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An image password system based on gaze detection

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Abstract. In this paper we propose a system which can be used as an image password for different applications such as ATMs which can provide the benefits of a novel password input mode without any contact. In this method there is no need to use infrared sources which could be a bit dangerous for the eyes and also against previous works there is no need to define predetermined shooting range to have a whole-region image. By using face detection algorithms in this method it would be possible to use the images that contain user's face and the backgrounds. The whole face would be extracted from the image and its coordinate will be used for lateral frames. A target face image is displayed by a display device, and then processed by an image processing device, thereby calculating a center coordinate point of the target eye in the facial image, compiling a password constituted by a movement position of the detected eyes. Therefore, the novel password input would be more secure and range free.

Keywords: image password, eye tracking, face detection, gaze detection

1. Introduction

A person's eyes convey a great deal of information with regards to the meaning behind certain facial expressions. Also, the direction in which an individual is looking shows where his or her attention is focused. By tracking the position of the irises, useful interfaces can be developed that allow the user to control and manipulate devices in a more natural manner [1]. With the advent of personal computers, potential integration of such systems has been considered only recently in 1991 [2]. Successful attempts to employ gaze tracking as user interface were made to allow users with movement disabilities to type by looking at virtual keyboard [3], or for mouse pointer control [4]. Systems of this kind also have been used by individuals without any disabilities to enhance performance [5, 6]. In recent years, gaze tracking is widely used in the areas of intelligent control [7], virtual reality, video games, robotics, human computer interaction, eye diseases diagnosis, human behavior studies, etc [8,9].

There are so many researches based on the eye tracking algorithms and their applications such as eye-mouse which uses the eye coordinates to control the computer [10]. These methods mostly use a user-worn device and infrared source that increase the accuracy [11]. There are also some other methods which can calculate the coordinate of the eyes and gaze respected to the screen [12]. Although these methods need a high accuracy, they should also be so fast in order to be able to calculate the gaze coordinate in sequence of frames.

The use of an eye tracker to input alphanumeric passwords was presented in a system called Eye Password (Kumar et al., 2007) and since then so many efforts have been done to reduce the errors and to make it safer and more applicable.[13]

In this paper, a new method for an improved image password lock system by using face detection and tracing position information of the pupil is described. This method will be more beneficial than traditional locks and also would ignore some drawbacks of previous works on image password.

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This system consists of a screen which shows numbers 0 to 4 in different locations, a web cam which is mounted at the top of the screen and a keypad just to validate the password. The schematic design of this system is shown in Fig.1.

Fig. 2 shows the different steps of this method which will be explained in detail in next sections.

Fig. 1: Schematic design of the system.

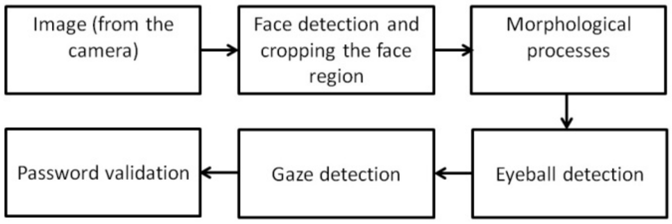


Fig. 2: Block diagram of the image password system based on gaze tracking.

2. Face Detection

In our method we would first detect the face and crop the facial image which will isolate the face region from the background image and makes the eye detection more accurate because in this case instead of processing the whole image we would just focus on the facial image. We use a simple webcam which takes gray scale frames and by using a face detection library [14] we can accurately determine the position of the face. In the face detection processes a new reduced set method for support vector machines (SVMs) is used which creates sparse kernel expansions that can be evaluated via separable filters. The details of this method are described in [14].

After finding the face region we would save the coordinate for lateral frames so by this way there is no need to detect the face region in every frame.

3. Eye Detection

After isolating the face from the background image, it is time to process the facial image to find the eyes in the cropped image. As we are using the grey scale images it is easy to separate the whole eye from the face by using its brightness and performing some morphological processes. In the next step after removing other parts of the face from the image we can use the roundness of the iris to determine the position of the eyes.

As we know the iris is the roundest object in the face so by defining two limits for the roundness we will check the roundness of the remained objects with these limitations and finally find the position and centroid of the eyes.

Fig.2 shows a sample of detected eye. As we can see in this figure there are other detected objects that can be omitted by defining limitations for the roundness of detected object and doing some morphological process the exact location of the eyes is determined. Fig.3 shows the detected eye by red circles.

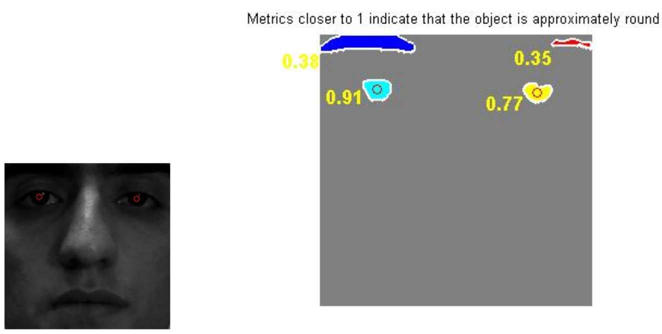


Fig. 3: The detected eyes after morphological processes and using predefined limitations for roundness are shown by red circles.

These limitations can be defined by the users but the optimum values are 0.6 and 1 for the lower and upper limitations. More details can be found in [15].

4. Gaze Detection

The whole calculation afterward is based on the centroid of the detected eyes after morphological processes. In order to calibrate the system it is asked to stare at the centre of the screen at first and after detecting the first pupil the position would be saved as the coordinate origin of the system (x_c,y_c) which is shown in Fig. 4.

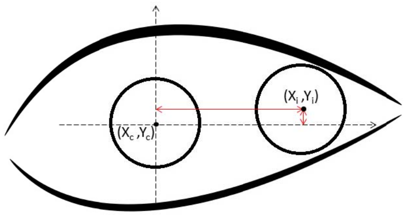


Fig. 4: The calculating process for the coordinate of the gaze point in accordance with central point.

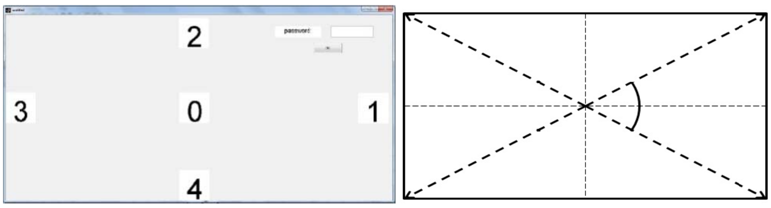
The lateral frames will be analysed and after detecting the pupils in these frames, the relative position of them will be calculated in polar coordinate according to the coordinate origin as follows:

$$r = \sqrt{(x_c - x_i)^2 + (y_c - y_i)^2} \quad (1)$$

$$\theta = \tan^{-1}(\frac{y_c - y_i}{x_c - x_i}) \quad (2)$$

The whole screen is divided into 5 regions which are shown in Fig.5 and digits from 0 to 4 can be selected by the user. In order to enter these digits by the gaze, the beep sound is played just before any image capturing so the user would be informed about capturing and will stare at the next password's digit.

By using equation 1 and 2 and also defining some limitation for each region, the region where the user is starring at can be determined. These limitations are presented in Table 1.



(a) (b)

Fig. 5: User interface of the system (a) and division of the regions (b).

As can be seen the whole 360º is divided into four regions which is used for detecting the numbers except zero that is independent of angle. The collection of these numbers forms the user's password which will be later checked by the user defined database.

Table 1: Division of the whole 360º region and defining the five numbers.

Number	Position	R	
Zero	Center	<10	any
One	Right	>10	
Two	Up	>10	
Three	Left	>10	
four	Down	>10	

5. Experimental results and discussion

In order to test the systems performance it was examined under different lighting conditions and distances. As it was mentioned earlier, face detection is crucial in this method because of omitting the background and the need of facial image for the next steps. There is no need to detect the both eyes in this method since the stair point could be determined only by detecting one. Table 2 demonstrates the accuracy in recognizing different facial properties.

Table 2: Number of correct detections in 100 frames.

Facial detected features	Number of detected item in 100 frames
Face	92
Both eye	73
At least one eye	86

As can be concluded from table 2, the success ratio of eye detection is 86% which is high enough for a system which is almost independent of lighting condition and distance from the screen.

It is important that the user do not move after the first detection for a few seconds. After the movement of the eye along a specific path, the system will make a ‘beep’ sound, which indicates the step is ended. This time duration is depends on the number of password’s digits which can be approximately 10 sec for a four digits password.

Success ratio in detecting the gaze dependent to the central point is different for the each direction. According to the different examinations of this method, it is understood that detecting numbers 0, 1 and 3 is easier than numbers 2 and 4. Table 3 demonstrates the success ratio for detecting different numbers.

Table 3: Success ratios for detecting different numbers.

Detected numbers	Success ratio in 10 attempts
0	10/10
1	9/10
2	7/10
3	10/10
4	8/10

The little difference between the success ratio of numbers 2 and 4 are related to the position of the camera. The best results were gained when the camera where located just in front of the user’s face. In this case there would be better contrast between numbers.

Fig. 6 shows the experimental results of the detected gaze position for the different numbers.

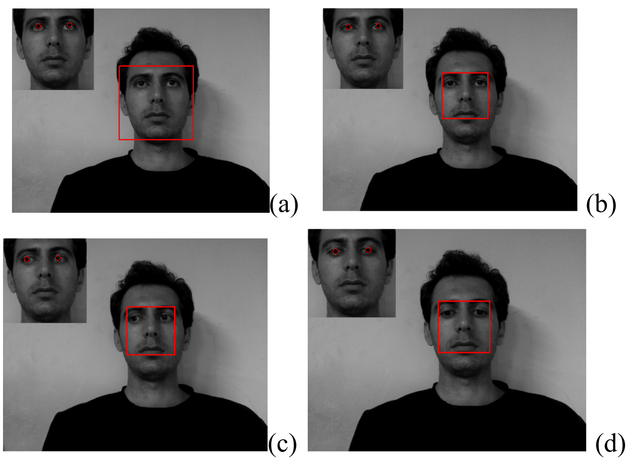


Fig. 6: Experimental results of the detected numbers: ‘zero’ (a), ‘one’ (b), ‘four’ (c) and ‘two’ (d).

6. Conclusions

We present a new image password system which needs no contact and on the other hand it has so many advantages in comparison with other methods of entering password and also other image password systems. Therefore, the advantages and efficacies of the present system can be summarized as follows.

This system such as previous works on image password avoids any contact and instead uses eye movement as password entry. The password may include numbers 0 to 4 and can have any digits number but it is clear that the more passwords digits are, the more time should user spend to enter his password and the failure ratio would also increase at the same time.

In comparison with the other password entering method such as voice based method, again this method seems to be safer because in voice based passwords there is always the possibility of overhearing of the password which is not desirable and make these methods not to be safe enough to be used in modern systems such as ATMs. In comparison with the previous image password systems, this method do not need any predefined distance, infrared source and also images which are completely filled by the eye pictures. This method can separate the face region from the images, search for the eyes in them and then in each step calculate the region where the user is looking at in order to enter the password.

7. References

[1] K. Kreutz. Infrared gaze tracking. *Bachelor of Engineering thesis*. School of Information technology and Electrical Engineering, University of Queensland, 2003.

[2] R. Jacob. The use of eye movements in human-computer interaction techniques: what you look at is what you get. *ACM Transactions on Information Systems.* 1991, **9**(2): 152–169.

[3] P. Majaranta, K. Raiha. Twenty years of eye typing: systems and design issues. *ACM Eye Tracking Research and Applications Symposium*. New Orleans, Louisiana, USA. March 2002, 1: 15–22.

[4] A. J. Hornof, A. Cavender, R. Hoselton. Eyedraw, a system for drawing pictureswith eye Movements. *ACM SIGACCESS Conference on Computers and Accessibility.* Atlanta, Georgia. October 2004, 1: 86–93.

[5] L. Sibert, R. Jacob. Evaluation of eye gaze interaction. *SIGCHI Conference on Human Factors in Computing Systems.* Hague, Netherlands. April 2000, 1: 281–288.

[6] V. Tanriverdi, R. Jacob. Interacting with eye movements in virtual environments. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* Hague, Netherlands. April 2000, 1: 265–272.

[7] Yang X, J. Sun, J. Liu, J. Chu, W. Lie, Y. Gao. A Gaze tracking scheme for eyebased intelligent control. *Proceedings of the 8th world Congress on Intelligent Control and Automation.* Jinan, China. July 2010, 1: 50-55.

[8] J. Sigut, S. A. Sidha. *Iris Center Corneal Reflection Method for Gaze Tracking Using Visible Light. IEEE Transaction on Biomedical Engineering.* 2011, **58**(2): 411-419.

[9] D. Putra, A. Cahyawan, Y. Perdana. Low-Cost Based Eye Tracking and Eye Gaze Estimation. *TELKOMNIKA*. 2011, Vol.**9**, No.2, pp.377-386.

[10] Y. P. Lin, Y. P. Chao, C. C. Lin, J. H. Chen. Webcam Mouse Using Face and Eye Tracking in Various Illumination Environments. *Engineering in Medicine and Biology 27th Annual Conference*. September 1-4, 2005, Shanghai, China.

[11] C.S. LIN, C.H. LIN, Y.L. LAY, M.S. YEH, H. C. CHANG. Image password lock system by tracing position information of the pupil. *Optica Applicata. 2009,* **39** (1), pp. 149–168.

[12] M. Kumar. Gaze enhanced user interface design. *PhD thesis*. Department of computer science, Stanford University, 2007.

[13] P. Dunphy, A. Fitch, P.Olivier. Gaze-contingent passwords at the ATM. *The 4th Conference on Communication by Gaze Interaction - Communication, Environment and Mobility Control by Gaze.* COGAIN, 2008.

[14] W. Kienzle, G. Bakir, M. Franz, B. Scholkopf. Face Detection - Efficient and Rank Deficient. In: *Advances in Neural Information Processing Systems. 2005,* **17**: 673-680,.

[15] M. Tanha, H. Seifoory. Morphological drowsy detection. *IEEE International Conference on Signal & Image Processing Applications* 2011, 16-18 November 2011, Kuala Lumpur, Malaysia (to be published).