Overview of Living Iris Detection Based on Multi-spectral Characteristics

Xin Wang¹, Jiangyong Duan¹ and Zhen Yan¹

¹Key Laboratory of Space Utilization, Technology and Engineering Center for Space Utilization, Chinese Academy of Sciences, China
²University of Chinese Academy of Sciences, China

Abstract. Biometrics refers to the technique of identifying people based on their physical characteristics. Among these many technologies of biometrics, iris recognition is currently the frontier research field and one of the most promising technologies. This paper focuses on the application of information technology in biometrics and outlines how to use the multi-spectral characteristics of living human eyes to identify forged irises, and improve the effectiveness and safety of identifications. Finally, the paper introduces the problem to be solved of iris recognition and its prospects.

1. Introduction

Identity identification is a common problem in our life, such as using ID cards, credit cards, passwords, telephone number to prove identity. Especially, we need more secure, efficient and fast authentication technology nowadays. However, cards and passwords are easily stolen and forged, and they are not safe enough, so biometrics have emerged [1].

Biometric recognition is based on the inherent physiological and behavioral characteristics of the human body to identify, including the inherent features of iris, face, fingerprint, palm print, arm blood vessels and other acquired behavior characteristics, such as gait, voiceprint. Compared with the traditional personal identification method, these technologies are self-characteristic and do not rely on artificial and additional items to prove themselves [2], so they have high security, reliability and stability.

Among these recognition technologies, iris recognition is the most important biometric technology with the lowest error rate. Its advantages are mainly as follows [3,4]: (1) High degree of uniqueness and stability. The iris has random texture images and features, its general structure is genetically determined, and the detailed features formed depend on the initial environment of the embryonic mother, so it is not replicated by natural processes, and has a fairly high stability once developed. Further, it is basically unchanged in our life. (2) Security. The iris is not easily stolen compared to features such as fingerprint and face. (3) Non-touching. It can be captured by a long distance camera when capturing iris image, but the technologies, such as fingerprint recognition and palm print recognition, directly contact the human body, so the iris is more and more accepted by people.

Comparison of iris recognition with other typical biometrics is shown in Table 1. As can be seen from the table, the iris recognition technology has obvious advantages, and is more reliable and convenient, so it has been more and more widely applied and researched.
2. Development and application of iris recognition technology

Iris recognition technology for identification can be traced back to the 1880s, when the technology can only be distinguished by the colour and shape of the iris. By 1936, ophthalmologist Burch pointed out that the iris has unique information that can be used for identification. Later, with the development of technology, more than 30 kinds of iris recognition algorithms were gradually derived. Among them, the method of using multi-stage Gabor filter to realize the iris phase texture phase structure information coding and the boundary detection algorithm proposed by Dr. Daugman of the United Kingdom are more typical. The algorithm uses edge detection and Hough transform to locate the segmented iris image, and then uses the multi-dimensional Gabor filter iris feature extraction method to encode the phase information of the filtered result [5,6]. Many of the later recognition methods are similar to this idea.

The research on iris recognition in China is mainly lead by the National Laboratory of Pattern Recognition of Institute of Automation of Chinese Academy of Sciences. The iris image acquisition device used in the establishment and sharing of the iris database for scientific research is established and shared by the CASIA iris database. Meanwhile, it is the largest shared iris database in the world.

The application of iris recognition is very extensive. The more common application in the early days was the “Iris Pass” of the airport, which was used for live detection and identification of terrorists. The most commonly used in our daily life are access control and attendance, which is the largest and most common application direction. Further, it is also used in various fields such as e-passport and ID card, medical insurance, pension insurance, public security tracking criminal investigation and so on [7]. With the development of technology and the needs of applications, iris recognition will have a broader development space.

3. Overview of Multispectral Image Recognition for Forged Iris

The principle of the iris recognition is basically similar to others. It is mainly composed of four parts: firstly, the iris image is acquired by some special optical imaging systems, and then the image is pre-processed. At this stage, the iris is positioned, denoised, enhancement and other processing, and it is also the basis for subsequent feature extraction and matching [8]. Then extract the features of the iris, and finally classify the extracted feature vectors using the classifier to match and identify. After obtaining the iris image and before feature extraction, there is a very critical step, the in vivo detection of the iris. In the early years, it was easy to identify the forged irises such as artificial eyes, printed iris images, and colored contact lenses when using the iris for recognition because the development of technology was not perfect [9,10]. In order to further improve the correctness and safety of the identification, it is necessary to perform a living body test.

Dr. Daugman of the United Kingdom proposed to determine the authenticity by detecting the expansion and contraction of the pupil of the human eyes, the reflection of the cornea, and later proposed to use the near-infrared 750nm and 850nm images to extract the feature classification and identification [11]. However, the common drawback of these methods is that they do not change the

| Biologic-al characte-ristics | Universality | Stabi-lity | Colle-ctability | safety | Acce-ptabl-ity | Uniq-uenes-s |
|-----------------------------|-------------|-----------|----------------|--------|--------------|-------------|
| Iris                        | high        | high      | medium-m      | high   | high         | high        |
| Face                        | high        | medium    | high          | medium | high         | low         |
| Fingerprin-nt               | high        | high      | high          | high   | high         | high        |
| Gait                        | medium      | low       | medium        | low    | medium       | low         |
| Voice                       | medium      | low       | high          | low    | high         | low         |

Table 1. Comparison of several typical biometrics.
influence of ambient illumination on the iris reflection characteristics, so the detection ability is flawed. In view of this concern, the paper briefly review the method of identifying forged iris by multi-spectral image from the perspective of conjunctival vascular feature extraction and texture entropy ratio calculation according to the special spectral characteristics of living human eyes.

3.1. Feature extraction using conjunctival vessels
The conjunctival vascular feature extraction method mainly uses the difference in the absorption rate and reflectance of the conjunctiva in the human eyes [12]. This method mainly consists of the following aspects. Firstly, the detection area is determined. The image is preprocessed using a filter, including denoising, binarization and image enhancement when the area is located. After the preprocessing is completed, the feature points are extracted.

The reason why the conjunctival blood vessels can be used for feature extraction is mainly based on the following reasons: the conjunctiva of the human eyes contains many capillaries, and the hemoglobin in the blood vessels has the highest absorption rate of light in the green and blue bands, and is close to infrared light has a large reflectivity. When the wavelength of the light source changes from 480 nm to 860 nm, the conjunctival blood vessels of the living human eyes become invisible, and this change does not occur in the case of artificial eyes or printed images [13]. Therefore, for the detection of counterfeit iris, the multi-spectral characteristics of the human eyes are mainly utilized.

Before using this feature, the first thing to determine is the effective area of the conjunctival blood vessel, which can be regarded as an approximate circle. The Canny operator is used for edge detection to obtain a binary boundary map, and then the Hough transform is used to determine the parameters of the circle and denoise processing. When detecting, it is necessary to select a region rich in conjunctival blood vessels for blood vessel detection, and generally two regions of 64×64 on the left and right sides of the outer edge of the iris are selected. After determining the detection area, it is necessary to preprocess the image, such as denoising, binarization, image enhancement processing, etc. for the interference parts such as eyelids and eyelashes in order to ensure the quality of the image to be processed. The method adopted here is commonly used the 3×3 median filter and the 2-D multiscale filter [14]. The filtering process is equivalent to using a decision function to determine whether each pixel belongs to a blood vessel or to a background noise. After the pre-processing, all the feature points can be extracted from the image point-by-point operation, stored in the matrix, and finally the defined feature expression is obtained.

3.2. Texture entropy ratio calculation
The iris of the living human eyes has many rich details. The above describes the feature extraction using the conjunctival blood vessels. The following mainly introduces how to extract the texture using the iris.

The study found that the iris texture of the living human eyes changes under the illumination of different wavelengths of light source, and the forged iris does not change with the wavelength change, so the authenticity of the iris can be judged by whether the texture changes with the wavelength. In the iris texture detection, the wavelet packet analysis method is mainly used. The method overcomes the shortcomings of the high frequency part of the frequency domain resolution by continuously dividing the high frequency part, so the details of the texture can be better represented [15]. Further, the information of the iris texture is mainly concentrated in the middle and high frequency bands. At the same time, in order to eliminate the texture change caused by the pupil expansion, the part of the lower semicircle of the iris is usually taken as the research area, then the area image is normalized using the elastic deformation model, and then the positioning is performed. The region performs wavelet packet decomposition, and uses the decomposition result to calculate the entropy of the iris texture according to the formula. Finally, the calculation formula of the texture entropy ratio can be obtained.

In order to improve the detection rate, the detection values of the above two methods can be combined into one feature vector, and the feature vector can be extracted by using Support Vector Machine (SVM) [16]. By selecting some test samples and conducting experiments, the following
conclusions were drawn: in terms of classification accuracy, the false acceptance rate (FAR) and false rejection rate (FRR) of the printed iris image and artificial eye are both 0%, and the FAR and FRR of the colour contact lens is not ideal 0% [17]. The possible reason for this result is that some real iris texture can be captured when wearing contact lenses. At the same time, the ROC curves were compared for various methods. From the experimental results, the error rate (ERR) of the forged iris detection using SVM decision method was the lowest, and the highest precision was obtained. Further, in terms of computing time, the average time of the SVM decision method is only 2ms, which is very fast. Therefore, the decision boundary obtained by this method can distinguish the living iris or the forged iris well, and the detection process is short and the efficiency is satisfied.

4. Summary
The paper first reviews the advantages of iris recognition compared to other biometric recognition technologies, as well as the research situation and application range of iris recognition. In the third part, the paper introduces how to use the multi-spectral characteristics of the human eyes to detect living irises. This part is mainly reviewed from the perspective of multi-spectral characteristics of conjunctival vessels and iris textures in living human eyes. After acquiring the iris image of a certain band, the conjunctival vascular feature and the texture entropy ratio are extracted, and the integrated feature vector is extracted by the SVM classifier, which can distinguish the forged iris and the living iris well, and the detection time is short.

It is precisely because of the high stability and uniqueness of the iris and the non-invasiveness in the recognition process that the iris recognition technology has become more and more popular, and has become a key research field of various scientific research institutions. In recent years, it has also achieved great progress. Of course, in the process of development, some problems have also arisen. For example, when collecting iris images, it is necessary for the detected person to cooperate with the machine to collect high-quality images.

In the subsequent research, the focus of the research is how to realize the automatic matching of human identifications with the machine detection, that is, to further improve the intelligent human-computer interaction degree of the iris recognition device, improve the user experience, and make the iris recognition more widely accepted by people [18]. Another issue is how to transform from a controllable scene to a complex scene. In real life, many scenes are complex and varied, and the light intensity, the presence or absence of dense crowds, and the presence or absence of occlusion will affect the correct rate of recognition. These issues present challenges for existing iris recognition technologies. It is believed that under the drive of technology and demands, the future iris recognition will be further developed, and the safety, efficiency and stability will be further improved, and it will gradually develop into a more mainstream biometric recognition technology.

References
[1] Proenca H, Alecandre LA. Toward covert iris biometric recognition experamental results from the NICE contests [J]. IEEE Transactions on Information Forensics and Security, 7(2012)
[2] Liu N, Zhang M, Li H, et al. DeepIris: Learning pairwise filter bank for heterogeneous iris verification [J]. Pattern Recognition Letters, 82(2016)
[3] Jeong D S, Hwang J W, Kang B J, et al. A new iris segmentation method for non-ideal iris images[J]. Image & Vision Computing, 28(2010)
[4] Daugman J. How iris recognition works[M]. IEEE Press(2004)
[5] He Z, Tan T, Sun Z, et al. Toward Accurate and Fast Iris Segmentation for Iris Biometrics[J]. IEEE Transactions on Pattern Analysis & Machine Intelligence, 31(2009)
[6] Kalka N D, Zuo J, Schmid N A, et al. Estimating and Fusing Quality Factors for Iris Biometric Images[J]. IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans, 40(2010)
[7] Saldan A I, Pavlov S, Kolesnic P, et al. Optical method for analysis of eye conjunctiva microcirculation[C]// International Conference on Optoelectronic Information Technologies. International Society for Optics and Photonics (2001)

[8] Sankowski W, Grabowski K, Zubert M, et al. Reliable algorithm for iris segmentation in eye image[J]. Image & Vision Computing, 28(2010)

[9] Tan T, He Z, Sun Z. Efficient and robust segmentation of noisy iris images for non-cooperative iris recognition[J]. Image & Vision Computing, 28(2010)

[10] Almeida P. A knowledge-based approach to the iris segmentation problem[J]. Image Vision Computing, 28(2014)

[11] Frangi A F, Niessen W J, Vincken K L, et al. Multiscale vessel enhancement filtering[C]// International Conference on Medical Image Computing and Computer-Assisted Intervention. Springer-Verlag (1998)

[12] Shi F, Yang J. Multiscale vesselness based bilateral filter for blood vessel enhancement[J]. Electronics Letters, 45(2009)

[13] Pawar M K, Mirajkar G S, Patil S S. Comparative analysis of iris segmentation methods along with quality enhancement[C]// Third International Conference on Computing Communication & NETWORKING Technologies. IEEE (2012)

[14] Bowyer K W, Hollingsworth K P, Flynn P J. A Survey of Iris Biometrics Research: 2008–2010[M]// Handbook of Iris Recognition. Springer London (2013)

[15] Hosseini S M, Araabi B N, Soltanianzadeh H. Shape Analysis of Stroma for Iris Recognition[C]// International Conference on Advances in Biometrics. Springer-Verlag (2007)

[16] Gu H Y, Zhuang Y T, Pan Y H. An iris recognition method based on multi-orientation features and Non-symmetrical SVM[J]. Journal of Zhejiang Universityence A, 6(2005)

[17] Park J H, Kang M G. Multispectral iris authentication system against counterfeit attack using gradient-based image fusion[J]. Optical Engineering, 46(2007)

[18] Gankin K A, Gneushev A N, Matveev I A. Iris image segmentation based on approximate methods with subsequent refinements[J]. Journal of Computer & Systems Sciences International, 53(2014)