Towards Non-Observable Authentication for Mobile Devices

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Abstract
When faced with the threat of observational attacks, mobile device users may attempt to mask the graphical interface to authenticate entry, to reduce the likelihood of third parties viewing and recreating the authentication sequence. However, interacting non-visually with a mobile interface is not without its own challenges. In this paper, we describe a study examining the efficacy of authenticating entry using both PINs and graphical patterns when the mobile interface is outside of the line of sight of third parties and the user (i.e. in the user's pocket, bag, or shielded by the non-dominant hand). A tactile aid intended to provide awareness of the orientation of the mobile device and to support authentication sequence entry is also being evaluated as part of the research.

Author Keywords
Mobile Device; Non-Observable Interaction; User Authentication.

ACM Classification Keywords
H.5.2. User Interfaces;

Introduction
As private or sensitive information is often stored on or accessed through mobile devices, users often secure entry to these technologies with PINs or graphical

Figure 1: Entering authentication sequence while phone is in the trouser pocket.

Figure 2: Entering authentication sequence while phone is in a bag near the user.

patterns. As mobile devices are used in a variety of environments, users are particularly vulnerable to observational attacks from both physical observers (shoulder surfers) and hidden cameras which may record authentication sequences, with the purpose of gaining unauthorized access.

To better resist the threat of observational attacks, mobile device users attempt to modify their behavior when entering a busy or unfamiliar environment, by masking the screen of the device from onlookers. Examples highlighted in the study by Abdolrahmani et al. [2] include interacting with a mobile device within the pocket or bag (Figures 1 and 2). Others may attempt to shield the screen using their non-dominant hand to reduce the likelihood of finger movements on the interface being observed (Figure 3). However, interacting non-visually with a mobile interface presents a number of challenges, due to the lack of accessible feedback from the device. The user's own view of the graphical interface is masked, often leading to errors being made when an authentication sequence is entered. Non-observable authentication behaviors are rarely examined by mobile interface designers when evaluating their products.

In this paper, we describe a study to determine the efficacy of authenticating entry to a mobile device in scenarios where the user may feel that they are at risk of an observational attack. A tactile aid, designed to support the user, is also being evaluated as part of this research.

Related Work

Researchers have examined the issues associated with observational attacks, and have designed solutions to limit the visibility of the whole or part of screen [10-12], detect the presence of shoulder surfers with the aim of alerting the user to modify their usage behavior accordingly [3,12], and developed solutions to support non-visual interaction to better support security in dynamic contexts [4,5]. Studies have also longitudinally characterized user perception of shoulder surfing as a threat, finding it a credible threat in 17% of real-world unlock actions [6].

If threats are anticipated or detected, workarounds are often used by mobile device users. For example, concealing the mobile device within the pocket or a bag enables users to interact with the interface, highlighted in the study by Abdolrahmani et al. [2], limits the abilities of third parties to view and recreate authentication sequences. However, errors can be made when attempting to enter data with the absence of visual feedback. To address this issue, researchers have aimed to use tactile feedback to support interaction with eyes-free interfaces. Examples include the study by Hoggan et al. [7] where tactile icons (tactons) were developed to represent events and keys that exist on a mobile interface. Pielot et al. [9] developed PocketMenu, a menu optimized for in-pocket interactions with a touchscreen device. Tactile information is presented to convey the position and state of buttons. Findings from the researchers' study showed that PocketMenu outperforms auditory output (VoiceOver) in terms of completion time, selection errors, and subjective usability, making it ideal for interactions where the user is on-the-go.

To better support location awareness when non-visually exploring the mobile interface, tactile landmarks have been developed using low-tech tools. Examples include

Figure 3: Entering authentication sequence while masking phone with non-dominant hand.

the interface described by McGookin et al., [8], where adhesive plastic bumps have been affixed to a section of the screen enabling users to return to a "home" location for further interactions. Vibrational feedback indicating the position, such as the center of the phone, may offer considerable potential to users when attempting to orient position on the interface, with the goal of entering authentication data with minimal errors.

Study Design

The main objective of the study is to determine whether the type or design of authentication sequence impacts entry when the device is outside of the user's and third parties' line of sight.

Twenty four volunteers are being recruited to participate in the within-subjects study. Each participant is introduced to a mobile interface developed for the study, which collects positional data when interacting with a pattern unlock screen and PIN screen, enabling analysis of user movement when non-visually interacting with the screen. Two tasks are presented, in randomized order.

Task 1

The aim of the first task is to determine the efficacy of a tactile aid to support orientation. Two conditions are presented. For the "without tactile" condition, participants are asked to enter pre-defined authentication sequences when the mobile device is located in a pocket affixed to their waist, a bag on their shoulder, or when the screen is obscured by the user's non-dominant hand.

For the "with tactile" condition, participants are asked to locate the center point of the screen. Short tactile bursts presented via the vibration actuators built into the phone (duration: 100ms) indicate the direction towards which the finger should move to locate the center of the screen (e.g. 1 buzz = move left, 2 buzzes = move right). Participants are asked to enter the same patterns and PINs as in the "without tactile" condition. Levels of accuracy and task time taken will then be compared. Each task is performed three times in randomized order, enabling us to examine whether performance improvements are evident over time. Participants are asked to think-aloud during the process of orienting position, to determine the process taken to support non-visual interaction with a mobile device.

Task 2

Participants are asked to play the role of adversarial observer, and review a prepared video of a mobile device user attempting to authenticate entry while the device is located in the pocket, bag or shielded by the hand. A similar method to Ali et al. [1] has been adopted. Participants then attempt to identify authentication sequences. The task may examine the impact of handedness, passcode length, and location on the interface.

Questions are then presented to examine the ease with which authentication sequences can be entered, and to determine the quality of the subjective interaction experience.

Current Status and Future Work

The study is currently underway. The findings will determine the efficacy of using different methods to authenticate non-visually with a mobile device.

Additional conditions may be applied to inquire about interaction with parameters of realistic mobile use, such as walking (e.g. while moving on a treadmill), and handheld devices with differing grip dimensions (e.g. width and depth). Also, differing interaction schemes may be considered, such as those offering a tactile cue at each passcode character entry, which may influence performance measures such as accuracy and completion time, as well as user preference. Insights from the study aim to offer guidance to users when selecting and entering authentication sequences, with the aim of limiting errors and reducing the cognitive burden on users.

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References

1. Abdullah Ali, Ravi Kuber, and Adam J. Aviv. 2016. Developing and evaluating a gestural and tactile mobile interface to support user authentication. In *Proceedings of iConference'16.* http://dx.doi.org/10.9776/16141
2. Ali Abdolrahmani, Ravi Kuber, and Amy Hurst. 2016. An empirical investigation of the situationally-induced impairments experienced by blind mobile device users. In *Proceedings of the 13th Web for All Conference* (W4A'16).
3. Frederik Brudy, David Ledo, and Saul Greenberg. 2014. Is anyone looking?: mediating shoulder surfing on public displays (the video). In *CHI '14 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '14), 159-160. http://dx.doi.org/10.1145/2559206.2579528
4. Alexander De Luca, Emanuel von Zezschwitz, and Heinrich Hußmann. 2009. Vibrapass: secure authentication based on shared lies. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '09), 913-916. http://dx.doi.org/10.1145/1518701.1518840
5. Alexander De Luca, Alina Hang, Frederik Brudy, Christian Lindner, and Heinrich Hussmann. 2012. Touch me once and i know it's you!: implicit authentication based on touch screen patterns. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '12), 987-996. http://dx.doi.org/10.1145/2207676.2208544.
6. Marian Harbach, Emanuel von Zezschwitz, Andreas Fichtner, Alexander De Luca, and Matthew Smith, 2014. It's a hard lock life: A field study of smartphone (un) locking behavior and risk perception. In *Symposium on Usable Privacy and Security* (SOUPS 2014), 213-230.
7. Eve Hoggan, Stephen A. Brewster, and Jody Johnston. 2008. Investigating the effectiveness of tactile feedback for mobile touchscreens. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (CHI '08), 1573-1582. http://dx.doi.org/10.1145/1357054.1357300
8. David McGookin, Stephen Brewster, and WeiWei Jiang. 2008. Investigating touchscreen accessibility for people with visual impairments. In *Proceedings of the 5th Nordic Conference on Human-Computer Interaction: Building Bridges* (NordiCHI '08), 298-307. http://dx.doi.org/10.1145/1463160.1463193
9. Martin Pielot, Anastasia Kazakova, Tobias Hesselmann, Wilko Heuten, and Susanne Boll. 2012. PocketMenu: non-visual menus for touch screen devices. In *Proceedings of the 14th International Conference on Human-Computer Interaction with Mobile Devices and Services* (MobileHCI '12), 327-330. http://dx.doi.org/10.1145/2371574.2371624
10. George T. Probst. 2000. Analysis of the effects of privacy filter use on horizontal deviations in posture

of VDT operators. Masters Thesis. Virginia Tech, Blacksburg, VA.

11. Peter Tarasewich, Jun Gong, and Richard Conlan. 2006. Protecting private data in public. In *CHI '06 Extended Abstracts on Human Factors in Computing Systems* (CHI EA '06), 1409-1414. http://dx.doi.org/10.1145/1125451.1125711
12. Huiyuan Zhou, Khalid Tearo, Aniruddha Waje, Elham Alghamdi, Thamara Alves, Vinicius Ferreira, Kirstie Hawkey, and Derek Reilly. 2016. Enhancing Mobile Content Privacy with Proxemics Aware Notifications and Protection. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (CHI '16), 1362-1373. http://dx.doi.org/10.1145/2858036.2858232