

# A Study of Identical Twins' Palmprints for Personal Authentication

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**Abstract.** *Biometric recognition based on human characteristics for personal identification has attracted great attention. The performance of biometric systems highly depends on the distinctive information in the biometrics. However, identical twins having the closest genetics-based relationship are expected to have maximum similarity between their biometrics. Classifying identical twins is a challenging problem for some automatic biometric systems. In this paper, we summarize the exiting experimental results about identical twins' biometrics including face, iris, fingerprint and voice verification. Then, we systemically examine identical twins' palmprints. The experimental results show that we can employ low-resolution palmprint images to distinguish identical twins.*

## 1 Introduction

Biometric systems measuring our biological and behavioral features for personal authentication have inherent advantages over traditional knowledge-based approach such as password and over token-based approach such as physical key. Over thirty years' development, various biometric systems such as face, iris, retina, fingerprint and signature, have been proposed, implemented and deployed [1]. Biometric systems verifying different people are based on the distinctive information in the biometrics. Nevertheless, not all biometrics have sufficient information to classify identical twins, who have the same genetic expression.

There are two types of twins, monozygotic and dizygotic twins. Dizygotic twins result from two different fertilized eggs so they have different Deoxyribo Nucleic Acid (DNA). Monozygotic twins, also called identical twins are the result of a single fertilized egg splitting into two individual cells and developing into two individuals. Thus,

identical twins have the same DNA. The frequency of identical twins is about 0.4% across different populations [2]. Some people believe that this is the accuracy limit of face recognition systems [18].

### 1.1 From DNA to biometrics

DNA contains all the genetic information required to generate an organ of a species. The mapping from the genetic information to actual expression of an organ is very complex. First of all, the genetic information is copied from DNA molecule into RNA (Ribo Nucleic Acid) molecule. Next, the information in RNA is used to generate amino acids and the amino acids are converted into functioning proteins. The functioning proteins are assembled to be an organ. In this process, genetic information is not the only one factor affecting the organ. It can be influenced by various other factors. As a result, identical twins who share the same genetic expression have many different biometrics including fingerprint, iris and retina [3, 15, 17]. In fact, some biometrics such as faces continually change after we are born. The changes depend on environmental conditions such as living style, diet and climate. They make identical twins more different when they age. Fig. 1 shows two pairs of identical twins at different ages. The older twins in Fig. 1(b) are easier to be distinguished.

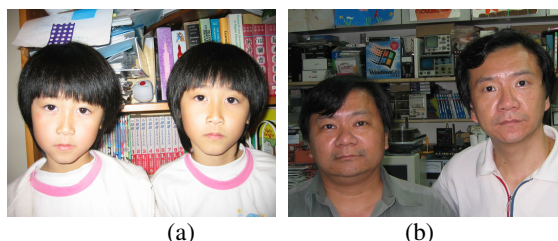


Fig. 1. Two pairs of identical twins at different ages

### 1.2 Motivations

Identifying identical twins is crucial for all biometric systems. The systems that cannot handle identical twins have a serious security hole. According to our best knowledge, so far no paper summarizes the testing results of identical twins. In addition, no one investigates the similarity between low-resolution identical twins' palmprints.

The rest of this paper is organized as follows. Section 2 summarizes the testing reports from different sources. Section 3 gives the experimental results of identical twins' palmprints. Section 4 discusses the experimental results and the summary. Finally, Section 5 offers some concluding remarks.

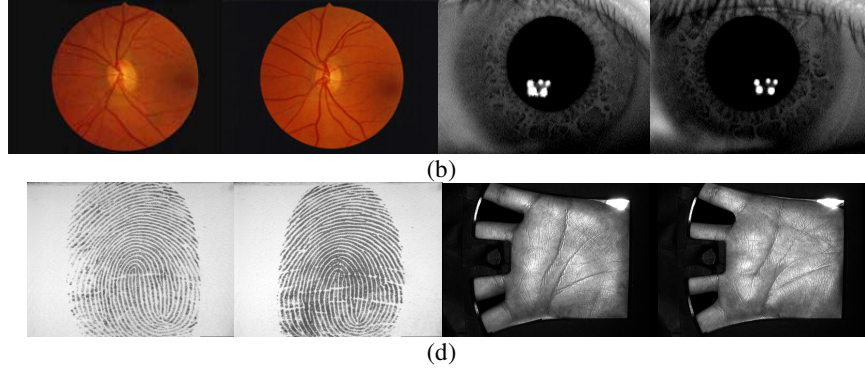
## 2. Summary of the existing reports

In this paper, we only discuss the biological biometrics including retina, iris, face, voice and fingerprint that are directly affected by genetic factors. Fig. 2 illustrates identical twins' retinas, irises, fingerprints and palmprints. These images are collected from different pairs of twins. The iris and palmprint images are collected using our self-designed devices [20] and the retina images are obtained from [6] with permission to reprint. The fingerprint images are collected using a standard optical fingerprint scanner. Fig. 2 shows that the retinas, irises and palmprints can easily be distinguished by human vision. For the fingerprints, we have to pay more attention at the minutiae points, commonly utilized in fingerprint systems. Based on the positions and directions of the minutiae points, the twins' fingerprints can be distinguished without any problem.

In many cases, biometrics are proposed by medical doctors or ophthalmologists [15-16] but almost all the biometric identification systems are designed by engineers. The features discovered by doctors or ophthalmologists and the features applied to authentication systems may not be the same. The iris is a typical example [6, 17]. Ophthalmologists distinguish irises based on the structural features including moles, freckles, nevi and crypts while current iris recognition systems use binary sequences to represent the textural features. Therefore, the experimental results or observation given by doctors or ophthalmologists about identical twins may not be applicable to automatic biometric systems. In other words, it is essential to test automatic biometric systems on identical twins. Table 1 summarizes the testing results including, iris, face, palmprint and voice. We also give the sizes of testing databases and age ranges of the testing samples in Table 1. The database size refers to the number of different biometrics, not the number of twin pairs. The testing results are represented by the symbols "+" and "-". The symbol "+" denotes that the tested method can distinguish identical twins, just as it can distinguish non-twins. The symbol "-" denotes that the tested method cannot correctly distinguish them.

All the results in Table 1 are positive, except voice recognition. Some of the results are not significant since their testing databases are too small. Based on [7, 9] and experimental results in Section 3, we ensure that iris, palmprint and fingerprint can be used to separate identical twins. However, testing on large databases is required to verify the results of 3D face, 2D face and fusion of lip motion and voice [10-11, 13, 14]. It is generally believed that faces cannot be used for separating identical twins. Experts in National Institute of Standards and Technology (USA) said "although identical twins might have slight facial differences, we cannot expect a face biometric system to recognize those differences." [18]. Interestingly, the results in Table 1 contradict our general beliefs.

In addition to fingerprint, palmprint and iris, retina and thermogram are considered as distinctive features for identical twins [9]. So far, we have not obtained any testing report about them.



**Fig. 2.** Different features from identical twins', (a) retinas, (b) irises, (c) fingerprints and (d) palmprints

**Table 1.** Summary of the existing twin tests

Biometric	Results	Age Ranges	Database Size	Reference
Iris	+	*	648 <sup>#</sup>	[7]
3D face	+	*	Several	[10-11]
2D face	+	*	20	[13]
Fingerprint	+	*	188	[9]
Palmprint	+	6-45	106	Section 3
Voice	-	*	32	[12]
Lip motion and speech	+	18-26	4	[14]

\* The age ranges are not available.

<sup>#</sup>In this test, 648 right/left iris pairs from 324 persons are tested since our left and right irises are generated from the same DNA.

### 3. Study of twins' palmprints

According to our best knowledge, no one studies identical twins' palmprints for automatic personal authentication. In this experiment, we utilize the orientation fields of palmprints as feature vectors to represent low-resolution palmprint images and use angular distance to compare the feature vectors. Readers can refer to [8] for the computational detail of this method. Shorter angular distance represents more similarity between two palmprint images. This method is a modification of our previous work [20]. To compare with the palmprints from general persons and identical twins, we prepare two databases for this study. The details of the databases are given in the following sub-sections.

### 3.1. Twin and general palmprint databases

The twin database contains 1028 images collected from 53 pairs of identical twins' palms. We collect the images from their left and right palms. Around 10 images are collected from each palm. All the images are collected by our self-designed palmprint capture device [20]. The image size is 384×284.

To produce a reliable genuine distribution, we prepare a palmprint database containing 7,752 images from the right and left palms of 193 individuals. This database is called general palmprint database. The images in this database are collected on two separate occasions, two months apart. On each occasion, the subject was asked to provide about 10 images, each of the left palm and the right palm. The average interval between the first and second collections was 69 days. More information about this database can be referred to [20].

### 3.2. Experimental results

To study the similarity of identical twins' palmprints and to obtain twin imposter distribution, we match a palmprint in the twin database with his/her identical twin sibling's palmprints (twin match). We also match every palmprint in the general database with other palmprints in the general database to obtain genuine and imposter (general match) distributions of normal persons. In addition, we match different person's left palmprints and match different person's right palmprints to obtain a side imposter distribution (side match). Total number of genuine matchings, general imposter matchings, side imposter matchings and twin imposter matchings are 74,068, 29,968,808, 14,945,448 and 4,900, respectively. The genuine distribution and imposter distributions of general match, twin match and side match are given in Fig. 3(a). The genuine distribution along with the three imposter distributions in Fig. 3(a) is used to generate the Receiver Operating Characteristics (ROC) curves given in Fig. 3(b). Fig. 3(b) shows that we can use low-resolution palmprint images to distinguish identical twins but identical twins' palms have some inherent correlation, which is not due to side matching.

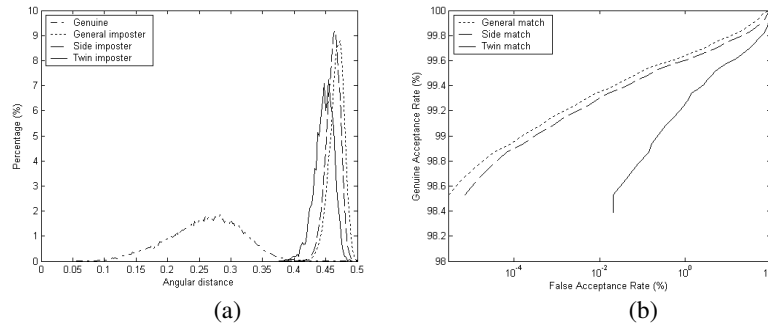
## 4. Discussion

According to the summary and the experimental results in Section 3, we have confidence to say that, iris, fingerprint and palmprint are three effective biometrics to distinguish identical twins. The subjective comparisons of these three biometrics are given in Table 2. The comments of fingerprint and iris are obtained from [1]. We also agree the comments about palmprint in [1], except collectability. The palmprints discussed in this paper are collected by a CCD camera-based palmprint scanner. Thus, the collectability of palmprint should be similar to that of hand geometry (High). According to Table 2, none of them is perfect. Each of them has strengths and weaknesses. Our low-resolution palmprint recognition method has combined the advantages of hand geometry and fingerprints, with high collectability and high perform-

ance. In addition, low-resolution palmprints do not have the problem of latent prints, which can be used to make artificial fingerprints to fool current commercial fingerprint systems [4].

## 5. Conclusion

In this paper, we have summarized the testing reports about examining biometric systems on identical twins. Although identical twins have the same DNA, their biometric traits including iris palmprints and fingerprint are different. Currently, biometric systems can effectively classify identical twins' irises and fingerprints. The existing reports about face recognition for identical twins give some encouraging results. They show that face is possible to be a foolproof way to tell the differences between identical twins. However, they should test their methods on larger twin databases. Since their testing databases are too small, their results may not be reliable. In addition to the summary, the experimental results show that identical twins' palmprints are distinguishable but they have some inherent correlation.



**Figure 3.** Verification results. (a) Twin imposter, side imposter, general imposter and genuine distributions and (b) ROC curves for corresponding distributions

**Table 2.** Comparison of palmprint, fingerprint and iris

	Palmprint [8, 20]	Fingerprint [1]	Iris [1]
Universality	Middle	Middle	High
Distinctiveness	High	High	High
Permanence	High	High	High
Collectability	High*	Middle	Middle
Performance	High	High	High
Acceptability	Middle	Middle	Low
Circumvention	Middle	Middle	Low

\*The authors' comments are different from [1].

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