Enter your PIN Code Securely! - Utilization of Personal Difference of Angle Kappa

Daiki Sakai
Kwansei Gakuin University

Michiya Yamamoto*
Kwansei Gakuin University

Takashi Nagamatsu
Kobe University

Satoshi Fukumori
Kwansei Gakuin University

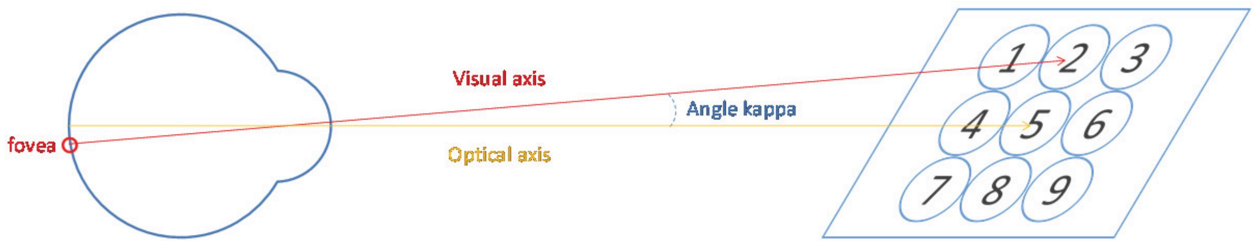

Figure 1: *In the near future, all PIN entries may be learned by using upcoming UHD surveillance cameras for shoulder surfing. We propose a novel method that would, in theory, permit no shoulder surfing by utilizing the personal difference of the angle kappa – the offset between the optical and visual axes of the human eye.*

Abstract

In previous studies, the angle kappa, the offset between the optical axis and visual axis, was considered to be calibrated when eye trackers based on a 3D model were used. However, we found that the angle kappa could be used as personal information, which is immeasurable from outside the human body. This paper proposes a concept for PIN entry by considering the characteristics of the angle kappa. Thus, we measured the distribution of the angle kappa and developed a prototype of the system. We demonstrated the effectiveness of the method.

Keywords: PIN entry, 3D-model based eye trackers, Angle Kappa

Concepts: **• Human-centered computing ~ interaction design;** *Interaction design theory, concepts and paradigms;*

1 Introduction

For many years, shoulder surfing has been a concern of anyone who has had to use a device, such as an ATM, smart phone, or public display, which required them to enter their PIN code. This problem is expected to become much more of a reality as the deployment of UHD surveillance cameras becomes more widespread in the near future. Biometric authentication is one of the technologies being widely used against it. However, there is concern that biometric data can be stolen.

*e-mail:michiya.yamamoto@kwansei.ac.jp

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Many studies are currently focusing on this problem and many approaches have been proposed. Utilizing gaze interaction is one of the dominant approaches. For example, the study by Kumar et al. demonstrates the basic principle of gaze-based PIN input [Kumar et al., 2007]. De Luca et al. extended the idea by integrating a number pad and gestures [De Luca et al., 2007] [De Luca et al., 2009]. Forget et al. introduced a graphical password [Forget et al., 2010], whereas Bulling et al. utilized saliency masks for a graphical password [Bulling et al., 2012]. The progress that has been made as a result of these studies has lowered the possibility of shoulder surfing has been lowered. However, pre-calibrated eye trackers are employed in all of the studies.

In this study, we propose a novel method of PIN entry by focusing on the personal difference of the angle kappa between the optical axis and visual axis of the human eye in using 3D model based eye trackers.

2 Concept

As shown in Fig. 1, there is angle kappa - an offset between the optical axis and visual axis of the eye. The optical axis can be measured by using cameras. The use of eye trackers based on a 3D model requires the angle kappa to be calibrated, because it differs for each person. However, for each individual the angle kappa is consistent at all times, because it depends on the person's cognition as well as the geometrical shape, for example the position of the fovea, of the person's eye.

According to previous studies, the angle kappa was about 5 degrees [Hansen et al., 2010]. The accuracy of typical calibration-free eye tracker was about 5 degrees, which is the same as the angle kappa. Although Miyawaki et al. re-configured visual image by using fMRI, the accuracy they achieved was approximately 3 degrees. On the other hand, the accuracy of eye trackers based on the 3D model is less than 1 degree when calibrated.

This means that the angle kappa can be utilized as a form of personal information, which is theoretically immeasurable from outside the human body.

3 Prototype

Before developing a prototype PIN entry system, we measured the distribution of the angle kappa of five participants by using our original eye tracker [Nagamatsu et al., 2010]. Figure 2 shows the result. Here, we used a XGA display (DTI- 520U, Wacom) positioned at a length of 50 cm from a participant (30 px ≅1°). The distribution was 400 and 300 px in the horizontal and vertical directions, respectively, which was larger than in our previous study [Hansen et al., 2010].

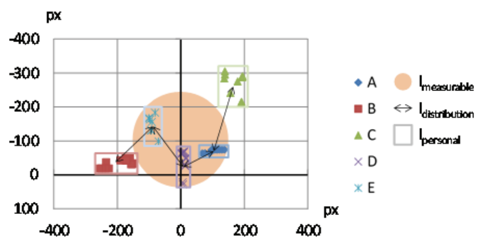

Figure 2: *Distribution of the angle kappa. The use of external cameras, including a typical calibration-free eye tracker, is unable to determine the difference between participants.*

When the value satisfies the following equation (1), it can be utilized as personal information, which is theoretically immeasurable from the outside. Here, $l_{measurable}$ means the length measurable from the outside by using typical system. $l_{distribution}$ means the length which is specific for each person. $l_{personal}$ means length within a person. The angle kappa satisfies the equation (1), and is one of the immeasurable parameters as shown in Figure 2.

$$l_{mesurable} > l_{distribution} > l_{personal} \quad (1)$$

Next, we arranged a number pad on the computer display. We set the length between the keys l_{key} as indicated by the following equation (2). In detail, we set l_{key} equal to 150 px.

$$l_{distribution} > l_{key} > l_{personal} \quad (2)$$

Figure 3 shows a prototype of the keypad and the result. Here, we placed key images on the display. Entering a number required the user to look at one of the keys and push the space key. First, we asked participant D to calibrate the eye tracker to enable us to measure his angle kappa. Then, we asked him to input his PIN as 3759. He tried it 10 times and the false rejection was 0 %. Then, assuming that the pin was shoulder surfed, we asked participant E to input the PIN 3759. Because the angle kappa of participant E was a little smaller than that of participant D, the entered PIN was recognized as 6789. After trying this procedure 10 times, the false acceptance rates were 0 %. This means that the prototype did not allow PIN entry by way of shoulder surfing.

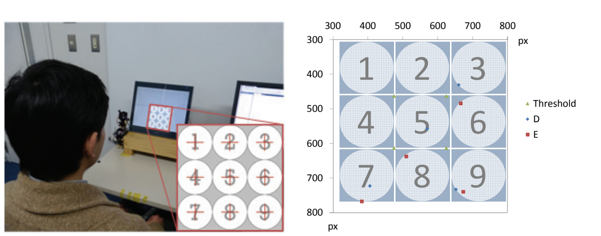

Figure 3: *Keypad enabling the PIN to be entered and examples of results for two participants.*

4 Summary

As a result of this study we are able to propose a novel method, which theoretically does not allow PIN entry by way of shoulder surfing. The method utilizes the personal difference of the angle kappa each individual. We developed a prototype of the system to demonstrate the effectiveness of the method. Combination of the proposed method with conventional security technology such as iris verification as well as PIN entry would enable this technology to be applied in various situations. It is also applicable for secure input of authentication data or personal data on any information devices.

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