android SDK [1].

To investigate the performance of our DoubleFlip recognizer, we conducted a two-stage data collection task. We began by collecting ambient motion generated by the normal use of Android phones from 99 users, resulting in 2,169 hours of data. Next, we asked each of our 20 volunteers to perform the DoubleFlip gesture 20 times. The DoubleFlip recognizer being tested employed a set of 20 templates generated by five users who did not participate in the previous data collection task.

Using the collected data, we first searched for an optimal threshold (minimum DTW distance to stored templates) for determining whether a segment of the motion input stream should be considered as a DoubleFlip gesture, using a ROC analysis (see Figure 2). The analysis showed that true positive rates quickly converged to 100% as we increased the threshold. Using the optimal threshold obtained from our ROC analysis, false positives occurred less than once every 8 hours of ambient motion. As a result, our recognizer was able to provide a 100% true positive rate while maintaining a low false positive rate given the collected test data.

DISCUSSION

We aimed at developing a novel motion gesture delimiter for mobile interaction. In contrast to methods that rely on the current state (or context) of the system to limit false positives, DoubleFlip is state independent. Being state independent is important as it allows DoubleFlip to deploy an

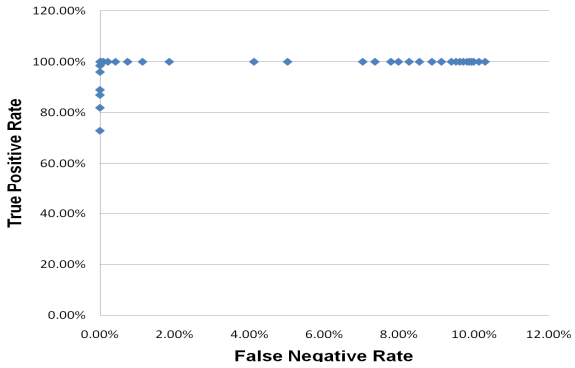

Figure 2: ROC Curve of the DoubleFlip recognizer.

"always on" listening strategy, which is a key requirement for an input delimiter.

The ability to distinguish the DoubleFlip gesture from normal motion creates many possibilities for motion-gesture based interaction. It allows the user to activate and deactivate a motion gesture mode by simple flipping and enlarges the design space of motion gestures by not requiring gestures to be different from ambient motion. In addition, the DoubleFlip gesture can also be attached to an intended motion gesture as either an interaction prefix or postfix.

CONCLUSION

We presented DoubleFlip, a motion gesture that acts as a delimiter for motion-gesture based interaction. Through experimentation we showed that DoubleFlip is easy to recognize and resilient to false positives during normal motion.

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