

New algorithm for localization of iris recognition using deep learning neural networks

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Article Info

Article history:

Received May 29, 2022

Revised Sep 21, 2022

Accepted Oct 14, 2022

Keywords:

Biometric identification
CASIA Iris-V1 dataset
Convolutional neural network
Iris image recognition
Median filter
Semi-discrete matrix
decomposition features

ABSTRACT

Iris recognition is the most reliable and accurate method for eye identification. A novel strategy for localizing iris printing is proposed in this paper. The median filter and histogram were used for this purpose. To extract iris features from iris photographs, an algebraic method known as semi-discrete matrix decomposition (SDD) is used. For classification, neural network (NN) is used to extract the SDD feature. This study also included the setup of convolution neural network (CNN), a convolution neural network that does not require feature extraction, as well as a comparison of the two types of classifiers is made. Iris images are obtained from the Chinese Academy of Sciences Institute of Automation dataset (CASIA Iris-V1), a common database used for the iris recognition system. The proposed algorithm is straightforward, simple, efficient, and fast. The experimental results showed that the proposed algorithm achieved high classification accuracy of approximately 95.5% and 95% for CNN and NN based on SDD features respectively. The proposed algorithms outperformed literature works and required less time for determining the location of iris region.

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1. INTRODUCTION

Biometrics is an acknowledgment and confirmation of an individual's personality in terms of physiological features. Advances in Information technology require using biometrics in applications that verify individual identity [1]. Many biometrics are commonly used such as speech, finger impression, face, penmanship, walk, hand calculation, and iris. The iris method is a new and reliable method compared to the other methods [2], [3]. Iris recognition applications include banking, border security, and mobile phones. The iris image is an internal organ that is not directly connected to the input pattern. Everyone has a unique iris pattern. It has been shown that no two people have the same iris characteristics. A typical iris image is shown in Figure 1. The iris located between the pupil and the white sclera. The iris diameter is 12mm, and the pupil size is 10% to 80% of the iris diameter [4], [5].

Daugman is the creator of the most popular commercial algorithms for iris recognition technology, which is released first in 1993 [4]. For iris recognition, these algorithms use pattern recognition methods as well as some mathematical computations. Multiple researchers [1]-[6] have used the Hough transform-based automated segmentation method to identify iris location. This method locate the circular and pupil area, as well as occluding eyelids, eyelashes, and reflections. To accommodate the imaging inconsistencies, the area of the extracted iris was normalized into a rectangular block of uniform size.

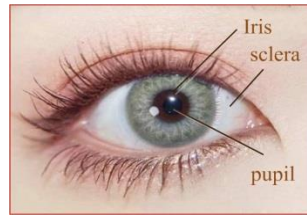


Figure 1. A typical eye structure

Many feature extraction approaches exist to increase the accuracy of iris recognition. Boles and Boashash [7] suggested a one dimensional (1D) wavelet transform with zero crossing. While [8]-[10] used frequency domain to extract the features as one-dimension discrete cosine transform (1D-DCT). Recent advances in numerical linear algebra have influenced image feature extraction techniques such as singular value decomposition (SVD) and semi-discrete decomposition (SDD). SVD has been used in [11], [12] to extract iris characteristics. While in [13] SDD was used to present a reduced number of feature words. It excels at transmitting data accurately [14].

Several researchers have used artificial neural network (ANN) for iris recognition based on Chinese Academy of Sciences Institute of Automation (CASIA) datasets, a popular database for Iris images, using a self-organizing map neural network [15]. The doughnut-shaped iris is rectangular-sized and placed in the neural network. Alim and Sharkas [16], Erding and Allahverdi [17] used multilayer perceptron (MLP) to recognize iris images. MLP is one of the most widely used techniques in recent advances and challenging applications related to machine learning such as object identification using Image Net, face recognition, and image classification contribution of the work.

In this paper, a new localization algorithm is proposed for extracting the position of the iris region from the other parts of the eye such as the eyelid, eyelashes, and sclera to improve the Iris recognition system. The new algorithm focuses on finding the left and right iris region which includes the most important information that may be used to extract data. The inner and outer circle of the iris region is determined according to the proposed algorithm. Parts of the iris are removed from the eyelids and eyelashes. The size of these parts is small so, it does not require a normalization technique, which is a stage used normally to reduce the size of the segmented iris images to a regular size. The median filter and histogram analysis were used for localizing iris images. SDD numerical linear algebra approach is used for extracting features. Two type of classifiers are used ANN with adaptive learning rate based on SDD and convolution neural network (CNN). The implementation time for determining the iris location is considered and compared with the literature works.

The rest of the paper is arranged as follows: section 2 describes the proposed algorithm for iris recognition in detail. The experimental results are demonstrate in section 3 and compared with other studies. Section 4 summarizes the conclusion of the study.

2. THE PROPOSED ALGORITHM FOR IRIS RECOGNITION SYSTEM

The proposed iris recognition algorithm contains four main steps as shown in Figure 2. The images are acquired using a common dataset (i.e. CASIA Iris-V1 dataset). The preprocessing mechanism consists of two stages. In stage 1, the images are converted from RGB format to red band format. Then the iris is detected from the image according to the proposed algorithm. Two techniques are utilized to classify detected iris image, CNN and NN. The features of the detected iris are extracted using the SDD method and classified by NN. The four steps of the proposed algorithm is demonstrated in details by the following subsections.

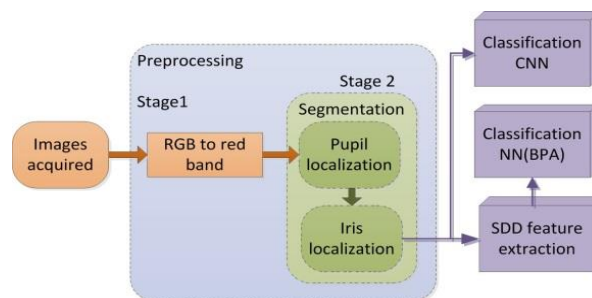


Figure 2. The schematic block diagram of the proposed work for iris recognition

2.1. Acquire image

Often the iris images are collected using infrared camera from a distance of 4 centimeters. Usually, the collected eye images has a size 320×280 pixels. The near-infrared spectrum highlights the iris' texture patterns, making iris identification become more reliable. In this study, the database CASIA-V1 [18] is employed to validate and evaluate the proposed algorithm. This dataset consists of 756 iris images acquired from 108 eyes. These images have a resolution 320-280. Seven images from each eye were gathered in two sessions. Three images are obtained from the first session while the others are collected from the second session. In this dataset, the pupil regions of all iris images are revealed. These images are substituted by a circular region of uniform intensity in order to mask out the specular reflections from the NIR illuminators. This work conducts the ideal conditions experiments using this database because the image of pupil's iris has been edited and its quality is very clear.

2.2. Data preprocessing

The preprocessing data of the proposed algorithm have two stages, as shown in Figure 2. In the first stage, the iris image in database CASIA-V1 is converted from RGB into a red band. In the second stage, the resulting red band image is segmented to identify the iris region of each person. These stages are explained in details as follows:

2.2.1. Stage 1: RGB to red band

In the preprocessing stage, the red color space is separated from RGB color space of the iris images. The reason is due to the reliability of recognition of the red component compared to the green (G), blue (B) components or grayscale images. As a result, the image is stored in one band which reduced the amount of information stored. For more details see Daugman [9].

2.2.2. Stage 2: segmentation stage

The annular iris area is segmented from the full eye image during the iris segmentation technique. At first, the boundaries of circular inner and outer is located first (the iris-pupil and iris-sclera boundaries). To illustrate the proposed algorithm, let the input image is $F(V,W)$ where size of F is $[V,W]$, $x=1,2,\dots,V$; $y=1,2,\dots,W$. The output image is $I_s(N,N)$, $N=40$. A median filter is used to convolve with the iris image [19]. To reduce the effect of the eyelashes and eyelid in image, the size of median filter is chosen to be $[10\times 10]$. The histogram of the eye image that output from the filter is examined. The maximum value of the histogram is chosen at range (1 to 85) of gray level as a threshold value t . So, the original iris image is converted to a binary image using the threshold as in (1).

$$g(x,y) = \begin{cases} 1 & f(x,y) = t \\ 0 & f(x,y) \neq t \end{cases} \quad (1)$$

Then, the horizontal and vertical vectors that represent the number of pixels is calculated as in the (2) and (3),

$$h(x) = \sum_y^C g(x,y) \quad (2)$$

$$v(y) = \sum_x^R g(x,y) \quad (3)$$

the maximum value of these vectors represents the center of the pupil as in the (4) and (5):

$$xp = \max(h(x)) \quad (4)$$

$$yp = \max(v(y)) \quad (5)$$

the radius of the pupil is calculated as in the (6).

$$r = \sum_{n=1}^{xp} g(x_n, yp) \quad (6)$$

Finally, the iris image area is captured from the pupil's right and left sides by the mask (40×20) left and (40×20) right in order to include the most important information that can be used for extracting data.

$$Irrdown(h,h) = f(xp + (1:h+1), yp + 2r: yp + (2r+h)) \quad (10)$$

$$I_s(N,N) = [Irlup Irrup; Irlown Irrdown] \quad (11)$$

The flowchart of the proposed iris image segmentation is shown in Figure 3.

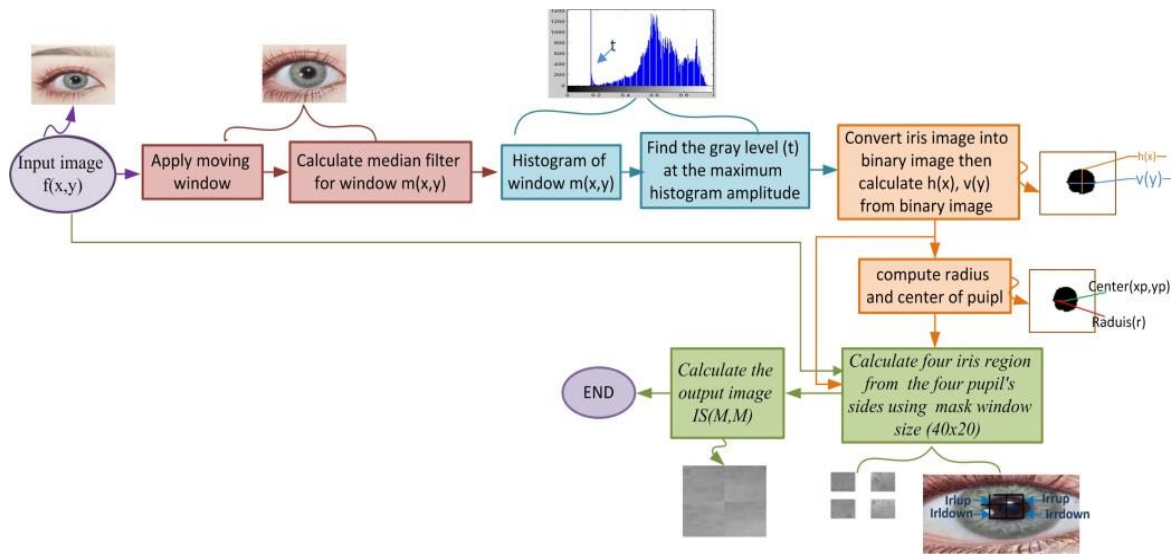


Figure 3. Flowchart of the proposed iris image segmentation

2.3. Features extraction

SDD technique is used to generate a feature vector from 2D iris images. These features are applied as an input to the stage of iris classification of BP neural network. Let semi discrete decomposition of iris image (Is) is defined as in the (12).

$$Is \approx Is_z = X_z D_z Y_z^T \tag{12}$$

Where R denotes the rank of the original matrix Is (iris image), z is reduced singular decomposition of Is. $z(0 < z < R)$. Each coordinate of X_z and Y_z is constrained to have entries from a set equal $\{-1, 0, 1\}$, and the matrix D_z represent a diagonal matrix with positive coordinates [13]. An SDD approximation can be formed iteratively via a greedy algorithm. Let A_z denote the z-term approximation ($A_0 = 0$). Let R_z be the residual at the zth step where $R_z = A - A_z$. Then the optimal choice of the next triplet (d_z, x_z, y_z) is the solution of the following (13).

$$F_z(d, x, y) = \|R_z - dxy^T\|_F^2 \quad s, t, x, y \in \{-1, 0, 1\}, d > 0 \tag{13}$$

The detail of SDD algorithm is illustrated in [20]. SDD is used for feature extraction and image reduction. The dimension of the input pattern is changed from a matrix $N \times N$ to only a vector of N elements. For these reasons, SDD is utilized to derive a compact and representative collection of iris image characteristics. In this work, the main diagonal is used and reduced by rank z. The features that extracted from Is matrix is expressed by $D_z = [d_1 \ d_2 \ \dots \ d_z]$.

2.4. Classification process

In this study, the iris images recognition is performed using two networks. A neural network based on back a propagation algorithm with an adaptive learning rate is used on the other hand, a CNN is designed using multiple building blocks, such as convolution layers, pooling layers, and fully connected layers. CNN is used to learn the features automatically and adaptively through backpropagation NN.

2.4.1. Neural network

In this work, the network have three-layer design; input layer, hidden layer, and output layer. The input layer has the same number of neurons as the dimension of pattern vectors obtained from the algebraic approach SDD. To ensure reliable classification performance, the number of neurons in the hidden layer is chosen as twice that of the input layer. The number of neurons in output layer is chosen related to the number of classes to be recognized. The actual algorithm for a 3-layer network (only one hidden layer) is depicted in details in [21], [22].

2.4.2. Convolutional neural network

A CNN can learn visual features automatically, hence it has exceeded several older hand-crafted feature methods [23], [24]. Models of neural structures are multi-level information representations that depend on layer computations, where the output of the previous layer is fed into the next layer [25]-[27]. In this work the CNN structure contains five layers as shown in Figure 4. Each layer has network parameters and a number of features maps. The input data are collected using a convolution kernel. Each layer has number of neurons.

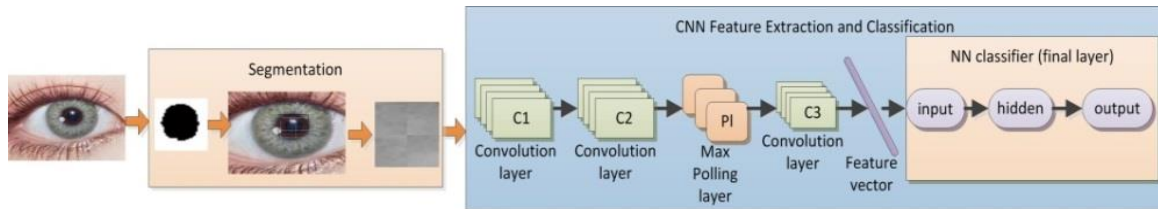


Figure 4. The CNN architecture of the proposed work

In CNN, the weights are distributed locally, so each input point has the same weights. The kernel filter consists of weights tied to similar outputs [28]. The preprocessed image (IS(40,40)) is fed into the network structure through the input layer. The input layer is the first layer that represents a convolution layer (C1). The convolution layer C1 has six kernel of size 55. After processing the C1 layer, there are 36,366 neurons. A convolution layer (C2) is the next convolution layer in the CNN architecture. The convolution layer C2 has eight kernels of size 55. After processing the C2 layer, there are 32,328 neurons. The third layer is the pooling layer (PI). Using the maximum pooling function, the 2*2 window pooling layer will reduce the size of data in C2 layer by half. After processing the PI layer, there are 16,168 neurons. The output of pooling layer is fed to the convolution layer C3. C3 layer contains a 5*5 filter and 8 kernels. After processing the C3 layer, there will be 28*28*8 neurons. Layer C3 has 6,272 neurons when transforming the size of it to a vector. The features vector is fed into NN classifier which includes three layers; input, hidden, and output layers. The input layer contains the same number of neurons as the dimension of patterns vector obtained from the output of the C3 layer.

3. RESULTS AND DISCUSSION

To test the proposed algorithm, CASIA Iris-V1iris datasets are utilized. The digitized image is RGB with a resolution of 320*280 pixels. For the four iris images, only the red (R) component of the RGB image was used, as shown in Figure 5.

A median filter with 10*10 window size is applied to the resulting red band images. The important impact of the median blur filter is to minimize the iris image's noise and pixel intensity complexity while maintaining the edge fidelity of the original image. The median blurred images are shown in Figure 6.

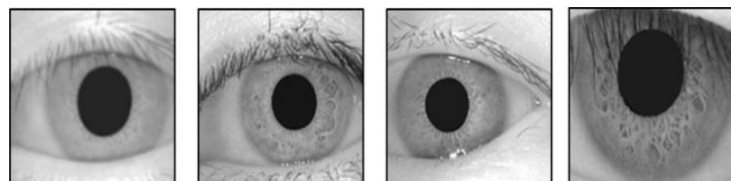


Figure 5. Red band images

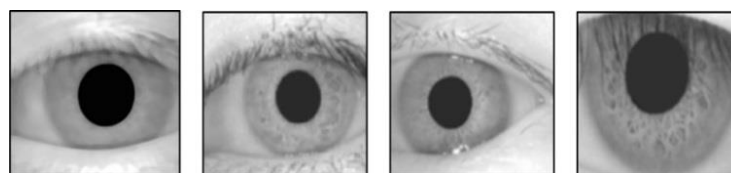


Figure 6. Median blurred iris images

Histogram is applied after obtaining a median blur of iris images. Histogram that applied on the median filter iris images is shown in the Figure 7. It is clear that there is a unique, left-most (darkest pixel values) peak as a typical pupil's pixel signature.

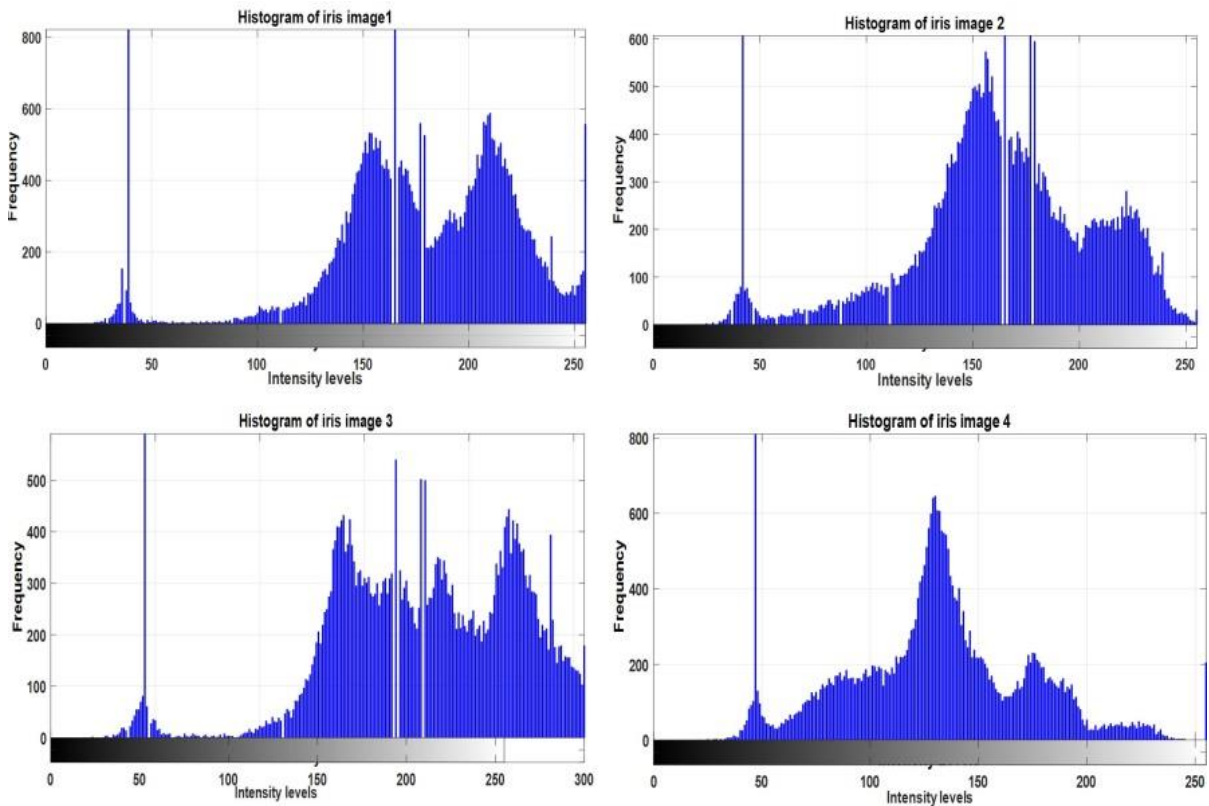


Figure 7. Histogram of median filter images

To obtain the pupil area, an acceptable threshold value is chosen. The threshold value is the maximum value in the histogram from zero to 85 gray axis. Since the intensity values of the pupil regions are lower than those of other regions in the whole eye image, the proposed work examines the histogram of the original eye image and set a threshold value. Using the threshold limits, the original iris image is converted to a binary image. Then the pupil is separated, and the centroid (x_p, y_p) is calculated. Pupil information are extracted according to the horizontally and vertically vectors of the binary image. Figure 8 displays the threshold image, which was automatically cropped to remove the eyelashes and select the suggested threshold. This study proposes to cut-off the area of iris image into four regions, above the upper border of the pupil and below the lower limit of the pupil, as shown in Figure 9. The goal of this procedure is to produce an iris mask, which can be used to eliminate the superfluous regions of the iris for effective identification. The four region of iris image is combined in a single image as shown in Figure 10. The dimensions of the resulting iris images will be equal to (40×40)

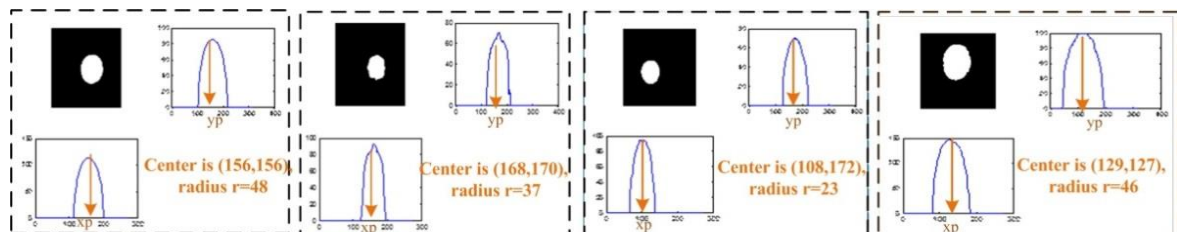


Figure 8. Center and radius of pupil based on the vertical and horizontal vector

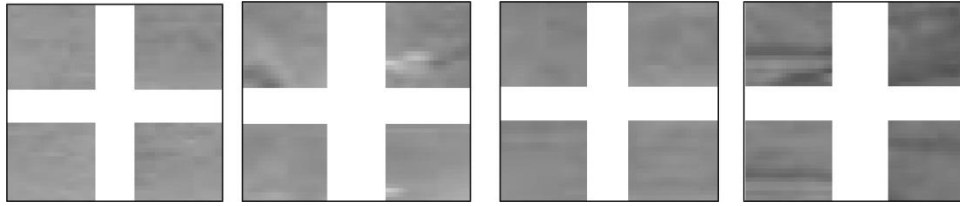


Figure 9. Four region of iris image segmented from four pupil's sides (i.e. Irlup, rrup, Irltdown, Irrdown)

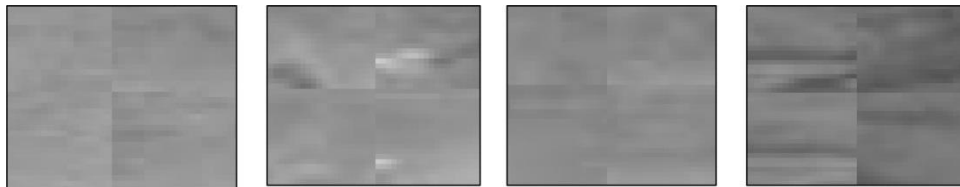


Figure 10. Output images of segmented stage

SDD algorithm is applied to the iris images (40×40). In this study, D_z matrix is obtained as the iris image size (40×40), so that the rank of D_z is 40. The diameter of this matrix is characterized by the values of the frequencies from the highest value to almost zero. The residual values of the array are zeros. It is seen that when choosing the highest values, the number of such values approximately $z=15$ (rank). The other values are neglected because they are close to zero as shown in Figure 11. The features that extracted from Is matrix is expressed by $D_z = [d_1 d_2 \dots d_{15}]$.

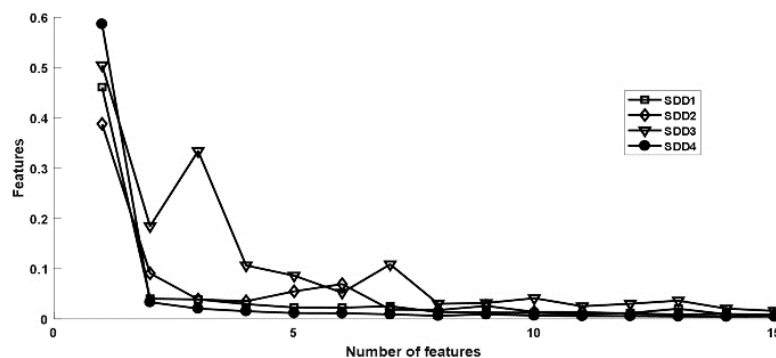


Figure 11. SDD pattern vectors for four iris images

In order to show the reliability of the proposed work, a comparison is made with existing previous works [29], [30]. The previous works used other iris localization techniques. The proposed work is compared with the previous works in term of classification accuracy and the average time needed to obtain the localization of iris image. Table 1 displays the comparison of the proposed work with the literature works.

Table 1. Comparison with the previous works based on accuracy rate and average time for iris segmentation

Previous works	Classification accuracy	Average time
Daugman [29]	57.7%	90 s
Wildes [30]	86.49%	110 s
The proposed work	95%	1.4 s

It is noticed from Table 1 that the proposed work outperformed the previous works [29], [30]. The proposed work achieved an improvement rates of approximately 37.3%, 8.51% over the previous works [29], [30] respectively. Moreover, the average time of the proposed work for iris segmentation is

significantly lower than that of previous works. The proposed work does not require a normalization stage that many researchers have used to reduce the size of segmented iris image to normal size. This stage requires more computational costs and time to localize the iris image. In the proposed work, the inner and outer circle of the iris region is determined according to the proposed algorithm. Parts of the iris are removed from the eyelids and eyelashes. The size of these parts is small so, it does not require a normalization technique.

Another comparison was made to show the effect of the proposed features extraction method with other methods presented in existing literature works [31]-[34] as shown in Table 2. The proposed work used SDD method for extracting features. It is clear that the proposed work outperformed other state of the art works. The proposed work has no modification to the SDD algorithm. However, this is the first time that this algorithm has been used to extract features in the proposed work. Moreover, Table 2 shows the comparison of CNN of the proposed work with. [34]. D. Scherer *et al.* [34] used the same dataset used in our work (CASIA Iris-V1iris datasets). However, the proposed work superior than Scherer *et al.* [34] with improvement rate of 10.5%.

Table 2. Comparison of the proposed method with other researchers based on different features extraction methods

State of the art works	Authors	Method	Accuracy %
1	Firake and Mahajan [31]	Gabor filter	92.82%
2	Hamd and Ahmed [32]	PCA	94%
3	Rana <i>et al.</i> [33]	PCA+DWT	95.4%
4	Scherer <i>et al.</i> [34]	CNN	85%
5	The proposed work	SDD+NN	95%
6	The proposed work	CNN	95.5%

The convergence action of a neural network using the gradient descent technique is depicted in Figure 12. It is seen that the mean square error (MSE) was achieved within 411 epoch for 10 classes. The recognition rate of NN system based on SDD is 95%.

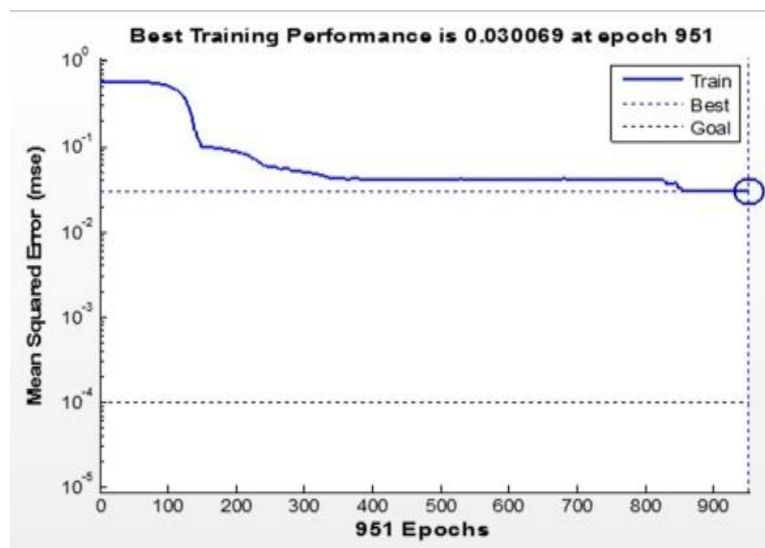


Figure 12. Training of the feed forward neural network

The recognition rate of this study was compared with previous work [12] in order to show the effect of SVD method and the recent version of SVD which is SDD to improve the recognition rate. Patil and Subbaraman [12] used SVD to extract features. The comparison was made in term of classification accuracy based on different number of SVD and SDD dimensions and several number of classes as shown in Table 3. The results showed that the proposed NN based on SDD features outperformed the previous work [12] when increasing the number of classes and dimensions. The results confirm that the proposed method for determining iris rectangle area provides the best performance according to the test results.

Table 3. The performance of the proposed NN based on features of SDD compared to Babasaheb [12]

Number of Classes	Accuracy rate %							
	Number of SVD Dimensions (Babasaheb[12])				Number of SDD Dimensions (Proposed)			
3	50%	100%	100%	100%	55%	98%	98.5%	100%
4	50%	87.5%	100%	100%	60%	96%	97.5%	100%
5	50%	80%	100%	100%	77.3%	88.4%	95%	97%
6	41.66%	58.33%	91.67%	91.67%	90%	55%	85%	93.9%
7	57.14%	64.29%	92.86%	93.57%	59%	65.34%	92.5%	93.4%
9	61.11%	55.55%	94.44%	83.33%	75%	77%	80%	81%
10	35%	55%	70%	65%	88%	90%	92%	95%

4. CONCLUSION

In this study, a new method for iris classification is presented. This method focuses on finding the right and left iris region that contains the most important information that can be used to extract data and the most important factors to improve recognition performance. An algebraic approach such as semi-discrete matrix decomposition is used as a foundation analysis to extract iris features. Coefficients were the most essential aspects of the feature vector, along with quality, statistics, and texture of the iris image. As SDD approach reduced the complexity of layered neural network, the dimensions of input vectors were optimized. Two classifiers are used for iris recognition, the NN neural network based on SDD features and the convolution neural network. The proposed work is efficient and fast compared to other existing works. The experimental results showed that the proposed algorithm achieved high classification accuracy of approximately about 95.5% and 95% for CNN and NN based SDD features respectively. In order to obtain a reliable performance for iris recognition, the iris location must be precisely located. Therefore, the proposed algorithm focuses on accurately defining the iris region to extract efficient features from this region. Moreover, the results confirm that the proposed algorithm outperformed the state of the arts works with less time needed to localize iris image.




REFERENCES

- [1] H. Proença and A. Alexandre, "Towards non-cooperative iris recognition: A classification approach using multiple signatures," *IEEE Transaction on Pattern Analysis*, vol. 29, no. 4, pp. 607-612, 2007, doi: 10.1109/TPAMI.2007.1016.
- [2] P. Podder, T. Z. Khan, M. H. Khan, M. M. Rahman, R. Ahmed, and S. M. Rahman, "An efficient iris segmentation model based on eyelids and eyelashes detection in iris recognition system," *International Conference on Computer Communication and Informatics (ICCCI)*, 2015, pp. 1-7, doi: 10.1109/ICCCI.2015.7218078.
- [3] R. S. Reillo and C. Sanchez-Avila, "Processing of the human iris pattern for biometric identification," *8th International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems*, 2000.
- [4] W. Chen and S. Yuan, "A novel personal biometric authentication technique using human iris based on fractal dimension features," *IEEE International Conference on Acoustics, Speech, and Signal Processing, (ICASSP '03)*, 2003, pp. III-201, doi: 10.1109/ICASSP.2003.1199142.
- [5] M. Donald, M. Rakshit, and D. Zhang, "DCT-based iris recognition," *IEEE transactions on pattern analysis and machine intelligence*, vol. 29, no. 4, pp 586-595, 2007, doi: 10.1109/TPAMI.2007.1002.
- [6] P. Hyun-Ae and K. R. Park, "Iris recognition based on score level fusion by using SVM," *Pattern Recognition Letters*, vol. 28, no. 15, pp 2019-2028, 2007, doi: 10.1016/j.patrec.2007.05.017.
- [7] W. W. Boles and B. Boashash, "A human identification technique using images of the iris and wavelet transform," *IEEE Transactions on Signal Processing*, vol. 46, no. 4, pp. 1185-1188, 1998, doi: 10.1109/78.668573.
- [8] S. Lim, K. Lee, O. Byeon, and T. Kim, "Efficient iris recognition through improvement of feature vector and classifier," *ETRI Journal*, vol. 23, no. 2, pp. 61-70, 2001, doi:10.4218/etrij.01.0101.0203.
- [9] D. M. Monro, S. Rakshit, and D. Zhang, "Dct-based iris recognition," *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 29, no. 4, pp. 586-595, 2007, doi: 10.1109/TPAMI.2007.1002.
- [10] K. Abhineet, A. Potnis, and A. Singh, "Iris recognition and feature extraction in iris recognition system by employing 2D DCT," *IRJET Int. Res. Comput. Sci. Softw. Eng. Technol.*, vol. 3, no. 12, pp. 503-510, 2016.
- [11] M. M. Khedkar and S. A. Ladhake, "Neural network based human iris pattern recognition system using SVD transform features," *ITSI Transactions on Electrical and Electronics Engineering (ITSI-TEEE)*, vol. 1, no. 5, pp. 2320-8945, 2013.
- [12] B. G. Patil and S. Subbaraman, "SVD-EBP algorithm for 'iris pattern recognition,'" *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 2, no. 12, 2011, doi: 10.48550/arXiv.1204.2062.2013.
- [13] V. Snášel, P. Moravec, and J. Pokorný, "Using Semi-discrete Decomposition for Topic Identification," *Eighth International Conference on Intelligent Systems Design and Applications*, 2008, pp. 415-420, doi: 10.1109/ISDA.2008.62.
- [14] H. Demirel and G. Anbarjafari, "Iris recognition system using combined histogram statistics," *23rd International Symposium on Computer and Information Sciences*, pp. 1-4, 2008, doi: 10.1109/ISCIS.2008.4717879P.
- [15] L. W. Liam, A. Chekima, L. C. Fan, and J. A. Dargham, "Iris recognition using self-organizing neural network," *Student Conference on Research and Development*, 2002, pp. 169-172, doi: 10.1109/SCORED.2002.1033084.
- [16] A. Alim and M. Sharkas, "Texture classification of the human iris using artificial neural networks," *11th IEEE Mediterranean Electrotechnical Conference (IEEE Cat. No.02CH37379)*, 2002, pp. 580-583, doi: 10.1109/MELECON.2002.1014659.
- [17] H. E. Kocer and N. Allahverdi, "An efficient iris recognition system based on modular neural networks," *9th WSEAS International Conference on Neural Networks (NN'08)*, 2008, pp 42-47.
- [18] CASIA-IrisV1dataset. 21 October 2019. <http://biometrics.idealtest.org/> accessed on (accessed Sep. 1, 2022).
- [19] A. E. Hussain, A. H. Reja, and L. H. Abood, "Design hybrid filter technique for mixed noise reduction from synthetic aperture radar imagery," *Bulletin of Electrical Engineering and Informatics*, vol. 11, no. 3, pp 1325-1331, 2022, doi: 10.11591/eei.v11i3.3708.




- [20] G. T. Kolda and D. P. O'Leary, "Algorithm 805 computation and uses of the semi discrete matrix decomposition," *ACM Transactions on Mathematical Software*, vol. 26, no. 3, pp. 415-435, 2000, doi: 10.1145/358407.358424.
- [21] S. Iranmanesh and M. A. Mahdavi, "A differential adaptive learning rate method for back-propagation neural networks," *World Academy of Science, Engineering and Technology*, vol. 50, no. 1, pp. 285-288, 2009.
- [22] U. A. Badawi, "Fish classification using extraction of appropriate feature set," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 12, no. 3, pp. 2488-2500, 2022, doi: 10.11591/ijece.v12i3.pp2488-2500.
- [23] O. Oyebade, and A. Khashman, "Iris nevus diagnosis: convolutional neural network and deep belief network," *Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 25, no. 2, pp. 1106-1115, 2017, doi: 10.3906/elk-1507-190.
- [24] B. A. Ali and E. H. Ali, "Human identification system based on brainprint using machine learning algorithms," *Journal of Engineering and Sustainable Development*, vol. 26, no. 2, pp. 13-22, 2022, doi: 10.31272/jeasd.26.2.2.
- [25] B. K. Oleiwi, L. H. Abood, and A. K. Farhan, "Integrated different fingerprint identification and classification systems based deep learning," *International Conference on Computer Science and Software Engineering (CSASE)*, 2022, pp. 188-193, doi: 10.1109/CSASE51777.2022.9759632.
- [26] S. Ekhande, U. Patil, and K. V. Kulhalli, "Review on effectiveness of deep learning approach in digital forensics," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 12, no. 5, pp. 5481-5492, 2022, doi: 10.11591/ijece.v12i5.pp5481-5592.
- [27] I. Abu-Qasmieh, H. Alquran, and A. M. Alqudah, "Occluded iris classification and segmentation using self-customized artificial intelligence models and iterative randomized Hough transform," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 11, no. 5, pp. 4037-4049, 2021, doi: 10.11591/ijece.v11i5.pp4037-4049.
- [28] A. M. D. Shafiul and H. K. Rana, "Iris recognition using convolutional neural network," *International Journal of Computer Applications*, vol. 175, no. 12, pp. 24-28, 2020, doi: 10.1109/ICSET51301.2020.9265389.
- [29] J. Daugman and C. Downing, "Recognizing iris texture by phase demodulation," *IEE Colloquium on Image Processing for Biometric Measurement*, 1994, pp. 2-1.
- [30] R. Wildes *et al.* "A machine-vision system for iris recognition," *Machine Vision and Applications*, vol. 9, pp. 1-8, 1996.
- [31] S. G. Firake and P. M. Mahajan, "Comparison of iris recognition using Gabor wavelet principal component analysis and independent component analysis," *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 4, no. 6, pp. 12334-12342, doi: 10.15680/IJIRCCCE.2016.0406293, 2016.
- [32] M. H. Hamd and S. K. Ahmed, "Biometric system design for iris recognition using intelligent algorithms," *International Journal of Modern Education and Computer Science*, vol. 10, no. 3, pp. 9-16, 2018, doi: 10.5815/ijmecs.2018.03.02.
- [33] H. K. Rana, M. S. Azam, M. R. Akhtar, J. M. W. Quinn, and M. A. Moni, "A fast iris recognition system through optimum feature extraction," *PeerJ Comput Sci*, vol. 5, p. e184, 2019, doi: 10.7717/peerj-cs.184.
- [34] D. Scherer, A. Müller, and S. Behnke, "Evaluation of pooling operations in convolutional architectures for object recognition," *In International conference on artificial neural networks*, pp. 92-101. Springer, Berlin, Heidelberg, 2010, doi: 10.1007/978-3-642-15825-4_10.

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