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DEEP LEARNING BASED BIOMETRIC IRIS RECOGNITION

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Abstract— Biometric iris recognition is the most reliable and accurate technology among other biometric technologies like finger print mapping, facial recognition and voice recognition. The stability in the structure of the iris over time is the main reason behind this. This paper proposes a deep learning based iris recognition system using an efficient convolutional neural network architecture. The area of computer vision has achieved great results in the recent years through convolutional neural networks (CNN). The ability of CNN to learn complex features of each input iris image and to classify an unseen image with high accuracy makes the system highly efficient and suitable for identification task.

Keywords— Biometrics, Iris Recognition, Convolutional Neural Network, Authentication, Deep Learning, Feature Extraction

1. INTRODUCTION

The term biometrics refers to biological characteristics or behavioral characteristics of an individual. Biometric authentication is a highly reliable identification and access control method which is difficult to forge. Iris recognition is widely considered to be the most accurate method of biometric identification technology. The fact that complex patterns of iris is unique for every individual is the reason behind the high accuracy of biometric iris recognition. The complex patterns of iris remain stable throughout the life of the individual which contributes to the high reliability of this technology. The iris recognition process is contactless thus, hygienic. Iris recognition is the process involves capturing images of people's eyes and mapping unique iris patterns from it in order to authenticate them.

Iris recognition has a wide span of applications in border security, banking, authentication to machines, tracking missing and wanted people, home and buildings access control, person verification etc. United Arab Emirates Homeland Security Border Control has been operating an expellee tracking system using iris recognition technology [8]. US and Canadian airports facilitate entry into the US and Canada for preapproved, low-risk travelers by employing iris recognition [8]. Iris scanners are used by Google to control access to their datacenters [9]. Indian government enrolled the iris patterns and other biometrics of more than one billion citizens through a scheme called Aadhaar in 2011 run by the Unique Identification Authority of India (UIDAI) [9].

Iris recognition process generally follows a series of stages. The initial stage is called preprocessing stage which consists of localization of the iris region from the eye images, normalization of the localized region and enhancement. The next stage is the feature extraction stage and it is the most important stage of iris recognition process. In this stage the most significant features of the iris is extracted. In the final stage, a template matching is performed in order to authenticate the individual.

2. RELATED WORKS

Daugman received a patent for his pioneering work in the history of biometric iris recognition and his work became a standard reference model for iris biometrics [1]. Integro-differential operators are used in this work to extract the iris region. The image normalization is performed by means of cartesian coordinates to polar coordinates conversion. 2D Gabor wavelets is used for feature extraction of iris and template matching is achieved using Hamming distance.

Wildes proposed an iris recognition system in which iris region is localized using canny edge detection followed by applying circular Hough transform. A Laplacian of Gaussian filter at multiple scale was employed in this work for extracting features [2]. Boles and Boashash proposed an iris recognition model by using wavelet transform for feature extraction. The template matching was carries out by employing

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two dissimilarity functions between the iris image and iris template [3].

In recent years, several works have attempted to use deep learning techniques for iris recognition task. The authors in [4] proposed a deep learning based iris recognition system by manoeuvring a pre-trained convolutional neural network architecture called Alex-Net for feature extraction and support vector machine for classifying the images. Minaee and Abdolrashidi proposed an end-to-end deep learning framework for iris recognition by employing a residual convolutional neural network, which can jointly learn the complex features and perform identification [5]. The authors of [6] developed an efficient convolutional neural network based iris recognition system. In the preprocessing stage, the iris region is extracted and divided into eight rectangular sub-regions to feed into the CNN model for training. The authors in [7] proposed an iris recognition system by employing a pertained network called VGG-Net to extract the significant features. They have used a multi-class support vector machine for classification.

3. PROPOSED SYSTEM

The proposed iris recognition system has two stages: the preprocessing stage and the feature extraction & classification stage. Fig. 1 shows the architecture of the proposed system.

3.1. PREPROCESSING

Iris datasets usually consists of eye images of different individuals. To yield good results, the iris portion of each image is localized and the circular iris region is converted to a rectangular block. Then each image undergoes an enhancement process to project its features. Hence, image preprocessing has three stages: iris localization, iris normalization and enhancement. These three processes together prepare the images well for feature extraction and classification with convolutional neural network.

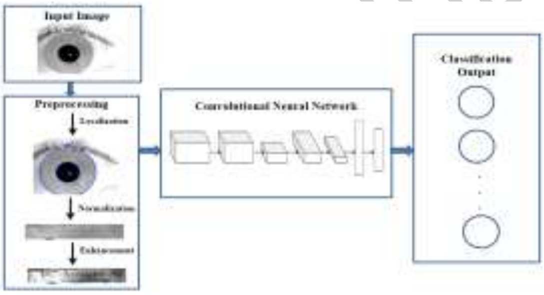

Fig. 1 Architecture of the proposed system

3.1.1. IRIS LOCALIZATION

Iris is the annular portion of the eye which surrounds the pupil. By performing localization in the eye images, iris regions are extracted. The eye images are initially filtered using morphological filters and smoothed images are obtained. Circular Hough Transform is then applied on the smoothed images to find the annular boundaries of iris. Fig. 2 shows the localized iris image. A circular Hough transform is an image transform that allows for circular objects to be detected from an image. Initially an edge map is produced by applying an edge detector to the image. Each (x, y) points in the edge map, votes for a circle in the Hough parameter space centered with center (x, y) and radius r. Circle with most votes is selected from all the possible circles.

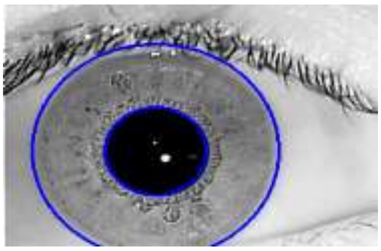

Fig. 2 Localized iris image

3.1.2. IRIS NORMALIZATION

Images in dataset may have some variations in terms of camera distance or illumination. With changes in the illumination, the radial size of the pupil may dilate or contract. Iris normalization is performed to compensate these variations in iris images. Homogeneous Rubber Sheet Model which was proposed by Daugman [1] is used to map the iris ring to a rectangular block of fixed size by means of cartesian to polar reference transform.

This method resolves the problems such as dilation and contraction of the pupil as well as camera distance variation. Fig.3 shows a normalized iris image.

Fig. 3 Normalized iris image

The rubber sheet for normalization is a linear model that assigns to each pixel of the iris (x, y), a pair of real coordinates (r, θ). The mapping of iris image can be represented as in equation (1),

$$I(x(r,\theta), y(r,\theta)) = I(r,\theta) \qquad (1)$$

Where $x(r,\theta)$ and $y(r,\theta)$ are the linear combinations of set of pupillary boundary points $(x_i(\theta), y_i(\theta))$ and the set of iris boundary points $(x_j(\theta), y_j\ (\theta)$ as in equation (2).

$$x(r,\theta) = (1-r) * x_i(\theta) + r * x_j(\theta)$$
$$y(r,\theta) = (1-r) * y_i(\theta) + r * y_j\ (\theta) \quad (2)$$

Daugman's rubber-sheet model for remapping of iris region is illustrated in Fig. 4.

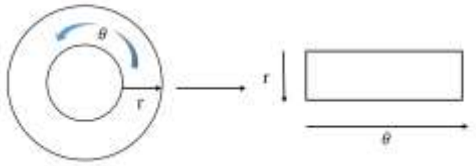

Fig. 4 Daugman's rubber sheet model

3.1.3 IRIS ENHANCEMENT

The normalized images have to undergo image enhancement in order to improve the quality and contrast of an image. Image enhancement will ensure a well distributed texture image, which will complement the feature extraction process of the convolutional neural network. Fig. 5 shows the output image which undergone image enhancement.

Fig. 5 Enhanced iris image

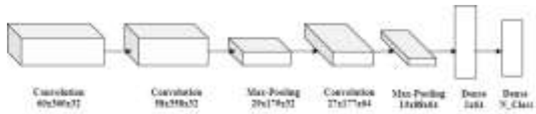

Fig. 6 Convolutional neural network architecture

A histogram equalization technique is used for enhancement of normalized iris image. It is a process of transforming an original image into equally likely intensity image. It will increase the contrast of the image.

3.2. FEATURE EXTRACTION AND CLASSIFICATION

A convolutional neural network is used for feature extraction and classification. A deep learning approach can learn the complex patterns of the iris better than a hand crafted method. Convolutional neural network is a deep learning model based on supervised learning. A supervised learning algorithm has known set of labels. The convolutional and pooling layers are the used for learning the features and the fully connected layer is responsible for the classification.

The proposed system consists of three convolutional layers, two max-pooling layers and two dense layers. The first layers is a convolutional layers with number of filters 32 and kernel size 3*3 with same padding. The second layer is also a convolution layer with 32 filters and 3*3 kernel size. The third layer is a max-pooling layer with 2*2 kernel. Forth layer consists of another convolutional layer with 64 filters and 3*3 kernel. The fifth layer is a max-pooling layer with 2*2 kernel. The following layer is a dense layer with 64 neurons and ReLu activation. ReLu activation function is used in all the convolutional layers. The final dense layer has neurons equal to the number of classes and a softmax activation function is applied in this layer for classification.

4. EXPERIMENTAL RESULTS AND ANALYSIS

This work is implemented in Python language using Keras library with TensorFlow back-end. The Iris image dataset provided by IIT Delhi is used for as the input data to the network. The resolution of these images is 320*240 pixels and all the images are in bitmap (*.bmp) format.

The result of localization using circular Hough transform on the IIT Delhi dataset sample is shown in Fig. 7.

Fig. 7 Images with iris localized

Fig. 8 shows the result of iris normalization using Daugman's rubber-sheet model. The resolution of the normalized image is 60*360.

Fig. 8 Normalized iris images

The outcome of image enhancement using histogram equalization is shown in Fig 9. The resolution of the enhanced image is same as the resolution of the normalized image.

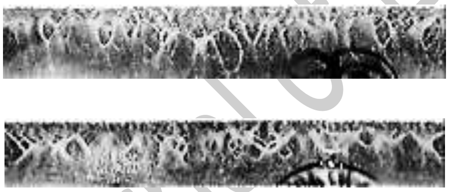

Fig. 9 Enhanced iris images

The convolutional neural network yields training accuracy of 96.67% and validation accuracy 100% in the data of 15 classes of iris images of IIT Delhi dataset. Plot between training accuracy and validation accuracy is shown in Fig.
10. X-axis represent epochs and Y-axis represents accuracy.

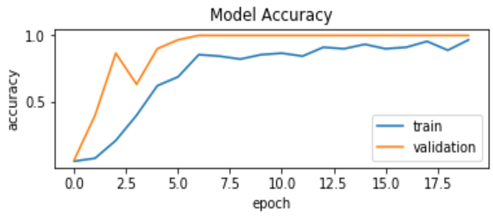

Fig. 10 Plot of accuracy of the model

The plot between training loss and validation loss is shown in Fig. 11. X-axis represent epochs and Y-axis represents loss.

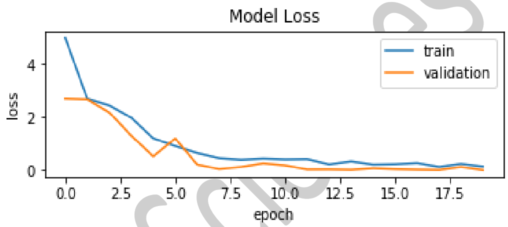

Fig. 11 Plot of loss values of the model

5. CONCLUSION

This work attempts a deep learning approach towards iris recognition task as iris recognition is the most accurate biometric technology among other technologies. Deep learning is a branch of machine learning in which deep neural networks learns features by itself from the input data. A deep learning architecture called convolutional neural network is employed in this work to perform the iris recognition considering it as a classification problem. The input iris images are preprocessed before feeding it to the convolutional neural network. The system yields a training accuracy of 96.67% and accurately predicts all the unseen images in the test dataset.

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REFERENCES

[1] Daugman, J. 1994. Biometric Personal Identification System Based on Iris Analysis. Google Patents.

[2] Wildes, R. P. A., Green, G. L., Hsu, S. C., Kolczynski, R. J., Matey, J. R., and McBride, S. E. 1994. A System for Automated Iris Recognition. IEEE. Workshop on Applications of Computer Vision. 121-128.

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ISSN NO:0377-9254

[3] Boles, W. W. B. B. 1998. A Human Identification Technique Using Images of the Iris and Wavelet Transform. IEEE Transactions on Signal Processing. 46: 1185-1188.

[4] Alaslani, Maram. G and Lamiaa A. Elrefaei. "Convolutional Neural Network Based Feature Extraction for IRIS Recognition." International Journal of Computer Science and Information Technology 10 (2018): 65-78.

[5] Minaee, Shervin & Abdolrashidi, Amirali. (2019). DeepIris: Iris Recognition Using A Deep Learning Approach.

[6] W. Zhang, C. Wang and P. Xue, "Application of convolution neural network in Iris recognition technology," 2017 4th International Conference on Systems and Informatics (ICSAI), Hangzhou, 2017, pp. 1169-1174.

[7] S. Minaee, A. Abdolrashidiy and Y. Wang, "An experimental study of deep convolutional features for iris recognition," 2016 IEEE Signal Processing in Medicine and Biology Symposium (SPMB), Philadelphia, PA, 2016, pp. 1-6.

[8] Olatinwo, S.O. & Shoewu, Oluwagbemiga & Omitola, Olusegun. (2013). Iris Recognition Technology: Implementation, Application, and Security Consideration. The Pacific Journal of Science and Technology. 14. 228-233.

[9] Wikipedia contributors. "Iris recognition." Wikipedia, The Free Encyclopedia. Wikipedia, The Free Encyclopedia, 10 Jun. 2020. Web. 17 Jun. 2020.