Poster: On Design of Audio Instructions for Multisensory Authentication for Portable Touchscreen Device

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1. INTRODUCTION

Recently, the touchscreen has become a major user interface for portable devices such as smart phones and tablets. In these devices, the personal identification number (PIN) based authentication mechanism is often used to authenticate the user. However, the regular PIN entry method using a numeric pad is vulnerable against observation attacks. PINs are easily observed if a malicious attacker can look over the user's shoulder while s/he is typing the numbers because the touch screen is relatively bigger than the screen of mobile phones. Moreover, user's PIN or key pattern may be guessed from the trace of a finger print on the screen. The pattern screen lock used in the Android devices also has the similar problem. A usable authentication method which is robust against the observation attack for the portable touchscreen device is desired.

For automated teller machines (ATMs), several methods have been proposed to prevent observation attacks. Luca et al. proposed the ColorPIN that uses indirect input of alphabets to provide security enhanced PIN entry [1]. Sasamoto et al. proposed the Undercover that uses visible information and hidden one to assemble user's response for key entry [2]. Their system uses a graphical password based on image selection as the visible information and a trackball device for conveying the hidden signal. The multisensory authentication [3] utilized the same concept and replaced the visible part with a number entry interface using a 2-by-5 colored cell. The hidden information is audio instructions sent via a headset. However, its number entry interface has a design flaw in the movement of numbers [4].

In this paper, we designed a new number entry interface of the multisensory authentication for portable touchscreen devices. In addition to the colored cell, we newly designed four kinds of screen interfaces and audio instructions: animal sounds, clock positions, short beeps with different pitches, and short beeps with different lengths. We conducted a user study to evaluate usability of audio instructions in this authentication system.

2. MULTISENSORY AUTHENTICATION FOR TOUCHSCREEN DEVICES

Multisensory authentication is one of the solutions for preventing the observation attack. Figure 1 shows the basic concept of the system. Two types of perceptual information are used in the multisensory authentication: the visible images/numbers displayed on the screen and the hidden audio signal that is delivered through a headset. The user decides his/her response using both of these types of information. Therefore, malicious observers cannot identify the meaning of the user's response because they cannot obtain the hidden signals. In the preceding study [3], a 2-by-5 colored cell interface was used for the visible information. To remove the design flaw of the interface and apply the multisensory authentication method to the touchscreen device, we designed new user interfaces consist of a wheel with 10 divisions.

We present the colored cell interface before discussing other interfaces. Figure 2 (a) shows the screen layout of the colored cell interface. All cells on the screen are of a different color, and the audio signal indicates the color of the "destination" cell in which the user's PIN digit should be placed.

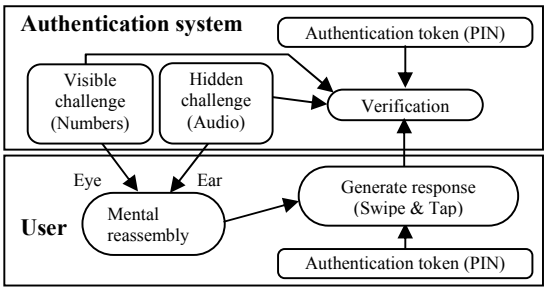
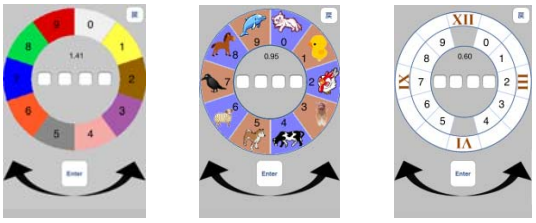
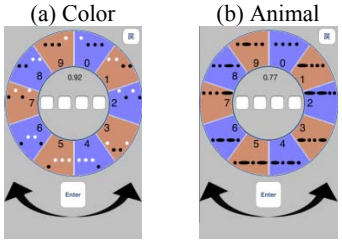


Figure 1. Multisensory authentication



(a) Color (b) Animal (c) Clock



(d) Pitch (e) Length

Figure 2. Screen layout of visible challenge

We use a 4-digit PIN as authentication token. An authentication sequence consists of four challenges, corresponding to each digit of the PIN. A challenge starts with an audio instruction delivered through a headset. For instance, assume that the user's PIN starts with a "2," and the audio instruction is "red." With the starting position of in Figure 2 (a), the user slides (swipes) his/her finger on the two-way arrow located at the bottom of the screen and the number in each cell moves clockwise or counterclockwise to the next cell. When the number "2" is placed in the red cell, user taps the "enter" icon located below the ring and the first digit is validated. The process is repeated,

with audio instructions, until all four digits in the user's PIN have been entered. The starting position and the audio instructions are randomly selected by the system in each challenge. Users may prefer to spin the wheel directly with their finger. However, we do not use such interface because they might inadvertently reveal the PIN numbers based on where they touch the wheel to spin it.

We compare five types of audio instructions shown in Table 1. Figure 2 (a)-(e) shows screen interfaces for each audio instructions. In the "color" type, all cells on the screen are of a different color, and the audio signal indicates the color of the "destination" cell in which the user's PIN digit should be placed. The "animal sound" instructions give the animal icon of the destination cell, such as "dog." The "clock position" instructions give the time on the clock face of the destination cell, such as "one o'clock." The "pitch" instructions and the "length" instructions give the beep sound assigned to the destination cell. In the column of "Pitch" in Table 1, "H" and "L" represent a note of high and low pitch, respectively. In this type, each note has the same length. In the column of "Length", dash (-) and dot (.) represent a note of long and short length, respectively. In this type, each note has the same pitch.

Table 1. List of audio instructions

Color	Animal sound	Clock	Pitch	Length
white	meow (cat)	I	HLLL	….
yellow	cheep-cheep (chick)	II	HHLL	-…
brown	cocka-a-doodle-doo (rooster)	III	HLHL	--..
purple	sing (cicada)	IV	HLLH	-..-
pink	moo (cow)	V	HHHL	-.-.
gray	bowwow (dog)	VII	LHHH	.-.-
orange	baa (sheep)	VIII	LHHL	.--.
blue	caw (rook)	VIIII	LHLH	…-
green	whinny (horse)	X	LLHH	..-.
red	click (dolphin)	XI	LLLH	.-..

3. USER STUDY

The aim of this user study is to compare the usability of the audio instructions. We used the average time for authentication and the average success ratio as metrics for evaluating the usability.

3.1 Apparatus

A prototype of this system was implemented on a PDA. The PDA has a 3.5 inch TFT display and its display resolution is 960 by 640 pixels. A headset is connected to the PDA to convey the audio instructions to the user.

3.2 Procedures

The experiment was conducted in a controlled laboratory environment shown in Figure 3. Twenty five participants were recruited for this experiment (male: 22, female: 3). All participants were university students majoring in engineering. More than half (16) of the participants reported using PDAs or smartphones in daily life and the rest (9) of them reported using mobile phones.

We used a within-subjects design for this test. All participants were asked to use all types of the audio instructions. To eliminate the order effect, the order of the audio type is randomly assigned for each participant. For each audio type, each participant tried the authentication 7 times for practice and 5 times for the actual measurement.

Figure 3. Laboratory environment

3.3 Results

Figure 4 shows the average authentication time. Error bars represent the standard deviation of each data. Table 2 shows the average success ratio of authentication trials. These results show that the mental assembly burdens of "color," "animal sound" and "clock position" are light compared to those of "pitch" and "length." In the post-experiment interview, participants commented that "pitch type and length type are difficult to find out the destination cell."

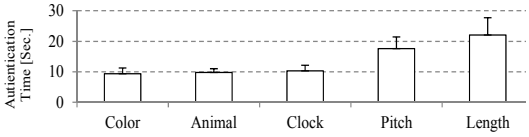


Figure 4. Average authentication time

Table 2. Average success ratio

	Color	Animal	Clock	Pitch	Length
Ratio[%]	94.4	93.6	92.8	83.2	80.0
(S.D.)	(9.0)	(9.3)	(11.1)	(18.5)	(24.0)

4. CONCLUSIONS

We developed a new multisensory authentication prototype for portable touch screen devices and evaluated the usability. The user test revealed that audio instructions using colors, animal sounds, and clock positions are easy to grasp the information compared with beeps. We are planning further user test using the eye mark recorder to analyze user's eye movement during the authentication. Future work includes the evaluation of robustness against the observation attack.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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