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Human Iris identification and recognition using soft computing techniques

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Abstract

Iris recognition is a crucial method in the field of Biometric Identification. In the modern world, a reliable and trustworthy identification system is very necessary for several reasons. Out of various biometric identification methods, iris recognition outperforms due to the uniqueness of the human eye. The study has proven that there is a difference in the right and left eye of the same individual. In this review paper, a thorough analysis of various soft technologies used for iris recognition has been discussed. Technologies like Alex Net gave an accuracy of 99.1%, open cv (Computer vision) python library gave an accuracy of 100% on the right eye iris data, and Naïve Bayes gave approx. 98% accuracy. The comparative analysis result demonstrated that the Canny edge detector, Open CV python library, biometric iris recognition, and 2D convolutional neural network gave an accuracy of 100% which are the best results and optimized technique for Iris recognition.

Keywords: Iris recognition, Machine Learning, Deep Learning, Human eye, Biometric Identification.

1. Introduction

In recent years, the field of soft technology, especially biometrics has achieved remarkable progress. Soft technologies have some significant applications that enhance security at borders, airports, mobile phones, citizen registration, criminal investigation, health monitoring, and even the repatriation efforts of Afghan refugees [1]. The term Biometrics refers to using a person's physiological and behavioural characteristics such as fingerprints, face, iris, handwriting, stride, etc to automatically identify the person's identification. It has applications indifferent fields such as health care, government, banking, transportation, public safety, and justice [2].

The recent rise in terrorism, criminal activity, and online purchasing has necessitated stricter security measures like the terrorist attack that occurred on September 11, 2001, proving that there is a need for more robust and long-lasting security measures. As a result, iris recognition technology rapidly become the preferred choice for biometric verification due to its many desirable qualities [3].

Recognition of a person through analysis of their unique iris pattern is known as Iris recognition [4]. The iris is a ring-shaped eye muscle, that regulates the size of the pupil and light intake and provides detailed information about the eye's texture when illuminated with near-infrared light. The human iris, pupil, and retina that are part of the Human eye are illustrated in Figure [5].

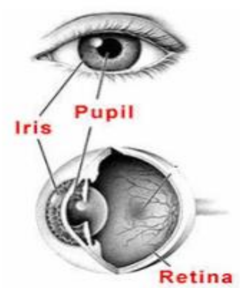

Figure 1: The Human Eye

In 1885, a French ophthalmologist named Alphonse Bertillon was the first person to suggest using iris patterns for identification purposes. Unfortunately, the concept of automated iris biometrics did not materialize due to a lack of research findings, as reported by Johnston in 1992 [6]. Later Daugman created the first famous iris detection technology in 1993 which was followed by Wildes in 1997. Many systems that aimed to increase the recognition rate were built by using the methodology of these two methods [7]. The goal of iris recognition is to automatically preprocess, analyze, and compare iris images to assign each image a unique identity label. However, there are also iris biometric programs that group iris images into different categories based on subject similarity, which helps in recognizing whether the iris scans are genuine or not by differentiating between real and fake identifications [8]. The IRS (Iris Recognition System) structure follows a seven-stage structure in both the conventional and deep learning versions. The process involves acquiring iris images, processing them, segmenting them, normalizing them, extracting the features, selecting those features, and finally classifying or matching the iris images [9]. The process involved in the iris is illustrated in the figure 2 [10].

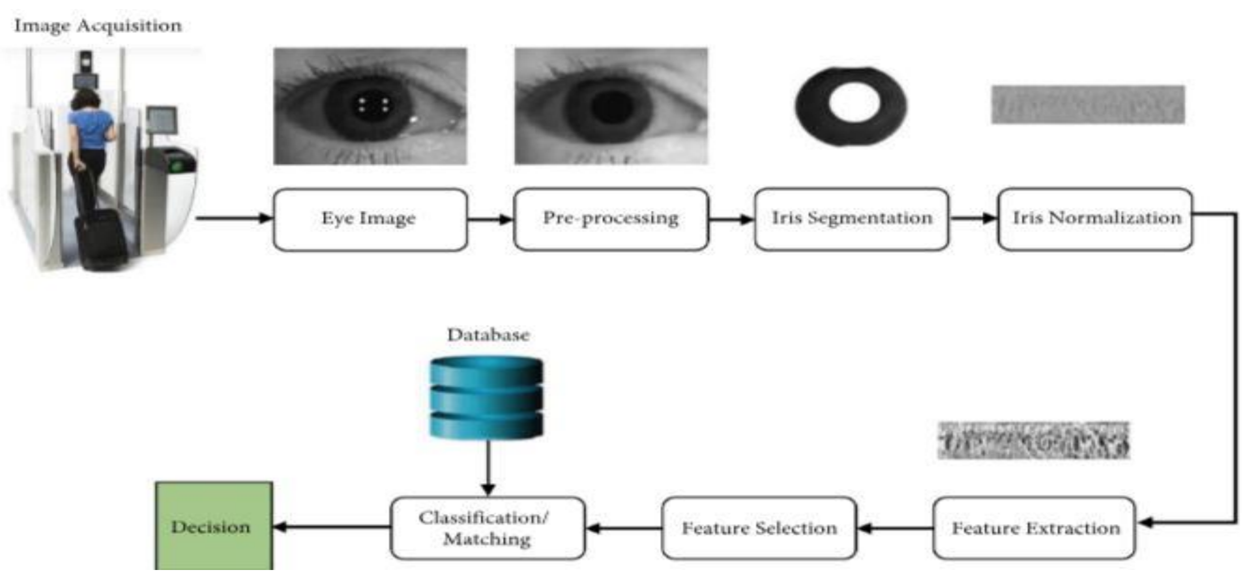

Figure 2: Fundamental system of Iris Recognition System [10].

The Iris recognition offers several advantages. Firstly, iris recognition data can be stored securely. Secondly, the iris structure is extremely difficult to manipulate, making it highly secure. Lastly, the unique physiological response of the human iris to light ensures that it is possible to differentiate real and fake iris identifications [11]. Iris recognition offers a very trustworthy means of person authentication because iris texture is considered a genotypic biometric pattern that remains constant throughout a person's life [12]. Therefore, one can verify someone's identity confidently through an iris scan [13].

1.1. Soft Technologies for Iris Recognition

Soft computing is becoming very popular in the biometrics industry due to the inherent inaccuracy and high False Rejection Rate (FRR) and False Acceptance Rate (FAR) of biometric data. There is a significant relationship between biometric recognition and systems developed with the help of Soft Computing techniques. Soft computing approaches help to adapt these changes and make them compatible with biometric recognition systems [14]. Soft computing is a method used to develop Artificial Intelligence that follows the principles of human intelligence, especially when dealing with high levels of uncertainty and imprecision. It combines various computational models like neural networks, fuzzy logic, Convolutional Neural Networks (CNNs), and evolutionary computing to work together, enabling intelligent information processing [14]. To perform iris recognition, various methods are used, including wavelet transform, zero crossing, Gabor filtering, and phase-based approaches. These methods utilize local and global characteristics of the iris [15]. Various types and applications of soft technologies that are used in biometric recognition and identification are illustrated in Figure 3 [14].

Achieving automatic feature extraction from images without the need for preprocessing is made possible through Convolutional Neural Networks (CNNs), a subset of Deep Neural Networks. Their efficiency in pattern recognition and image processing is outstanding [16]. CNNs provide advantages such as rapid convergence, reduced design complexity, and adaptability, all while maintaining the integrity of image scaling and rotation. In iris recognition, various methodologies can bring significant benefits. For instance, a hybrid approach combining neural networks and fuzzy logic, alongside genetic algorithms, has been demonstrated to exhibit superior effectiveness in human iris recognition compared to alternative methods [17].

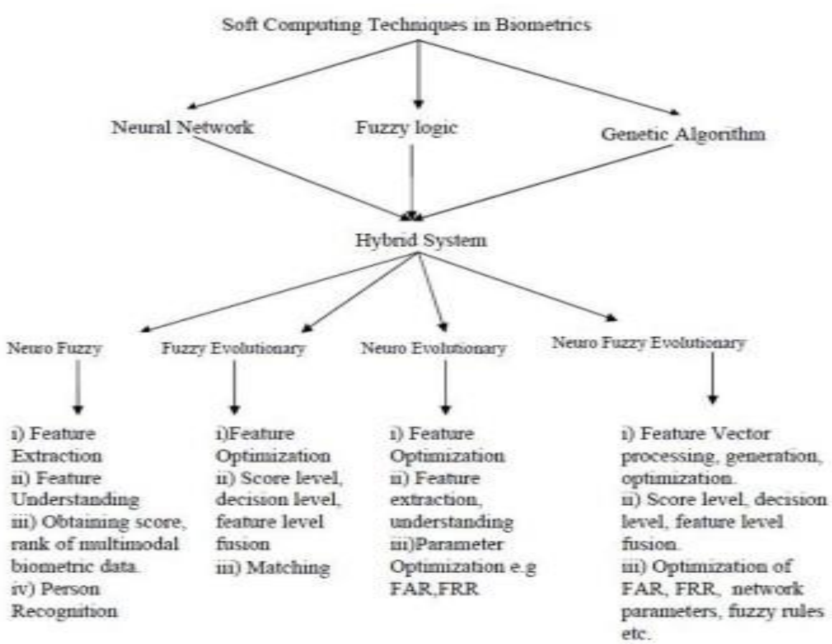

Figure 3: Applications of Soft Computing Techniques in Biometrics [14].

2 Related works

The previous studies presented in the application of Soft Technology for Human Iris Recognitionare critically examined in this section. The important research of several authors is also considered.

Hassan et al. [18] developed enhance iris segmentation method Firstly, the issue of iris outer segmentation was resolved, followed by identifying the pupil's border by utilizing techniques like gamma adjustment, Canny edge detector, image binarization, and circular Hough transform. Chinese Academy of Sciences' Institute of Automation's (CASIA) database verified and tested the system. The results showed that this approach greatly reduced the processing time and accomplished correct iris segmentation. The CASIA-V1 dataset had 100% accuracy while the V4 dataset had 99.16%.

Jamaludin et al. [19] proposed the strategy of Alexnet, a deep-learning neural network system for categorizing iris images. Initially, eyes were photographed to identify the center and the edge of the pupil. The identification was done by comparing the center of the iris. Several left-right points (MLRP) methods were used to segment the iriswith a unique pupil area feature. The square gradient decay factor (GDF) was implemented by taking out iris features to train other layers of Alexnet. Trained Alexnet irises were validated by using their suitable classifications. Iris's classification success rate was 99.1% with this system. This suggested method had an F1-score of 0.995, a sensitivity of 99.68%, and a specificity of 98.36%.

Theraret [20] implemented a biometric authentication system that continuously integrated smart cards, Public Key Infrastructure (PKI), and iris verification technologies, enhancing the robustness and security of personal authentication. Biometrics that used a personal authentication system that blended smart cards, Public Key Infrastructure (PKI), and iris verification technologies. The hardware of the IR camera was based on Raspberry Pi 4 Model B+. Open CV/Python was used for the image-processing algorithm for feature extraction and recognition. Person verification was performed for identification and system authentication using the iris function as the next step. In the NTU Iris dataset, key generation time took 5.17 seconds while signature time took 0.288 seconds and verification time took only 0.056 seconds. The system was trained to a 97% success rate on the left iris dataset, and a100% success rate on the right iris dataset.

Ghourabi et al., [21] designed a model for detecting eyes, especially among the aged population by analyzing thermal images captured by individuals. A multi-age YOLOv7 (You Only Look Once) model was trained with transfer learning and applied to normalize the YOLOv7 model error distance to 0.03, the bounding box of eyes could be scanned for the highest temperature.

Huo et al. [22] presented an iris recognition model based on deep metric learning to solve the problem of open-set few-shot iris recognition. This approach involved training a deep convolutional neural network (CNN) with the central similarity quantity as a supervisory signal, guiding the clustering of retrieved iris features towards predetermined clustering centers. This methodology was employed to enhance the discrimination capability of the feature vectors. The experimental results of IITD and CASIA-Iris-Interval iris datasets showed that the model developed in this study performed excellently for open-set few-shot iris identification. For the two datasets, their respective Equal Error Rate (EER) scores are 0.24% and 0.93%.

Singh et al. [23] investigated the influence of pupil dilation on biometric iris recognition (BIR) systems for individual authentication and identification from subjects ranging from November 2017 up to November 2019. The IRITECH-MK2120U scanner was used to enroll subjects with non-dilated pupils. A significant effect of the size of the pupil on Hamming distance at Probability < 0.05 and after dilatation all three hundred twenty-one eyes were matched. This research recorded a perfect recognition rate of 100% without any false matches. Based on this study, a BIR system was reliable for personal authentication and identification.

Alwawi et al. [24] proposed a solution for the recognition of the human iris using a 2D Convolutional

Neural Network. The system used some data that had been preprocessed and enhanced via methods such as contrast-limited adaptive histogram equalization and data augmentation to extract features as well as classify the iris patterns. The convolutional neural network (CNN) architecture consisted of convolutional, ReLu, pooling, fully connected, and Softmax layers. Adam optimizer with a backpropagation algorithm was used to train and update weights in the model. The system achieved a combined training accuracy of 95.33% within less than twelve seconds and a testing accuracy of 100%.

Shaker et al. [25] presented a method for identifying human iris. The Navie-Bays method was used for person identification. Uni-Netwas activated to extract features from iris sections, while another sub-net handled parts that did not contain iris information. On the CASIA-v4, ITT-Delhi, and (Multimedia University) MMU datasets, the approach achieved accuracy scores of 98.55%, 99.25%, and 99.81%, respectively. With just 17.58 minutes of training time, the method improved preprocessed patterns and achieved an overall accuracy of 95.31%.

Therar et al. [26] suggested a real-time multi-dimensional biometric approach that used iris visuals and a deep learning algorithm. The system incorporated a backpropagation method, Adam's optimization strategy, convolutional neural networks, and transfer learning approaches. The study evaluated the system's performance on two publicly available datasets, IITD, and CASIA-Iris-V3 Interval. The outcomes showed an accuracy of 99% on the left as well as right iris shortly after training, and 94% and 93% accuracy on the CASIA-iris-V3 interval datasets, respectively.

Zin et al. [27] suggested an approach to segment the soft lens boundary in the iris which was difficult because of the flash lighting's variable illumination and low contrast. For better contrast and more uniform intensity distribution, three picture enhancement methods were suggested. For automated visibility situation classification of the contact lens edge, a histogram approach was employed; for directed magnitude determination, the detection algorithm was employed. Using the Notre Dame Contact Lens Detection 2013 database, the approach was tested and showed that segmented the lens boundary result in attaining aprecision of more than 92%.

Mostofa et al. [28] investigated the utilization of deep convolutional generative adversarial network (DCGAN) designs to enhance iris detection. Utilized convolutional generative adversarial networks (cGANs) as their foundational architecture, two novel approaches were produced: first, training a cGAN to convert cross-resolution and cross-spectral tasks into a single, consistent resolution and spectrum; and second, designing a coupled generative adversarial network to project near-infrared and visible-light iris images into a low-dimensional. The findings outperformed the existing literature. With a (False Acceptance Rate) FAR of 0.01 and recognition accuracy with lower EER (Equal Error Rate) values of 1.5% and 1.54% for the PolyU bi-spectral dataset and Cross-eyed spectrum database, respectively. The cGAN network surpassed the current benchmark convolutional neural network by 1.67% and 2.22%.

Soliman et al. [29] presented an innovative cancelable iris identification system based on comb filtering. It employed Gabor filtering to extract features after first localizing the iris from a coarse to a fine level. An iris-representative feature pattern was created by the comb filtering distortion process; the pattern can be canceled and reignited using the comb filter order. The experiments were implemented on the CASIA-IrisV3 database and compared with the findings of a cancelable random projection strategy. Both privacy and performance were significantly improved by the comb filtering approach, which achieved a peak precision of 99.75% at order 6 and an excellent EER of 0.36% at order 10.

3 Discussion

Various Soft technologies such as machine learning models, deep learning models, and many algorithms are discussed to implement Iris recognition.The comparative analysis of the models discussed in related work and the advantage of soft technology for iris recognition is illustrated in Table 1.

Table 1:Comparative analysis

Author	Technique	Outcome
Hassan et al.,[18]	Canny edge detector	For the two datasets, the corresponding accuracy rates are 100% and 99.16%.
Jamaludin et al., [19]	Alexnet	The method had an F1-score of 0.995, a sensitivity of 99.68%, a specificity of 98.36%, and a 99.1 percent success rate for iris classification
Therar et al., [20]	OpenCV/Python library	The system attained an accuracy of 97% for the left iris dataset and 100% for the right NTU dataset
Ghourabi et al.,) [21]	Transfer learning	The model achieved a Mean average precision of 0.996 and Frames per Second of 150.
Huo et al., [22]	Deep convolution neural network	The research model demonstrated Equal Error Rate scores of 0.24% and 0.93% for the IITD and CASIAIrisdatasets.
Singh et al., [23]	Biometric iris recognition (BIR)	A 100% recognition rate was achieved after pupil dilation, indicating that topically dilated pupils do not cause non-recognition.
Alwawi et al., [24]	2D CNN	The system achieved a total training accuracy of 95.33% and a testing accuracyof 100% in under 12 seconds.
Shaker et al., ([25]	Navie-Bays and Uni-Net	The approach achieved 98.55%, 99.25%, and 99.81% accuracy on CASIA-v4, ITT-Delhi, and MMU datasets
Therar et al., [26]	Iris visuals, CNN, and transfer learning	The training results were99% accurate on both left and right iris, and 94% and 93% accuracy on the CASIAirisV3 interval datasets.
Zin et al., [27]	The ridge detection algorithm	The Notre Dame Contact Lens Detection 2013 was used, achieving over 92% accuracy.
Mostofa et al., [28]	DCGAN	False Acceptance Rate of 0.01 and recognition accuracy of 1.5% and 1.54% for PolyU.
Soliman et al., [29]	Comb filtering	Achievedan accuracy of 99.75% on order 6 and an excellent Equal Error Rate of 0.36% on order 10.

4. Conclusion

The human iris has a feature called genotypic biometric pattern that remains constant throughout a person's life making the iris recognition most prominent in the field of biometric identification. This paper provides a thorough survey of diverse soft technologies, with a specific focus on the role of the human eye iris in iris recognition. Soft technologies are important for iris recognition as they make iris recognition easier by automating them and surpassing all the limitations of traditional iris recognition approaches. According to today's world condition, Iris recognition has become the most reliable biometric identification method due to the unalterable pattern of the human iris. Iris recognition is dominating in every field like Aadhar card generation, any national-level examination, and SIM card generation every national-related field now requires iris recognition.

The study discusses many soft technologies that can be implemented to make a suitable Iris recognition system. Soft technologies like Canny edge detector were implemented on the CASIA dataset giving an accuracy of 100%, Alex net gave a 99.1 percent success rate for iris classification, Open cv gave an accuracy of 97% on the left iris dataset (NTU) dataset,YOLOv7 model surpassed all the version of YOLO model. Among all models considered, Biometric iris recognition, Canny edge detector, Transfer learning, and 2D Convolutional Neural Network emerged as standout performers, achieving a remarkable 100% accuracy across diverse datasets for iris recognition. This outstanding achievement highlights the possibility of additional progress in improving and combining these state-of-the-art technologies. Looking ahead, future plans include more research to make iris recognition systems more reliable and flexible so they can be used in more real-world scenarios.

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