Iris Biometric Based Person Identification Using Deep Learning Technique

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Abstract - *Nowadays Iris recognition is commonly utilized in biometrics and is the most effective technique for identifying individuals. In comparison to other biometric modalities, iris recognition has a better chance of achieving high-precision recognition. Iris pattern recognition is one of the most efficient biometric authentication methods. This paper presents a person identification based on iris using deep learning approach. The iris images are pre-processed to eliminate specular reflections by employing morphological operator; the iris segmentation is performed with Daugman's Operator and normalized by Daugman's rubber sheet model. Furthermore, the pre-trained deep learning model ResNet-50 is loaded with normalized iris images and feature extraction is made using fully connected layers. Finally, person identification is performed using Multiclass SVM. The proposed method is evaluated on VISA Iris Database and obtained promising accuracy of around 95%.*

***Key Words*: Iris recognition, Deep learning, ResNet-50**

1. INTRODUCTION

In recent years, biometric recognition has become indispensable in person identification applications. In a person's life, security serves an essential and active part. People cannot pay online, log on to a website, or pass security screenings without first being confirmed. Using acquisition devices such as cameras and scanners to capture an individual's physical features (face, hand, iris, and fingerprint). Each person has unique qualities that set them apart from other people. Nobody has the same voice, fingerprint, or set of eyes as another person, for instance. Biometrics is a term that refers to technologies that study and measure human body features for the purpose of authentication. There are two ways that biometric systems can function. In verification mode, the system analyses the user's identification and biometric information with the database template. This template is saved at the enrolment stage, which involves a one-to-one comparison. Next in Identification mode, here the system looks for a match among all user's templates in the database to identify the user (one to many comparisons). Iris recognition is more accurate than any other biometric recognition technologies. Due to the presence of distinct patterns iris biometrics provides maximum level of security compared to face and fingerprint biometrics. The colour of the iris determines the colour of the eye. The texture of iris will be created through a chaotic process that has nothing to do with human genetics. Iris is a well-protected internal organ of an eye. Iris patterns are formed within six months after birth. The iris has an average diameter of 12 mm as shown in fig1.The opaque-coloured region of the eye that surrounds the pupil is known as the iris. Iris patterns are unique for identical twins and also every individual has distinct left and right iris patterns.

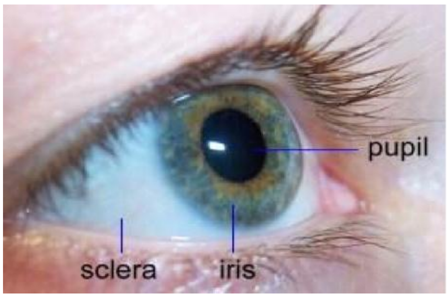


Figure.1. Image of an eye representing iris, pupil, sclera

Deep learning is used for the faster authentication and the models have very high level of accuracy in recognizing iris features. The left and right both eyes are considered for recognition. Iris recognition has many applications in airports, banking, border security and also the Indian government launched Aadhaar, a Unique Identification Authority of India (UIDAI) scheme in which more than a billion people's biometrics, including iris patterns, were enrolled.

2. RELATED WORK

Iris biometric is more accurate and highly protected trait among all the physiological modalities. Many researchers have contributed algorithms/methodologies for Iris recognition. The summary of some of the Iris recognition employing the deep learning is depicted in the following. Omar Medhat Moslhi [1] introduced a new iris segmentation method that employs a deep convolutional neural network (CNN) with the DenseNet-201 iris classification model. CASIA Iris-Thousand, CASIA Iris Interval, UBIRIS Version 1, and UBIRIS Version 2 datasets were considered for evaluation and gained accuracy of 99.32% , 100 %, and 98.29 % respectively.

Hammou Djalal Rafik and Mechab Boubaker [2]have used the knowledge gained from the weights that have been pre-trained in ImageNet's dataset and data-augmentation process is made easier using applied transfer learning. The MMU1 database was used to test the VGG16, DenseNet169, and Resnet50 CNN models, which yielded accuracy of 96.10 percent, 93.50 percent, and 98.70 percent, respectively.

Maryim Omran, Ebtesam N. AlShemmary 2020 [3] proposed the use of the irisnet system, which automatically extracts features and classes objects without the use of domain expertise. Convolutional Neural Network layers for feature extraction are part of the Irisnet architecture, along with a Softmax layer for feature classification into N classes. The suggested system's performance was measured using the IITD V1 iris database. The original and normalized image identification rates were 97.32 percent and 96.43 percent, respectively.

Aidan Boyd et al., 2020 [4] proposed a method to determine if models trained for non-iris tasks underperform iris-specific feature extractors, according to research that looked at five alternative weight sets for the well-known ResNet-50 architecture and put them to the test on the CASIA-Iris-Thousand database. The features of each convolutional layer are recovered, and the classification precision of a Support Vector Machine is evaluated on a dataset unrelated to the training samples of the ResNet-50 model.

Md. Shafiul Azam and Humayan Kabir Rana 2020 [5] presented an efficient method and to improve recognition rate, convolutional neural networks (CNN) and for the purposes of feature extraction and classification, support vector machines (SVM) were utilized. The methods were evaluated on CASIA dataset and achieved an accuracy of 96.3%.

Swati D. Shirke and C. Rajabhushnam 2019 [6] presented a method that uses Probabilistic Neural Network (PNN) algorithm. Median based filters and diffusion filter process are applied for de-noising along with that Hough transform is used to extract the various iris image curves or forms., spatial FCM was applied for segmentation Daugman's method for normalization. The methods were tested on CASIA V4 database.

Shervin Minaeeet et al., 2019 [7] proposed a deep learning framework based on residual convolutional neural network and transfer learning technique and the iris images were classified using ResNet. Also presented a visualization strategy for detecting significant areas in iris images.

Alaa S. Al-Waisy et al., 2017 [8] the suggested system's performance is evaluated using three public datasets acquired under various conditions: The iris databases, CASIA-IrisV1, SDUMLA-HMT, and obtained an accuracy of 99.07 and 96.99% respectively.

3. Proposed Methodology

The Proposed Iris recognition architecture based on transfer learning approach is shown in Fig 2.

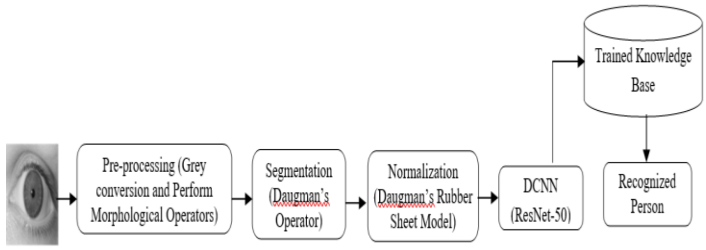


Fig.2. The Proposed Block Diagram for Iris Recognition

I Image Acquisition: The human iris information is embedded in both of the eye. In order to extract the iris image from both the eyes, the eye images are collected from the camera. For experimentation the publically available iris dataset namely VISA dataset is collected [9]. The VISA database was created using a simple image acquisition setup and devices to collect biometric information from people in uncontrolled situations. The VISA dataset consists of iris images obtained from 100 individuals in both indoor and outdoor from age group between 10 to 90 years. Some of the samples of Iris images of VISA database are shown in Figure 3.

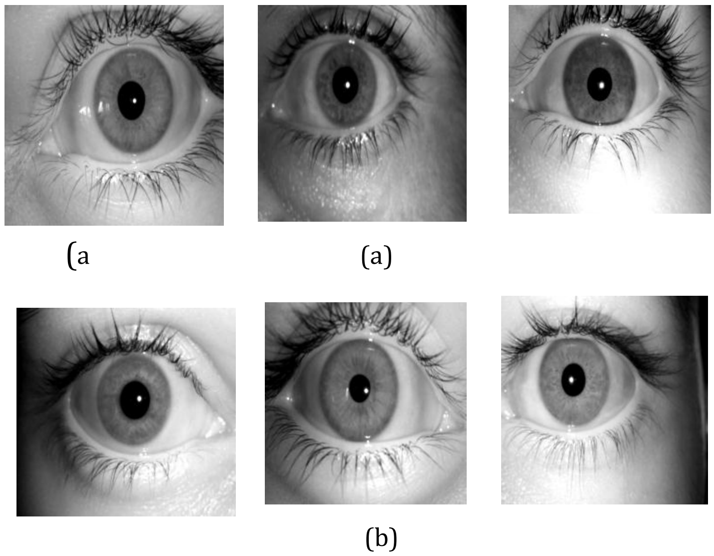
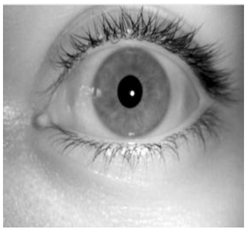
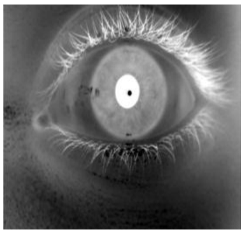
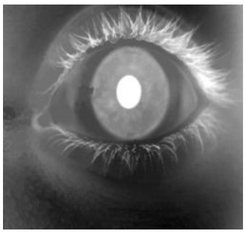


Fig.3. Sample Iris images of VISA database from (a) Right Eye (b) Left Eye

Pre-processing: The main goal of pre-processing is to reduce the noise present in the images and to enhance the image quality and to extract the region of interest. To maintain the uniformity and reduce the computational complexity the Iris images are converted from RGB to greyscale and resized to 640×480-pixel resolution. The light reflections present in the eye will cause obstacles in Iris detection and further recognition process. The light reflections in Iris images are alleviated by employing the morphological operators viz. complement and fill. The image complement operator is used initially to lighten dark regions and darken light parts. Further the image fill operator is applied to the complemented image, filling in the dark region with intensity similar to that of its surroundings. The image complement operator is applied once again to convert the light region to darker and dark region to lighter which removes specular reflections.

(a) (b)




(b) (d) (c)

Figure4. (a) Input Image (b) Complemented Image (c) Filled Image (d) Complemented image that has no specular reflections

Iris Segmentation/Localization: The basic purpose of iris segmentation is to remove non-essential portions of the input eye image, such as eyelids and eyelashes, and consider only iris for feature extraction. Iris localization is the process of locating the pupil and iris from an eye image. The system will fail to detect the person if the iris cannot be properly located. Segmentation is a very crucial stage in order to discern inner and outer boundaries. There are various segmentation methods available, namely Daugman's Integro-differential operator, Hough Transform and active contour models. The proposed methodology uses Daugman's Integro Differential Operator (DIO) algorithm due to its performance in iris recognition and it uses first derivative information to compute faster. To segment the circular iris and pupil regions, as well as the arcs of the upper and lower eyelids, Daugman's integro-differential operator is applied. The Daugman's operator searches the input image pixel by pixel and is defined as follows:

$$max_{(r,x_0,y_0)} \left| G_{\sigma(r)} * \frac{\partial}{\partial r} \oint_{(r,x_0,y_0)} \frac{I(x,y)}{2\pi r} ds \right| \qquad (1)$$

Where: $I(x, y)$ is the eye image, r is the radius, $G_{\sigma(r)}$ is a Gaussian Smoothing function with scale σ that searches iteratively for a maximum contour integral, * denotes convolution and S is the contour of the circle given by the parameters (r, x_0, y_0). For obtaining the correct location of eyelids, the operator searches for the circular path by changing the maximum pixel values by adjusting the radius and centre x and y position of the circular contour. The Segmentation process is shown in the figure 5.

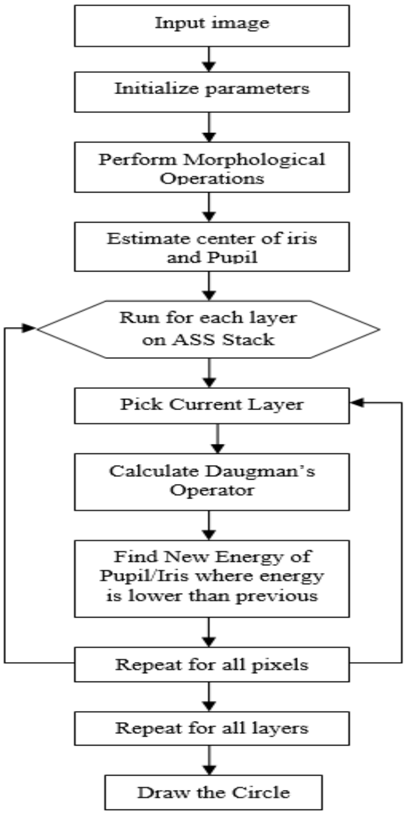


Fig 5. Segmentation using Daugman's Method

Normalization: The geometric shape of the iris is transformed to a rectangular shape during normalization. Normalization is used to reduce segmented iris pictures to a standard size so that features can be extracted properly. There are many normalization methods available such as Daugman's Rubber Sheet Model, Virtual Circles method and Wilde's Image Registration Technique. Here rubber sheet model is applied and the main advantage is that it reduces inconsistencies in iris images. To normalize the segmented iris region Daugman proposed a rubber sheet model which will remap all the Cartesian points in the iris region into polar coordinate (r, θ) system.

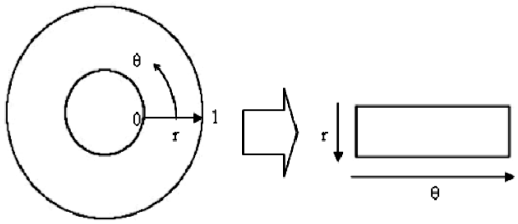


Fig.6. Daugman's Rubber Sheet Model

The non-concentric polar representation is normalized to a rectangular block of a specific size. The normalization by Daugman's Rubber Sheet Model that is the iris region is remapped to the pair of polar coordinates that is represented by (r, θ) into a Cartesian coordinate *(x, y)* and is given by:

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \quad (2)$$

$$x(r,\theta) = (1-r)x_p(\theta) + rx_1(\theta) \quad (3)$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_1(\theta) \quad (4)$$

Where: *I(x, y)* is an image of the iris, *(x, y)* are Cartesian coordinates, (r,θ) are the corresponding polar coordinates and x_p, y_p, x_1, y_1 are the pupil and iris border coordinates along the direction of angle θ.

The process of Daugman's Rubber Sheet Model is depicted in flow diagram as shown in fig 7.

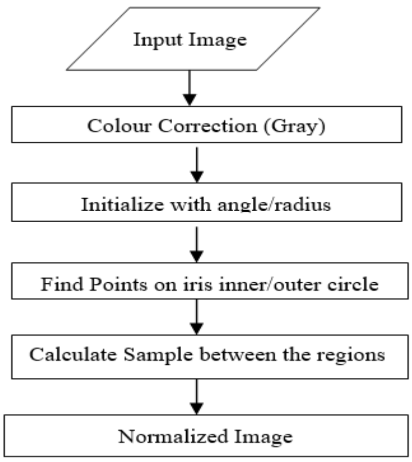
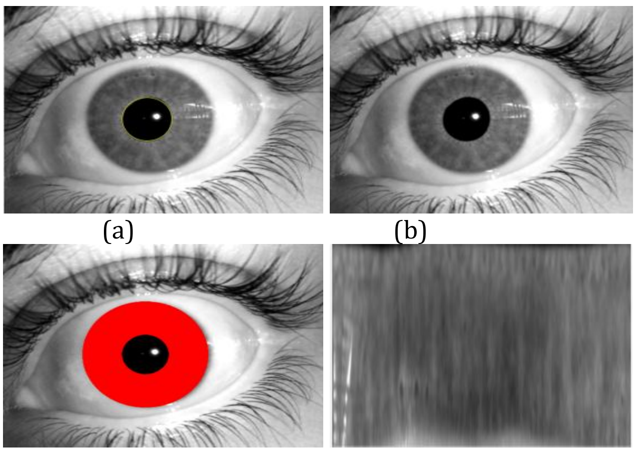


Figure 7. Daugman's Rubber Sheet Model



(a) (b)
(c) (d)

Figure. 8. (a) Input Image (b) Pupil Detection
(c) Iris Segmentation (d) Normalized Image

The Architecture of ResNet-50 Model

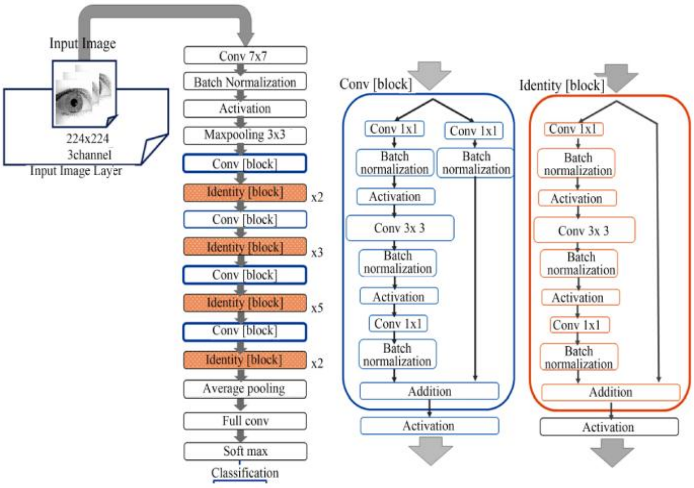


Figure .9. ResNet architecture for proposed Model

ResNet-50 Consists of 3-channel image input layer and the symbols ×2, ×3, and ×5 in the figure are the number of blocks.

Structure of a convolution block where input dimension varies. Identity block structure with a constant input dimension.

The ResNet-50 model is utilized in the experiment. The following diagram illustrates the fundamental structure of the implemented network architecture. The ResNet-50 model contains 16 processing blocks in addition to two kinds of shortcut modules. One of them is an identification (ID) block module, and features a convolutional layer-free shortcut path (the input has the same dimension as the output). The second type of module is referred to as a convolutional block module. It consists of a convolutional layer located in the shortcut path (the dimension of the input is smaller than that of the output). These modules have bottleneck structures consisting of a single block with layers (1X1, 3X3, 1X1 convolutional layers).

Performance Metrics

Genuine Accept Rate (GAR): It is the proportion of input samples that were correctly classified to all of the input samples.

False Reject Rate (FRR): It is the ratio of trained input samples that are falsely classified that is 1-GAR.

False Accept Rate (FAR): It is the ratio of samples which are not trained that are mistakenly recognized correctly.

Total No. of Images	GAR	FRR	FAR
180	0.95	0.05	0.01

Table1. Shows the ratio of GAR, FRR, FAR

Conclusion

This paper proposes a secure authentication system by using Iris biometric. The proposed method is experimented with VISA Iris Database. The method employs morphological operators for pre-processing, Daugman's operator for segmentation and Daugman's rubber sheet model for normalization. Deep learning technique namely ResNet50 is integrated with Multiclass SVM for performing effective feature recognition and person identification. The proposed system achieved genuine acceptance rate (GAR) of 0.95%, False Reject Rate (FRR) of 0.05% and False Accept Rate (FAR) of 0.01%. Furthermore, the proposed system can be extended to other Iris databases. In future the Iris biometric can be combined with other biometric modalities with optimal fusion rule and method to enhance system security with increasing the user authentication.

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