Mobile APP fingerprint feature extraction pattern recognition based on Random Game

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Abstract: The traditional feature extraction method for pattern recognition increases the computational complexity of the recognition method due to the excessive feature extraction, which leads to the low accuracy of the recognition method. To solve the above problems, a fingerprint feature extraction pattern recognition method based on random game is proposed for mobile APP. After the fingerprint image processing, the fingerprint features in the image are extracted. After removing the pseudo-feature points from the extracted image features, the pattern recognition of fingerprint features is completed by using the stochastic game theory. Through the simulation experiment, it is verified that the recognition accuracy of the proposed method increases by about 1/5, and has better recognition stability.

1. Introduction

The wide application of mobile devices has promoted the development of express delivery of mobile apps. However, along with the development and use of mobile apps, the hidden problems of information security have gradually become prominent. The identity authentication technology of mobile APP is an important way to ensure the security of APP usage. With the development of relevant technologies, the identity authentication technology of mobile apps has been transformed from the form of password and password authentication to the form of biological information such as fingerprint and face [1]. Fingerprint and other biological information has a high degree of information uniqueness, and has the advantages of simple collection operation and short time to use, making the application of fingerprint recognition more and more. For mobile apps, good fingerprint recognition efficiency affects users' sense of experience to a certain extent, while the performance of fingerprint feature extraction pattern recognition method is crucial. Traditional fingerprint feature extraction pattern recognition methods have too many fingerprint feature categories extracted, resulting in low resolution between extracted features and increased computational complexity of feature matching in the recognition process, resulting in poor actual recognition accuracy and low efficiency of traditional methods with strong limitations [2].

Stochastic game is a dynamic game process that involves the transition of the probability of conflict state when one or more players choose rational decisions. A random game is composed of multiple game stages. During the game, participants choose the appropriate game state according to their own needs, and then move to the next stage according to the probability distribution to complete the next game again [3]. Stochastic games can maximize the benefits of players under the state of mutual influence and reach the benefit equilibrium of multiple players. Based on the above analysis,
this paper will study the fingerprint feature extraction pattern recognition method of mobile APP based on random game.

2. Mobile APP fingerprint feature extraction pattern recognition based on Random Game

2.1. Fingerprint image segmentation

The fingerprint image collected by mobile APP can be divided into three parts: good area, recoverable area and unrecoverable area. Therefore, image enhancement processing is needed to improve the clarity of image information in recoverable area and delete the information affecting feature extraction in unrecoverable area [4].

Adaptive threshold segmentation is carried out according to the feature of large difference between the gray mean of image foreground and background. The image was divided into \( mn \times w \times w \) fingerprint image blocks with a size of \( w \times w \), and the mean gray value of each fingerprint image block was calculated as \( M_{(m,n)} \) and the variance of the mean gray value between each pixel in the image was calculated as \( V_{(m,n)} \) [5-6]. The calculation formula of pixel gray mean value and variance of gray mean value of each fingerprint image block is shown in formula (1).

\[
\begin{align*}
M_{(m,n)} &= \frac{1}{w \times w} \sum_{i=1}^{w} \sum_{j=1}^{w} I(i,j) \\
V_{(m,n)} &= \frac{1}{w \times w} \sum_{i=1}^{w} \sum_{j=1}^{w} \left( I(i,j) - M_{(m,n)} \right)^2
\end{align*}
\]

In formula (1), \((m,n)\) is the coordinate of the image block after fingerprint image segmentation; \(I(i,j)\) is the gray value of the pixel point \((i,j)\) of the fingerprint image. According to formula (1), the mean variance of each fingerprint block of the fingerprint image is \( V \) and the mean value of the gray mean is \( M \). The number of all image blocks larger than the mean value of the gray mean is \( M \) and all image blocks smaller than the mean value of the gray mean is \( V \) is taken as the adaptive segmentation threshold [7]. The image blocks whose gray value is less than the adaptive segmentation threshold are labeled as background blocks and fuzzy blocks. At the same time, the foreground image block is judged as the background by neighborhood judgment. When the sum of the background blocks around the image block is greater than 4, the background block is judged as the background block. If the sum of the number of background blocks around the image block is less than 4, it is judged as the foreground block. The pixel of each pixel in the background block and the fuzzy block is set to 0 to complete the segmentation of fingerprint image by threshold value. After fingerprint image processing, fingerprint features are extracted.

2.2. Fingerprint feature extraction

Fingerprint image contains fingerprint type and texture feature, among which fingerprint type belongs to global feature and texture feature belongs to local feature [8]. The gray value of the black pixel in the fingerprint image, namely the ridge line of the fingerprint image, is denoted as 1, and the gray value of the valley line and the background of the white pixel in the fingerprint image is denoted as 0. If the number of crossing points between ridge lines and valley lines at \( P \) central point of the test template is \( C_N(P) \), and the number of adjacent intersection points with the central point is \( S_N(P) \), the specific calculation is shown in formula (2).

\[
\begin{align*}
C_N(P) &= \frac{1}{2} \sum_{i=0}^{7} |P_{i+1} - P_i|, P_8 = P_7 \\
S_N(P) &= \sum_{i=0}^{7} P_i
\end{align*}
\]
In formula (2), \( P_i, i = 0, 1, 2, \ldots, 7 \) is the gray value of each detection point in the feature point detection template. If \( C_N(P) = 1 \) and \( S_N(P) = 1 \), the center pixel of the template is the endpoint of the template; When \( C_N(P) = 2 \) and the value of \( S_N(P) \) is 2, 3 or 4, the central pixel of the template is the continuous point in the fingerprint ridge, which contains more fingerprint feature points. When the values of \( C_N(P) \) and \( S_N(P) \) are 3, the central pixel of the template is the bifurcation point of fingerprint ridge.

2.3. Using random game to realize pattern recognition

Usually, the pseudo feature points are located at the end points of the fingerprint valley line and ridge line, and any endpoint is selected to traverse and search along its reverse direction, and the end points of the valley line and ridge line are found by taking 8 pixels as the distance threshold value of the traversal search\(^9\). Residual pseudo feature points are deleted according to the Euclidean distance and direction difference between the feature points. The calculation of Euclidean distance and reverse difference between two feature points is shown in formula (3).

\[
\begin{align*}
D(P_i, P_j) &= \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \\
\theta(P_i, P_j) &= \min \left(\left|\theta_{P_i} - \theta_{P_j}\right|, 2\pi - \left|\theta_{P_i} - \theta_{P_j}\right|\right)
\end{align*}
\] (3)

In formula (3), \((x_i, y_i)\) is the coordinate position of pixel point \( P_i \) in the fingerprint image; \((x_j, y_j)\) is the coordinate position of pixel point \( P_j \) in the fingerprint image; \( \theta_{P_i} \) and \( \theta_{P_j} \) are the corresponding directions of the two feature points respectively; \( D(P_i, P_j) \) is the Euclidean distance between the two feature points; \( \theta(P_i, P_j) \) is the direction difference between the two characteristic points.

According to the random game theory, if the random game form between the feature point set to be matched and the feature template to be matched is \( SG = \{S, A^k, Q, R^k, \sigma\} \), wherein \( S \) is the game state space set between the feature point set to be matched and the feature template to be matched, \( A^k \) is the behavior space of feature points to be matched at the time of matching, \( Q \) is the game state transition probability function between the two; \( R^k \) is the number of feature points to be matched successfully when matching; \( \sigma \) is the discount factor in the stochastic game process.

3. Experimental verification and analysis

3.1. Preparation and process of experiment

This experiment is a simulation experiment, and the verification group and control group methods are run on two experimental platforms with exactly the same configuration. The data set used in the experiment consists of 3,000 clear and complete fingerprint images, 1,000 incomplete fingerprint images of less than 30% and 500 complete but fuzzy fingerprint images, all of which have corresponding identity information. The experimental data sets were input into two computer simulation platforms, and the verification group and control group were used to extract and recognize the fingerprint features of the experimental images. The experimental data corresponding to each comparison item was recorded, and the data processing software configured in the simulation platform was used to process the recorded experimental data.
3.2. Experimental data and analysis

The comparison results of iteration times during fingerprint feature extraction using the two methods are shown in the figure below, and the relationship between curves in figure 1 is analyzed.

![Figure 1 Comparison of iterations of fingerprint extraction](image)

Analysis of the figure 1 shows that when the number of experimental samples is 2000, the control method needs more iterations to achieve the minimum recognition error, and the iterative curve fluctuation of the control method is more drastic than that of the verification group. When the number of experimental samples is 3500, the change rule of the iterative curve of the two groups is similar to that of the sample number is 2000. With the increase of the number of experimental samples, the validation group method still needs fewer iterations to achieve a small recognition error. The above contents indicate that the verification group method has fewer iterations and better extraction effect in fingerprint features.

According to the extracted fingerprint features, the verification group and control group were applied for fingerprint pattern recognition. The recognition accuracy and efficiency of the two methods are shown in the table 1.

| Serial number | Validation group | Control group |
|---------------|------------------|---------------|
|               | Accuracy rate (%)| Sensitivity (%)| Identification time /ms | Accuracy rate (%)| Sensitivity (%)| Identification time /ms |
| 1             | 92.7             | 93.2          | 18.8                    | 77.4             | 73.6          | 49.9                    |
| 2             | 94.2             | 89.4          | 20.9                    | 79.6             | 69.5          | 58.7                    |
| 3             | 95.3             | 93.6          | 18.2                    | 78.9             | 72.3          | 61.4                    |
| 4             | 94.7             | 93.5          | 18.2                    | 77.2             | 71.7          | 55.3                    |
| 5             | 93.1             | 88.9          | 18.2                    | 80.1             | 69.8          | 47.9                    |
| 6             | 92.5             | 91.6          | 21.0                    | 76.2             | 73.4          | 55.5                    |
| 7             | 91.6             | 90.8          | 20.8                    | 80.4             | 71.8          | 59.6                    |
| 8             | 92.4             | 91.5          | 19.6                    | 75.5             | 72.6          | 53.4                    |
| 9             | 94.3             | 91.1          | 19.7                    | 78.9             | 70.2          | 52.7                    |
| 10            | 91.8             | 93.0          | 21.1                    | 77.7             | 72.1          | 60.8                    |
| 11            | 95.2             | 89.7          | 20.1                    | 80.8             | 71.7          | 61.2                    |
| 12            | 91.0             | 89.5          | 21.2                    | 78.6             | 73.4          | 58.6                    |

By analyzing the data in table 1, it can be seen that the overall accuracy rate of the verification group method in fingerprint identification is higher than that of the control group method. Moreover, while the verification group method has a high accuracy rate, the overall time required for identification is shorter than 21.2ms, far less than the minimum identification time of the control group method which is 47.9ms. The difference of the minimum recognition time between the validation group method and the control group method was 26.7ms. The average recognition accuracy of the
validation group method was 93.2%, while that of the control group method was 78.45%, which was about 1/5 higher than that of the control group method. The sensitivity of the recognition method in the verification group was higher than that in the control group. The higher the sensitivity of the recognition method, the better the stability of the recognition method. According to the analysis of figure 1, the validation group method can obtain the minimum recognition error with the minimum number of iterations.

4. Conclusion
With the widespread and rapid popularization of mobile devices, the sense of use of mobile apps has become a decisive indicator for users to choose to download and update their APPs. Fingerprint features are widely used in mobile APPs as one of the main ways to protect user information, and the adaption between fingerprint feature extraction mode and software and user devices also affects users' sense of use to a certain extent. In this paper, the fingerprint feature extraction pattern recognition method of mobile APP based on random game is studied, and the experiment verifies that this method has higher accuracy than the traditional method, and the practical application effect is better.

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