An anti-peep passcode keypad based on hybrid image and fuzzy adaptive visual distance adjustment

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Abstract. Because traditional Android mobile phone passcode keypad without anti-peeping function, so we propose a kind of anti-peep code passcode keypad based on hybrid image and fuzzy adaptive visual distance adjustment. First, replace the key bitmaps with hybrid images to solve the problem that password keyboard doesn't have anti-peeping function. Then, the fuzzy logic and adaptive principle are used to solve the user's use problem. Finally, it is found through experiments that the time to refresh 10 hybrid images is between 0.38s and 0.48s, and the blur effect of the image can be automatically adjusted according to the distance. The results show that the anti-peep code keyboard makes up for the problem that the traditional passcode keypad has no anti-peeping function.

1. Introduction

Market research firm Gartner pointed out in the 2017 mobile device system market share survey that Android system market share accounted for 85.9%, IOS system accounted for 14%. While most Android smartphones on the market have replaced traditional hardware buttons with full-touch screens, privacy leaks on mobile screens remain unresolved. Based on the huge smartphone market and mobile phone holding rate in the world, how to solve the privacy leakage caused by using the password keyboard in public places has attracted more and more people's attention.

Probably because most smartphones already have fingerprint recognition and other features, the cryptographic keyboard interface has not improved much. However, the passcode keypad is the basic input tool for the phone, so it is necessary to solve the anti-peeping problem of the passcode keypad. Wei Qin and Jing Yu [1] proposed a peep-proof display that prevents people from peeking from the side view while providing an image display for users looking from the front. However, the cost of hardware is relatively high, which is not conducive to the promotion of hardware. Nolan Jones and J.D. Sherry proposed a system and method involving the use of graphical password verification devices or computer system users [2]. The user sequentially selects the graphic image and generates a password based on the combination of the attributes of the selected image. The generated password is compared to the stored password to verify the identity of the user and grant access to the device. However, the software is essentially a graphic image corresponding to a number, so the effect of the user's anti-peeping effect in public places is not obvious.

In this paper, we present an anti-peep passcode keypad based on hybrid image [3] and fuzzy adaptive visual distance adjustment. First, replace the traditional key bitmap with hybrid images.
Second, using the fuzzy logic principle [4-5], the face detection algorithm [6-8] and the eye positioning detection algorithm [9], the distance from the eye to the screen is divided into fuzzy sets, and then use the fuzzy function to establish a function of the hybrid images values. Third, according to the adaptive principle, the initial parameters of the fuzzy function are dynamically adjusted by using the data parameters input by the user. It was found through experiments that the software refreshed ten hybrid images for about 0.36s to 0.43s. The advantage of the fuzzy adaptive adjustment anti-peeping passcode keypad is that the hybrid images will see different image effects at different distances. At the same time, the digital images are hybrid with nine different digital images, so the method is sufficient for the user to use, and the problem that the passcode keypad does not have the anti-peeping function can be solved. At the same time, the software is low in cost and easy to promote and improve.

This article will introduce the process and results of our project. In Section 2, we discussed the solution to the problem. The experiment will be presented in Section 3, followed by conclusions and future work.

2. Method

In view of the current analysis of cryptographic keyboard defects and the study of the dominant unlocking method, we choose a hybrid image to replace the traditional key bitmap, because the viewer will see different image blur effects when viewing the hybrid images at different distances. The whole process of the model is based on fuzzy logic and hybrid images, and finally combined with the adaptive principle [10] to achieve the use of most people.

2.1. Get the distance from the eyes to the screen

The face and eyes show a certain distance on the photo, the face is close to the camera, and the distance between the eyes and the eyes becomes larger; the face is far away from the camera, and the distance between the eyes and the eyes becomes smaller. Moreover, the distance from the eye to the camera is approximately the same as the distance from the eye to the screen, and the calculation method of the eye-to-screen distance is proposed [11]. Since the maximum viewing angle $\varphi$ of the mobile phone camera is constant, the width $W$ of the photograph taken by the camera is also constant. Therefore, the distance from the eyes to the screen can be further obtained by obtaining the distance $L$ between the eyes and the distance $E$ between the eyes projected on the photograph. The actual eye-to-screen distance can be obtained by the following formula (1).

$$D = \frac{L}{2\tan\left(\frac{\varphi E}{2W}\right)}$$

Li zhuqi et al. proposed that the maximum error of the distance was 2.4 cm when the distance from the eye to the screen was 20 cm to 50 cm. We found through experiments that the maximum error of the distance is 2.9cm when the distance from the eye to the screen is 20cm to 70cm, which verifies the feasibility of the (1) method.

2.2. Hybrid image

Hybrid images see different blur effects at different distances, so it has a certain deceptive on vision. The way of the Android platform implements image blurring are mainly through two algorithms, FastBlur[12] and RenderScript[13]. After the developer weakened the algorithm further, it was found that the image blurring time achieved by the Fastblur algorithm was faster than the RenderScript algorithm. For example, a picture with a pixel of 324*376, the time of Fastblur blurring is 2ms, but the time of Rendscript blurring is 13ms. The Fastblur algorithm mainly uses a one-dimensional Gaussian filtering algorithm to quickly blur the image. The image separation algorithm achieves high frequency and low frequency separation of the image. Then, the image fusion algorithm is used to realize the hybrid of high-frequency images and low-frequency images of different images, which replaces the traditional key bitmap.
2.3. Fuzzy logic
By obscuring the principle of collections, variables can belong to multiple collections at the same time, and each collection part occupies a variable. Blur specific discrete values to obtain a fuzzy set. Then we interpret the set by fuzzy rules of different angles to calculate the fuzzy value to obtain a certain value. This process is called defuzzification [14].

In this application, we enter the distance from the eye to the screen as input data. Because researchers have demonstrated that the human visual system's perception of images is non-uniform and non-linear [15], we use Gaussian functions as membership functions. Here, we set up six membership functions and convert the distance from the eye to the screen into six different memberships. Here, we use a single-valued output membership function, which is essentially a pre-fuzzy output function. Suppose \( u \) is the degree to which the output geometry is true, \( x \) is the exact single value of the output geometry, and the final aggregate and defuzzified [16] output is as follows:

\[
    f(x) = \frac{\sum_{i=1}^{n} u_{i} x_{i}}{\sum_{i=1}^{n} u_{i}}
\]

2.4. Adaptive principle
Since the fuzzy logic is only based on the initial data, the blurring effect of the image is adjusted for different distances. Because everyone has a different understanding of the blurring effect of the image, so this type of adjustment may only apply to individuals or to certain types of people. Therefore, it is necessary for the software to adopt adaptive learning method to further achieve adaptive adjustment for most people.

Because the data that we adjust the initial parameters are directly from the user, so we adjust the learning method to achieve adaptive adjustment of fuzzy logic parameters [17]. First, we will give the initial parameters of the distance and image blur effect according to the principle of fuzzy logic. Then, by obtaining the setting of the user's fuzzy parameters and the distance from the eye to the screen, the model parameters are continuously optimized (the number of optimizations of the fuzzy parameters is determined according to the blurring effect of the user on the key bitmap). Achieve the most appropriate image blur effect that the user thinks is appropriate.

3. Experiments
In this section, we will test whether the software can implement image blending adjustment based on fuzzy logic in the first section. In the second subsection, the test software is able to implement adaptive adjustments to the initial parameters of different people. The experiment included an MI 5 smartphone and a Huawei mate 9 mobile phone using the test application algorithm described above to achieve a series of eye-to-screen distance measurements and image blend values (data from twelve people).

3.1. Hybrid images effect adjustment based on fuzzy logic
As shown in figure 1, The distance from the eye to the screen is different, and the effect of seeing the hybrid images is different. Explain as follows, you can look at a person from a distance, you can distinguish his or her gender, but you can't know if he or she has wrinkles or white hair, etc. When you are close enough to this person, you can have more clear understanding. It is verified that the software can realize the image blurring effect with the distance from the eye to the screen.
3.2. Adjustment between distance and blur effect

We decided to measure the relationship between the distance and the image blend value $\sigma$ over a screen distance of 18 cm to 80 cm, we start from the lower boundary and measure the distance by 1 cm after each step. The reason for the setup is discussed in Section 4. We start from the lower boundary and measure the distance by 1 cm after each step. The test application saves the data results in a table and performs the analysis on the computer while completing a series of measurements. As shown in figure 2, the relationship between the distance from the eyes to the screen and the hybrid images value $\sigma$ are obtained by twelve people.

![Figure 1](image1.png)

**Figure 1.** On the left is the traditional passcode keypad, the middle is the image blending effect obtained by the close-range software, and the right is the image blending effect obtained by the long-distance software.

![Figure 2](image2.png)

**Figure 2.** Through the analysis of data collection (data from twelve people), the relationship between distance and image blend values is plotted.

![Figure 3](image3.png)

**Figure 3.** Time required for different types of mobile phones to refresh once.

Through the data analysis of figure 2, the adaptive anti-peep code cipher keyboard can adaptively adjust the fuzzy logic parameters according to the user's usage habits and the user settings of the fuzzy
parameters. According to the data of figure 3, different types of mobile phones can also achieve the software to respond in less time.

4. Results
In our experiments, it was found that a single image refresh took approximately 33ms to 44ms. At the same time, the blurring effect of 10 images was changed, only the first time was about 0.5s, and the MI5 response time was about 0.38s to 0.44s. Since the mobile phone may be affected by other factors, such as hardware and Android version, the hybrid images refresh threshold are currently set to 0.65 seconds.

Our current adjustment distance is mainly between 18 cm and 80 cm. First, the distance from the eye to the screen is substantially above 18 cm, and the face detection has a minimum threshold. Secondly, 80 cm can be applied to the longest distance that most people stretch their arms. In figure 2, the feasibility of adaptively adjusting the image effect is verified. In experiments and studies, it was also found that in the case of crowding, the distance from the eyes to the screen was mainly between 25 cm and 49 cm.

5. Conclusion
In this paper, we propose an anti-peep passcode keypad based on hybird image and fuzzy adaptive visual distance adjustment. Fuzzy adaptive adjustment of the blended image is achieved by obtaining the distance from the eye to the screen. We also provide experimental proof that the software can be used in the range of 18 cm to 80 cm. Considering the other factors of different types of mobile phones, the refresh time of the current setting software is about 0.62 seconds. The utility model solves the defects that the traditional passcode keypad does not have the anti-peeping function, the application cost is low, the promotion is easy, and the user who needs to protect the privacy information has great attraction. But the project has some drawbacks. For example, a user may not be able to adjust the program adaptively with one or two adjustments. When the camera using the software is always on, the screen acquired by the camera will be used as the background for the password input, which may make the user feel uncomfortable. These are all areas for improvement.

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