ISBN 978-981-14-1455-8
Proceedings of 2019 the 9th International Workshop on Computer Science and Engineering
WCSE_2019_SPRING
Yangon, Myanmar, February 27-March 1, 2019, pp. 22-30
doi:10.18178/wcse.2019.03.005

Effective Local Features Matching Based Rapid Iris Recognition with Interference Elimination Pre-processing for Identity Identification

Kun-Cheng Li [1] and Chih-Peng Fan [1+]

[1] Department of Electrical Engineering, National Chung Hsing University, Taiwan (R.O.C.)

Abstract. In this paper, the effective local features matching based iris matching methods are developed for identity identification. To avoid the eyelid/eyelash interferences, the proposed interference elimination pre-processing scheme is effectively used to remove the image region due to the eyelid/eyelash obstruction, and the retrieved iris region only locates near the pupil around the ring area for the recognition. The iris features are enhanced by the Contrast Limited Adaptive Histogram Equalization (CLAHE) and Gabor filtering processes. Then the efficient local features matching based technologies, i.e. the Scale-Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) methods, are applied to the iris features matching. The local features matching technology uses the local features of images, and it keeps the feature invariance for the changes of rotation, scaling, and brightness. Finally, the Fast Library for Approximate Nearest Neighbors (FLANN) and the Random Sample Consensus (RANSAC) algorithms are used to increase the matching efficiency. By the similar iris database and the SIFT-based technologies, the proposed SIFT-based approach yields to better Correct Recognition Rate (CRR) and False Acceptance Rate (FAR) in comparison with the previous SIFT-based designs, where the CRR of the proposed design can be up to 97%.

Keywords: biometric, iris recognition, interference elimination, SIFT/SURF features, personal identifications.

1. Introduction

Biometrics have been applied to the personal recognition popularly and it becomes more important. The iris recognition is one of the biometric identification methods, and the technology provides the accurate personal recognition. For example, by the iris scan identification, the iris information can be linked to the passport data database, and the personal identity is functional. In recent years [1-9], the iris identification is used widely and increasingly in personal identifications. Even the mobile phone also begins to use the iris identification system, and the importance of biometrics gains more and more attention. The traditional iris recognition technology [1] transforms the iris features region into a square matrix by the polar coordinate method, and the square matrix is transformed to the feature codes, and then the signature code is used to the features matching.

By previous experimental results [5-7], the iris images may have low contrast and have non-uniform illumination created by the interferences of light sources. The frequency-domain based Gabor or Log Gabor wavelet is changeless for image brightness or contrast, and the Gabor wavelet method is suitable to indicate iris features under varying situations. The Gabor decomposition uses directional band-pass filters which have orientation-selective and frequency-selective properties for iris features [5]. However, the Gabor wavelet/Log Gabor wavelet methods have very heavy computational complexity compared with the Principal Component Analysis (PCA) method, where the PCA algorithm can process global features of iris images spatially. When the noise of iris image is not intense [6], the spatial-domain based PCA method is

+ Corresponding author. Tel.: +886-4-22851549 ext. 710; fax: ++886-4-22851410.
E-mail address: cpfan@dragon.nchu.edu.tw

computationally inexpensive and needs less computational time than the frequency-domain algorithms, such as the methodologies in [4] and [7].

For the feature extraction and matching of iris image, although the frequency-domain Gabor decomposition methods provide better recognition performances than the spatial-domain based method, the Gabor wavelet and Log Gabor wavelet methods have higher computational complexity compared with the spatial-domain based method [6]. Additionally, the frequency-domain based Gabor decomposition methods cannot keep the iris feature invariance for the changes of rotation, scaling, and brightness. In [2, 9], the Scale-Invariant Feature Transform (SIFT) uses the local features of images, and it keeps the feature invariance for the changes of rotation, scaling, and brightness. Besides, the SIFT skill also maintains a certain degree of stability for the change of perspective affine transformation and noise. Thus, the Scale-Invariant Feature Transform (SIFT) and Speeded Up Robust Features (SURF) [10] based technologies are suitable to be applied for iris features matching. By the SIFT local features based enhancement technologies, the effective iris matching method is proposed for identity identification. The rest of this paper is discussed as follows.

2. Proposed Iris-Based Identity Identification Design

The proposed design has six computational processes, which include the pupil location, iris extraction, interference elimination, features enhancement, features extraction, and features matching. Fig. 1 illustrates the proposed iris recognition processing flow.

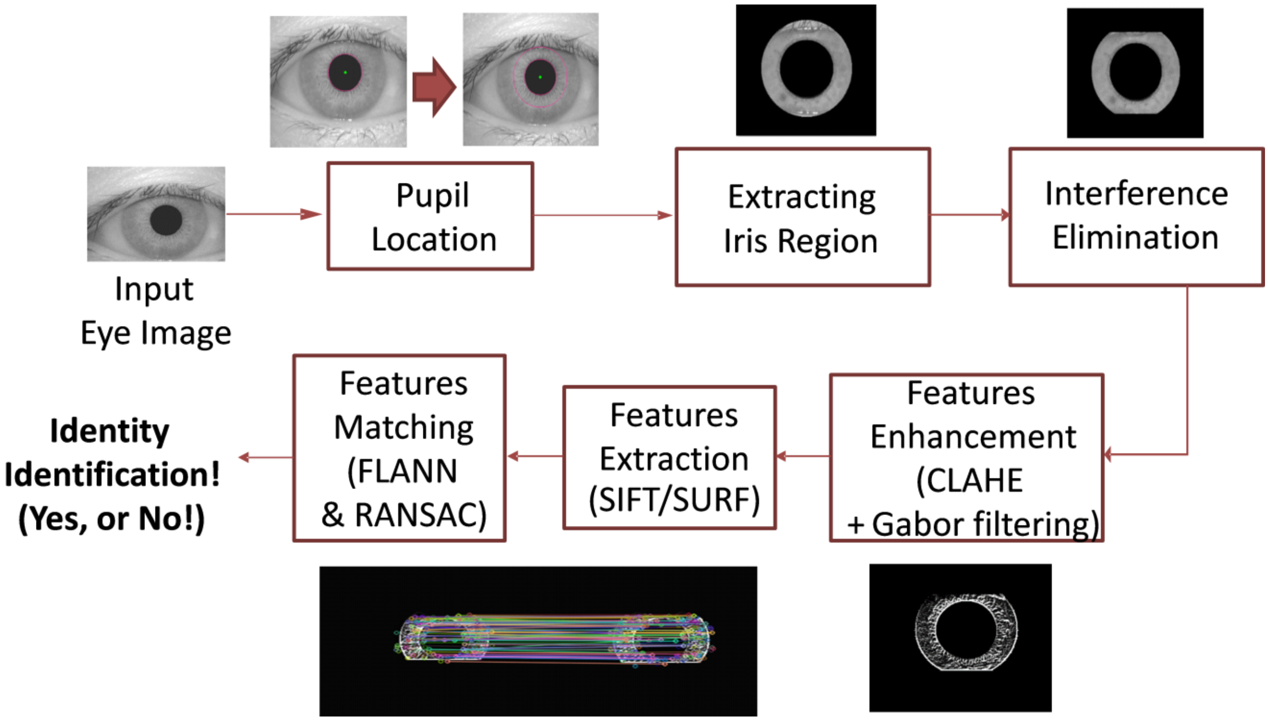


Fig. 1: The proposed processing flow for iris-based identity identification

2.1. Pupil Location

The proposed system detects the Canny boundary of pupil firstly, and the Sobel filtering process is used to compute the gradient of the first-order derivative of edges. Secondly, the circle-based Hough transform is applied to find the best possible circular contour from the boundary points. Then the Gaussian blur process is enabled to remove the noisy pixels in iris images. When the Gaussian blur operation is finished, the boundary points of non-pupil circle are filtered out. The Gaussian blur process is only used to search the circular boundary of a pupil, and the iris image by the Gaussian process does not be used in the following feature extraction processes. Finally, by the Hough-gradient algorithm, the proposed system obtains the pupil's contour for the pupil location. Fig. 2 illustrates the processing result after the pupil location operations.

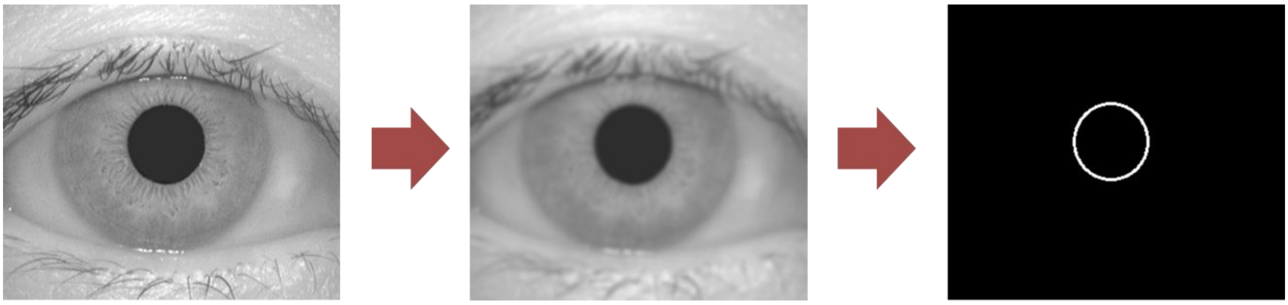


Fig. 2: The pupil location process

2.2. Extracting Iris Region and Interference Elimination

By observations, the most abundant and dense iris texture messages are distributed around the pupil. To avoid the important iris area being covered by the upper and lower eyelids and eyelashes interferences, when the circular contour of pupil is estimated, the proposed design locates a larger circle whose radius is 1.7 times of the estimated pupil circle. The iris area of interests is the circular ring region, which is located between the pupil and the outer circles, as shown in Fig. 3. Fig. 4(a) illustrates the NIR-based input eye images in [14], and Fig. 4(b) reveals the extracted iris regions of eye images shown in Fig. 4(a). However, in Fig. 4(b), the upper and lower eyelids and eyelashes interferences will cover part of the upper and lower iris regions respectively, and the covered iris texture information will be lost, and then the features matching efficiency for identity identification will be reduced.

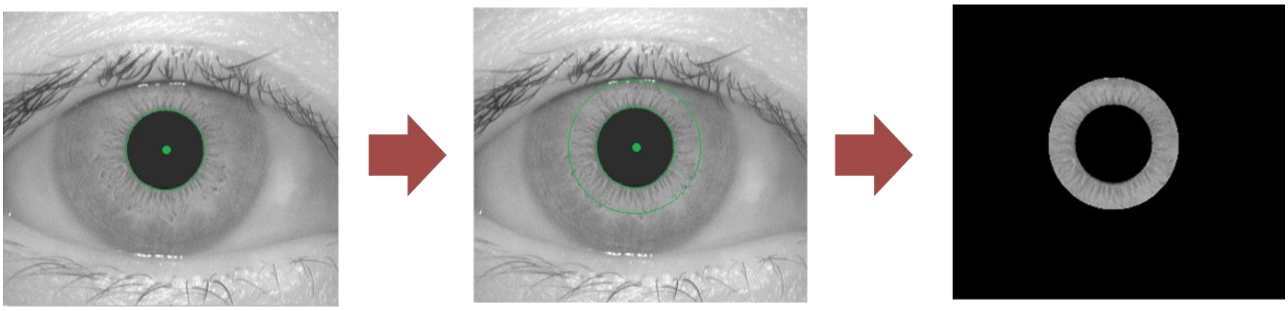
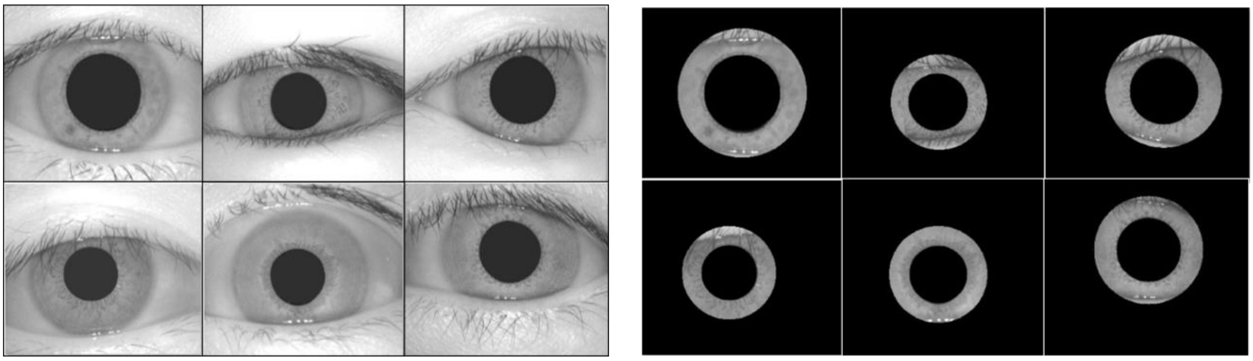


Fig. 3: The process of iris region extraction



(a) (b)

Fig. 4 (a) The inputted eye images

Fig. 4 (b) The extracted iris region with eyelid/eyelash interferences

To avoid the eyelid/eyelash interferences, the interference elimination pre-processing scheme is applied to remove the iris area, which is covered by the eyelid/eyelash. Fig. 5 depicts the proposed concept of the eyelid/eyelash interferences. In this paper, the applied interference elimination pre-processing scheme has two pre-processing modes, which are described as follows:

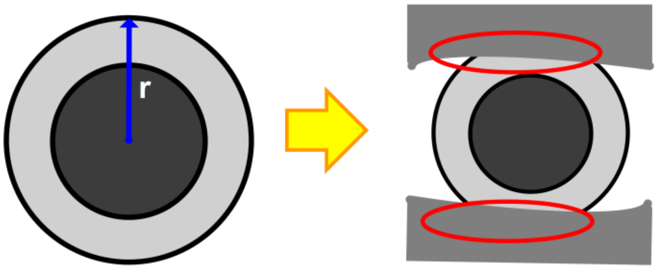


Fig. 5: Elimination of eyelid/eyelash interferences

By the Mode 1 scheme (Adaptive Selected ROI):

Fig. 6 depicts the interference elimination by the Mode 1 scheme. In Fig 6 (a), " P1 ", " P2 ", " P3 ", " P4 ", and " P5 " are the pixels in the iris region, and " t1 " and " t2 " are the thresholds for the boundary detection of interferences. To detect the boundary of the upper eyelid/eyelash interferences from the pupil boundary, when the absolute differences between the successive pixels are larger than the " t1 " threshold, the boundary of the upper eyelid/eyelash interferences is found. Similarly, to detect the boundary of the lower eyelid/eyelash interferences from the pupil boundary, when the absolute differences between the successive pixels are larger than the " t2 " threshold, the boundary of the lower eyelid/eyelash interferences is found. In Fig. 6, "A" means the iris region after interference eliminations, and " B " means the pupil region. Fig. 7(a) and Fig. 7(b) demonstrate the results of iris region extraction before and after the eyelid/eyelash interference elimination, respectively.

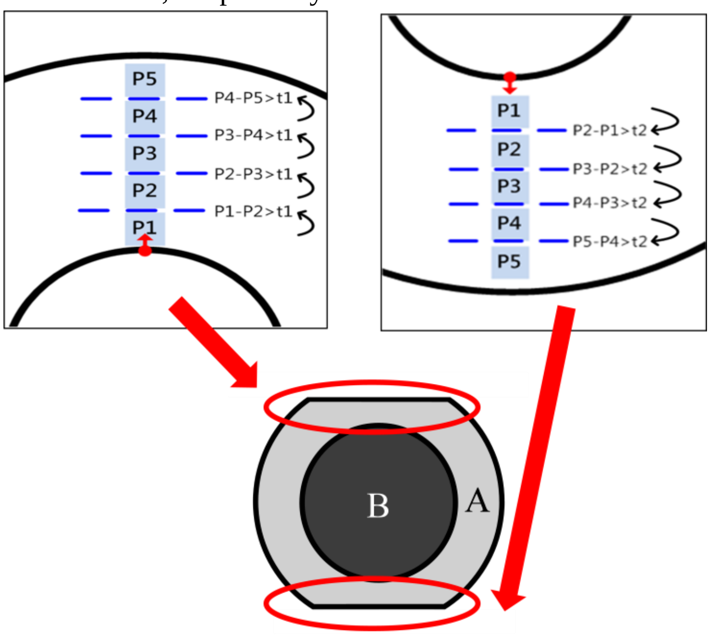
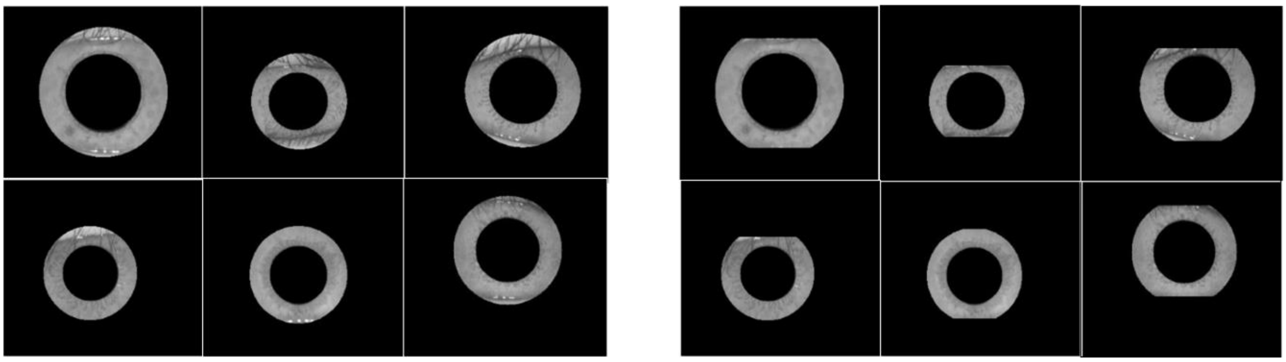


Fig. 6: The eyelid/eyelash interference elimination scheme by the Mode 1 scheme



(a) (b)

Fig. 7: The results of iris region extraction (a) before (b) after the interference elimination (By Mode 1)

By the Mode 2 scheme (Fixed Selected ROI):

Fig. 8 depicts the interference elimination by the Mode 2 scheme. The boundaries of upper and lower eyelid/eyelash interferences are fixedly selected, and The boundaries are located at the upper and lower boundary of the pupil. In Fig. 8, the "A" means the iris region after interference eliminations, and " B " means the pupil region. Fig. 9(a) and Fig. 9(b) demonstrate the results of iris region extraction before and after the eyelid/eyelash interference elimination, respectively.

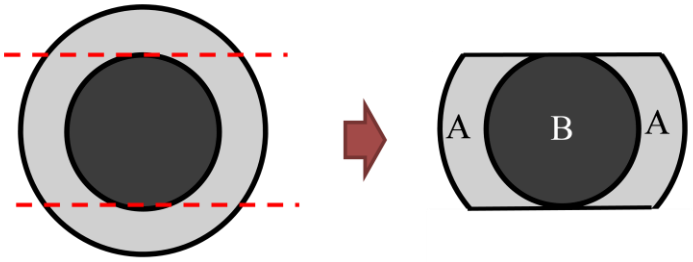


Fig. 8: The eyelid/eyelash interference elimination scheme by the Mode 2 scheme

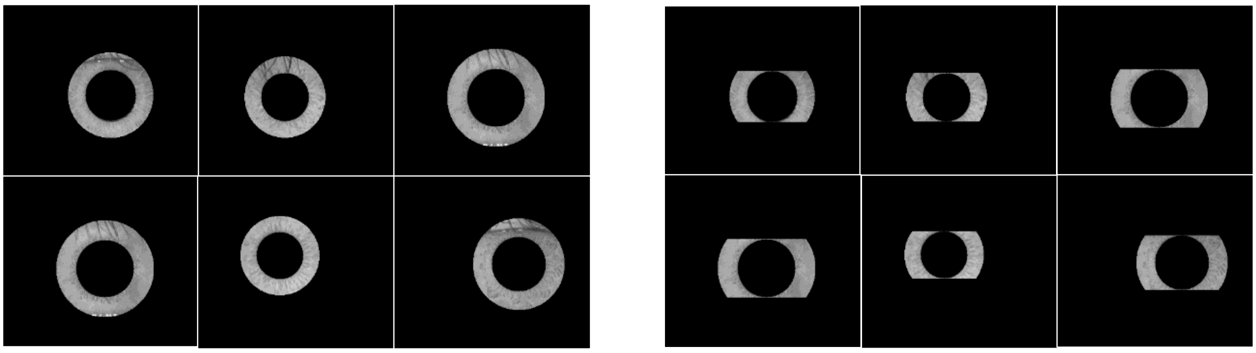


Fig. 9: The results of iris region extraction (a) before (b) after the interference elimination (By Mode 2)

2.3. Features Enhancement

At first, the Contrast Limited Adaptive Histogram Equalization (CLAHE) [8] is used for features enhancement. The CLAHE technology distributes and equalizes the histogram uniformly, and the features of iris texture are enhanced efficiently. By the contrast clipping in CLAHE, the images are processed to overcome the over-equalization issue in the traditional histogram method. By the CLAHE process, the iris texture features are enhanced more obviously. To strengthen the texture information further, when the CLAHE process is finished, and then the cascaded Gabor filtering process is followed. Fig. 10 indicates the iris images after the CLAHE and Gabor filtering processes.

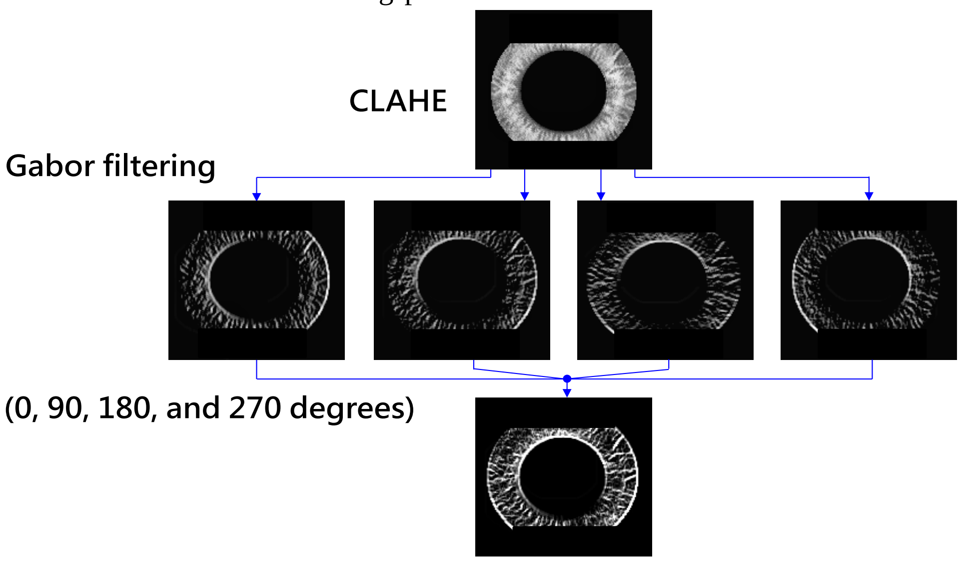
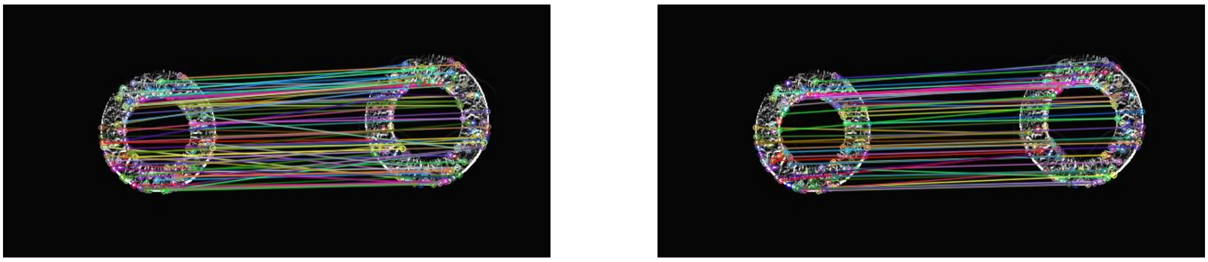


Fig. 10: The applied iris features enhancement scheme

2.4. Features Extraction & Features Matching

By the SIFT-based [2, 9] and the SURF-based schemes [10], the iris features are extracted efficiently, and then the features matching process will be done. Compared with the SIFT-based features extraction technologies, the SURF-based features extraction technologies require less computational time. Besides, to compute the features descriptions, the SURF technologies also provide the similar recognition rate, stability, and computational efficiency in comparison with the SIFT-based methodologies.

In algorithm designs, the brute-force search (or exhaustive search) is a very well-known problem-solving technique and algorithmic example that contains systematically listing all possible candidates for the solution and checking whether each candidate satisfies the problem's issue [11]. To speed up a brute-force method, if the number of candidate solutions is reduced, the search space will be decreased effectively. Therefore, the fast library for approximate nearest neighbours (FLANN) [12] is a library to execute fast approximate nearest neighbor searches in high dimensional spaces. The FLANN acts the best performance for the nearest neighbor search and for automatically choosing the best algorithm and optimum parameters depending on the dataset [12]. The RANSAC algorithm [13] is a mathematical model that can separate the features data into two categories (i.e. inner and outer groups) to find the best possible matching model. Thus, the RANSAC algorithm can improve the features matching performance. The design uses the RANSAC algorithm to get the maximum inner group feature matching operation, and eliminate the out-of-group corresponding to the space. By the RANSAC algorithm, the proposed design gets the largest inner group, and excludes the outer groups that do not fit the spatial correspondence. Thus, the system achieves the best matching result and improves the matching efficiency. Fig. 11 illustrates the features matching results with/without the RANSAC algorithm in [2]. By using the brute force or the fast library for approximate nearest neighbours (FLANN) with joint the RANSAC algorithm, the system gets the effective matching result and improves the matching efficiency simultaneously. Fig. 12 demonstrates the features matching results with the combined SURF, FLANN, and RANSAC algorithms for the correct matching case.



(a) (b)

Fig. 11: The features matching results (a) without and (b) with using the RANSAC algorithm in [2]

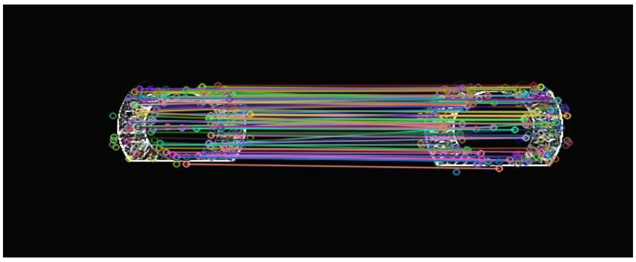
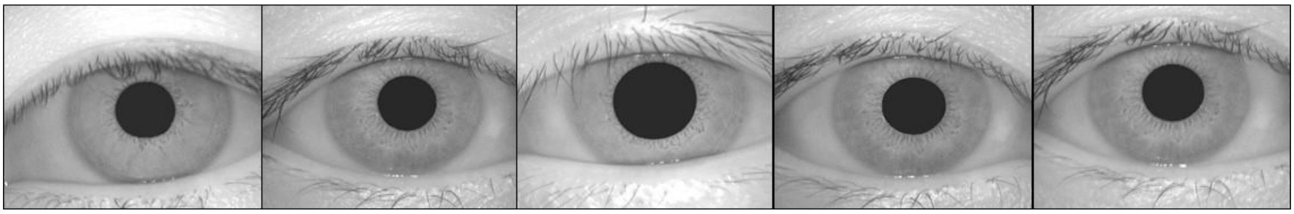


Fig. 12: The features matching results with the combined SURF+FLANN+RANSAC algorithm for the correct matching case

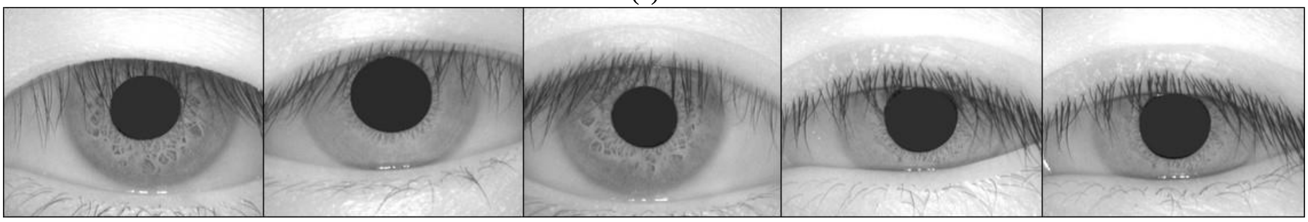
3. Experimental Results and Comparisons

The iris databases for testing are achieved from the Chinese Academy of Sciences (CASIA), i.e. CASIA-IrisV1 [14], and these iris data images are the NIR-based images. In the iris database, 108 persons are included, and each person has 7 sub-images. A total of 756 iris images are contained with a resolution of 320x280 pixels. To evaluate and test the proposed C-language software-based design, a personal computer, which has 32-bit operating system, 8GB memory, and a CPU by the 3.4GHz operational frequency, is used for the experiments. Fig.13(a) and Fig.13(b) show the iris images in [14] without/with the serious interferences, respectively. Due to the interference of the upper/lower eyelids and eyelashes, the iris images with serious interference, as shown in Fig. 13(b), are not selected for our experiments, and only 651 iris images (93 persons) are used for testing. In experiments, the iris samples for tests are classified into legal users and intruders. In general, the accuracy, also called the Correct Recognition Rate (CRR) and the False Acceptance Rate (FAR) are used for the assessment of the ability of the system to recognize the personal identity.

Table 1 lists the performance comparisons between six local features matching based designs. In Table 1, the proposed method 2 performs the best CRR and the least FAR values among the six local features matching based designs. However, since the computational complexity of the SIFT operations is larger than that of the SURF operations, for identifying one person, the average processing time by the Proposed method 2 (i.e. 0.692 seconds) is more than that by the Proposed method 4 (i.e. 0.312 seconds). In Table 1, the proposed method 4, which uses the fast algorithm based SURF and FLANN schemes, has better cost-effective and time-efficiency performances than the other methods. Table 2 demonstrates the performance comparisons between four different iris-recognition designs. The CRR of the proposed design (i.e. SIFT/FLANN) is better than that of the designs in [2] and [3], and the CRR of the proposed design is also the same as that of the previous design in [4]. The proposed design also has better FAR performance in comparison with the previous SIFT-based designs in [2] and [4].



(a)



(b)

Fig. 13: The iris images (a) without (b) with the serious interferences in [14]

Table 1 Performance comparisons between six local features matching based designs

	SIFT/ Bruteforce [2]	SIFT/ Bruteforce (Proposed Method 1)	SIFT/ FLANN (Proposed Method 2)	SURF/ Bruteforce (Proposed Method 3)	SURF/ FLANN (Proposed Method 4)	SURF/ FLANN (Proposed Method 5)
Database	CASIA-Iris V1 , 90 persons , 630 pictures .					
Interference Elimination Mode	Not Use	Adaptive ROI	Adaptive ROI	Adaptive ROI	Adaptive ROI	Fixed ROI
CRR	0.96886	0.97534	0.97915	0.96728	0.97296	0.96462
FAR	0.02606	0.02027	0.01670	0.02733	0.02114	0.03004
Computational time (seconds)						
Extracting Iris Region & Interference Elimination	0.022	0.016	0.013	0.012	0.015	0.047
Features Enhancement	0.016	0.015	0.016	0.016	0.016	0.016
Features Extraction	0.460	0.421	0.413	0.132	0.140	0.110
Features Matching	0.172	0.203	0.250	0.230	0.141	0.078
Total	0.670	0.655	0.692	0.390	0.312	0.251

Table 2 Performance comparisons between four different iris-recognition designs

	Yang, et. al [2]	Feddaoui, et. al [3]	Hunny, et. al [4]	This work (SIFT/ FLANN)
Used Databases	CASIA-V1	CASIA-V1	CASIA-V3	CASIA-V1
Used algorithms	SIFT	Gabor	F-SIFT	SURF
Operational domain	Spatial	Spatial	Frequency	Spatial
CRR	0.968	0.960	0.979	0.979
FAR	0.02606	0.00267	0.04	0.01670

4. Conclusion

Due to the efficient interference elimination pre-process, the SIFT/SURF based iris features matching algorithms are developed for identity identification. By integrating with features enhancement, features extraction, and joint features matching algorithms by FLANN and RANSAC, the iris matching efficiency of identity identification for the proposed SIFT-based method is raised effectively. Based on the same CASIA iris databases, the CRR of the proposed SIFT-based design can be up to 97%. The CRR performance of the proposed SIFT-based design is higher than that of the previous iris recognition designs in [2] and [3]. Besides, the proposed design also has better FAR performance in comparison with the previous SIFT-based designs in [2] and [4].

5. Acknowledgements

This work was supported by Ministry of Science and Technology, Taiwan, R.O.C. under Grant MOST 107-2218-E-005-019.

6. References

[1] J. Daugman, "How iris recognition works," IEEE Transactions on Circuits and Systems for Video Technology, vol. 14, no. 1, pp. 21-30, 2004.

[2] T. D. Yang and C. P. Fan, "Effective Scale-Invariant Feature Transform Based Iris Matching Technology for Identity Identification," IEEE International Conference on Consumer Electronics-Taiwan, 2018 (ICCE-TW 2018), Taichung city, Taiwan, May 2018.

[3] Feddaoui Nadia and Kamel Hamrouni, " An efficient and reliable algorithm for iris recognition based on Gabor filter," International Multi-Conference on Systems Signals and Devices, April 2009.

[4] Hunny Mehrotra, Banshidhar Majhi, and Pankaj Kumar Sa, "Unconstrained iris recognition using F-SIFT," 8th International Conference on Information, Communications & Signal Processing, Singapore, 13-16 Dec. 2011.

[5] C. C. Tsai, J. S. Taur, and C. W. Tao, "Iris Recognition Using Gabor Filters and the Fractal Dimension," Journal of Information Science and Engineering, Vol. 25, pp.633-648, 2009.

[6] Pravin S. Patil , S. R. Kolhe, R. V. Patil, and P. M. Patil, "The Comparison of Iris Recognition using Principal Component Analysis, Log Gabor and Gabor Wavelets," International Journal of Computer Applications, Vol. 43, No.1, pp.29-33, April 2012.

[7] R. M. Gad, M.A. Mohamed, and N. A. El-Fishawy, "Iris Recognition based on Log-Gabor and Discrete Cosine Transform Coding," Journal of Computer and Engineering, Vol. 5, Issue2, pp.19-26, Feb. 2011.

[8] G. Yadav, S. Maheshwari, and A. Agarwal, "Contrast limited adaptive histogram equalization (CLAHE) based enhancement for real time video system," International Conference on Advances in Computing, Communications

and Informatics, 2014.

[9] Y. Nakashima and Y. Kuroki, "SIFT feature point selection by using image segmentation," International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS), pp.275-280, 2017.

[10] https://en.wikipedia.org/wiki/Speeded_up_robust_features

[11] https://en.wikipedia.org/wiki/Brute-force_search

[12] https://docs.opencv.org/2.4/modules/flann/doc/flann_fast_approximate_nearest_neighbor_search.html

[13] https://en.wikipedia.org/wiki/Random_sample_consensus

[14] Chinese Academy of Sciences Institute of Automation (CASIA) Iris Database, http://biometrics.idealtest.org/findTotalDbByMode.do?mode=Iris