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Real-time Eye Tracking for Password Authentication

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Abstract - *Real-time eye and iris tracking is important for hands-off gaze-based password entry, instrument control by paraplegic patients, Internet user studies, as well as homeland security applications. Personal identification numbers are widely used for user authentication and security. Password authentication using PINs requires users to physically input the PIN, which could be vulnerable to password cracking via shoulder surfing or thermal tracking. PIN authentication with hands-off gaze-based PIN entry techniques, on the other hand, leaves no physical footprints behind and therefore offer a more secure password entry option. Gaze-based authentication refers to finding the eye location across sequential image frames, and tracking eye center over time. The purpose of this work is to enter and identify gaze-based PINs using a smart camera through real-time eye detection and tracking. NI Vision Builder and LabVIEW are used for eye tracking and for recording eye center location on board the camera real-time. The smart camera allows on-board data processing and collection. This project presents a real-time application for gaze-based PIN entry, and eye detection and tracking for PIN identification using a smart camera.*

Keywords —: Smart Camera, Personal Identification Number Entry, Eye Detection and Tracking, Gaze-based PIN Identification.

1. INTRODUCTION

The use of personal identification numbers (PINs) is a common user authentication method for many applications, such as money management in automatic teller machines (ATMs), approving electronic transactions, unlocking personal devices, and opening doors. Flawless identity authentication remains a challenge even when PIN authentication is used, such as in financial systems and gate access control. According to European ATM Security, fraud attacks on ATMs increased by 26% in 2016 compared to that of 2015. The fact that an authorized user must enter the code in open or public places make PIN entry vulnerable to password attacks, such as shoulder surfing as well as thermal tracking.

The purpose of this work is to enter and identify gaze-based PINs using a smart camera through real-time eye detection and tracking. The experimental evaluation of the algorithm is also described for eye detection and tracking under different conditions including different angles of the face, head motion, and eye occlusions to determine the usability of the system for real-time applications. NI Vision Builder and LabVIEW are used for eye tracking and for recording eye center location on board the camera real-time. The smart camera allows on-board data processing and collection. Non-contact PIN based authentication adds a layer of security to physical PIN entries and are expected to reduce the vulnerability of the authentication process [1].

2. REAL-TIME EYE DETECTION SYSTEM

2.1. Smart Camera

The main component of the eye tracking system is a NI 1762 smart camera with a Computer 12 mm lens and the Gigabit Ethernet interface as described in previous publications [1], [2]. The system has previously been used for eye detection to capture eye patterns of readers of various reading skill levels [3], where the users were asked to read texts while their eye location was saved on board the smart camera across image frames. In this particular application, the viewer gazes at the digits of a digital key pad (Fig. 1). The camera is located right above the keypad screen with camera lens directly viewing the user's eye. LabVIEW 8.5f.1 and Vision Builder AI 3.6 have been used to implement the eye detection algorithm on the smart camera.

1	2	3
4	5	6
7	8	9

Fig-1. Digital keypad for eye gazing and tracking

The smart camera contains a dual processor which permits the camera to work well with applications such as pattern matching, optical character recognition and data matrix code in real time. The camera is equipped with a 1/3-inch Sony ICX 424 AL solid-state image sensor. The whole setup produces high resolution gray-scale images which are necessary for the implementation of the real-time eye tracking algorithm. When the smart camera is connected through FTP or Ethernet hard drive, the data can then be transferred to other devices. The eye detection algorithm processes about seven frames per second. The camera frame rate specification is not very stringent for this application, since the user pauses over each digit for several seconds. Typical 33 fps or slower cameras could also be used for gaze based password identification. The advantage of the smart camera system is on-board data capture, processing and storage.

2.2. Real-time Eye Tracking Algorithm

The camera is programmed to track the eye motion continuously until stopped by the user. Figure 2 shows the flowchart for the real-time eye tracking algorithm.

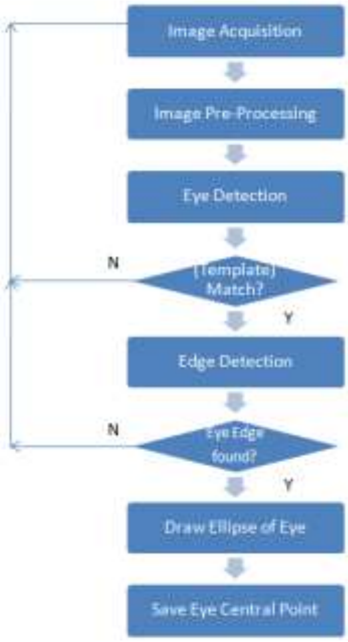

Fig-2. Flowchart of the Real-time Eye Tracking Algorithm

The flowchart of Figure 2 is explained below:-

• Step 1 - Image Acquisition: The raw image acquired automatically by the smart camera.

• Step 2 - Image Pre-processing: The acquired raw image is converted to a gray-scale image, also automatically by the smart camera.

• Step 3 - Eye Detection: Initially the user's eye is detected using template matching, In template matching, a template from the S is compared with the given image using a matching metric. The matching metric provides a measure of similarity between two templates. This similarity is converted into a numerical value as a score of the template match.

• Step 4 - Edge Detection: If the eye is detected, new Region of interest (ROI) which covers only the eye is extracted to reduce the processing area. An edge detection technique is applied to the new ROI to find points around the ellipse or circle of the eye.

• Step 5 - If at least 3 points (for circle) or 4 points (for ellipse) are found, the circle or the ellipse of the eye will be drawn. Otherwise, the current frame is skipped over with no match.

• Step 6 - If the ellipse/circle of the eye is drawn the coordinates of the center of calculated in the camera's processor and saved to spreadsheet for future reference. These coordinates are computed as the center of the rectangle bounding the detected eye.

Fig-3. NI Smart Camera and Eye Tracking System

2.3. Personal Identification Number Entry

Gaze-based PIN entry involves the user entering the PIN code by looking at the PIN pad (Fig. 1). The user stares at each digit of the PIN for a few seconds, and sequentially moves to the next digit with his/her eyes. While the user is viewing the PIN digits on the keypad, the smart camera captures the image of the partial face in sequential frames, computes the eye center location using implemented image processing algorithms, and records the Cartesian coordinates representing the eye center in an on-board spreadsheet file, together with the associated image frame number. The eye tracking application is stopped when PIN entry is completed.

2.4. Eye Detection Algorithm

Eye detection begins with training the algorithm. This is accomplished by capturing a single frame of the user's eye and saving it as the eye template. The process is followed by eye tracking algorithm, which starts with capturing the images of the user's face and detecting the position of the eye. Eye matching is accomplished using the saved template and scanning the real-time image frame for best fit using normalized cross-correlation. The coordinate system conversion is accomplished to standardize the coordinates of the reported eye location, to allow capturing eyes at various angles based on the tilt of the head. From the best matched eye image, iris of the eye is detected using circle or oval matching via edge detection and Hough transforms. The iris center is then mathematically computed as the center of the circle or oval, and recorded in a spreadsheet on board the camera as the eye center. The LabVIEW block diagram for eye detection and tracking is repeated in Fig. 4 for completeness.

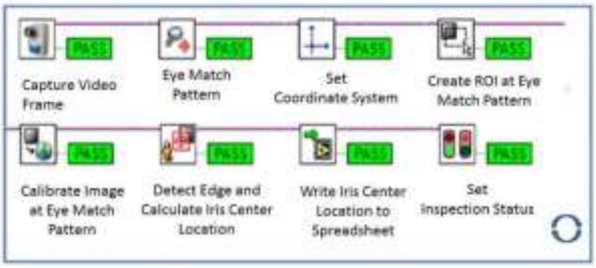

Fig-4. LabVIEW block diagram for eye detection and tracking

2.5. Gaze-based PIN Identification

For PIN identification, the eye center coordinates (horizontal and vertical) in the spreadsheet is first plotted on a 2D spreadsheet. Then the data points are grouped using clustering. This process determines the gazed digits, but not the order in which they were gazed. To determine the order of the entered digits, a 3D connected graph is plotted to demonstrate the order of gazed digits.

3. CONCLUSION

In this paper, we discussed possible way of password authentication by using real-time eye tracking. A smart-camera based eye-tracking system has been incorporated into a new application for gaze-based PIN identification.

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