

Iris Recognition System Using Integro Differential Model & Convolution Neural Networks

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ABSTRACT

Authorizing someone has become a substantial need in today's world.. In such circumstances, the integration of artificial intelligence into biometric systems has changed the way people lived and operated at various stages of their lives. Identifying a person basically works in two ways: characteristic or behavioral traits, like palmprint, earprint, iris, face & fingerprint etc. In this paper ,we have worked on Iris based Recognition System as it is one of the most reliable & secure biometric. In our work we have proposed modified segmentation technique(DaughmanIntegroDifferential) and efficient Convolution Neural Network (CNN) structure. We performed our experiments on CASIA iris database Version 1(v-1) consisting of 756 images in 108 folders having 7 images each and have obtained an accuracy of 98%.

Keywords

CNN, Daughman Differential model, iris, iris recognition, Median Blur, Neural Network

INTRODUCTION

As the digital technology advances People are managing massive amounts of information, including both public and private information using digital systems such as computers, mobile phones, banking and government management systems, and the internet. While public information can be available for others but private information needs to be secured from others. Hence protection has become an important term in digital systems. People have traditionally used two methods for this task: knowledge-based and token-based methods . To access a specific information resource using the knowledge-based method, each user must create and remember a password. The token-based method, as the second option, provides a key in which a user's identification information is stored for accessing information resources. However the key can be misused or stolen from the other and hence security was a major concern. To address such issues, a biometric system was developed. Biometric systems are those that use physical/behavioral characteristics such as the iris, face, fingerprints, and so on to identify people[1].

Iris recognition systems are widely used in security applications because they have a diverse set of features and do not change significantly over time[2]. The abundance of texture form in an iris identification system is used to identify individuals. It's made up of a group of dilator muscles and sphincter muscles that enable the pupil to dilate and contract. Collarette is a section of the iris that separates the ciliary and pupillary zones. A series of radial streaks caused by connective tissue bands that enclose the crypts straighten when the pupil contracts, and they become wavy when the pupil dilates.

The pupillary and limbus borders in 2D photographs of the eye determine the iris spatial spectrum and aid in distinguishing it from other ocular structures such as the eyelids, eyelashes, pupil, and sclera. The enriched textural details on the anterior surface of the iris provide a simple biometric signal for human recognition.[3]

Iris recognition has five stages: Preprocessing, localization, normalization, Feature extraction and classification. Each stage employs a distinct set of techniques.

Localization is a method of locating that involves isolating the exact structure of the iris from an image of the eye. This procedure serves as a lead for an iris recognition model. Gradient-based

algorithms are the most commonly used localization algorithms for locating edges between the pupil, iris, and iris sclera.[4]

Normalization is the process of preparing a segmented iris image for encoding. This process is used to achieve iris size, position, and degree of iris dilation invariance for matching different iris patterns at later stages of image processing. [4]

Feature extraction is the process of extracting features from an image that are used to distinguish it from others. Classification is a subset of categorization, which is the process of identifying, distinguishing, and analyzing things and objects.

The upcoming sections of this paper will accommodate the following data: Section 2 details about the various existing works till date. Section 3 presents the preprocessing technique used. Section 4,5 elaborates the normalization & classification technique used. Section 6 describes segmentation & feature extraction. Section 7,8 Concludes the paper with Results & discussions.

RELATED WORK

AlWaisy et al.[5] proposed an effective and realtime multimodal biometric system based on deep learning representations for images of a person's right and left irises and fusing the results obtained using the ranking level fusion method. IrisConvNet is the trained deep learning system, and its architecture is composed mainly of Convolutional Neural Network (CNN) and Softmax classifier. The proposed system was tested on 3 datasets: SDUMLA-HMT, CASIA-IrisV3 Interval and IITD iris databases.

Shervinminae et al.[6] suggested an end-to-end deep learning framework for iris recognition for iris recognition based on residual convolution neural network. The proposed work was applied on IIT Delhi dataset which is a well-known dataset hence achieving an accuracy of 95.5%. The proposed work well on only one database.

Muhammad Arsalan et al.[7] worked on iris recognition based on visible light environment to avoid the use of additional near infrared light camera and NIR illuminator as they increase the difficulty of iris segmentation. In order to overcome this problem, he proposed he proposed two iris segmentation schemes based on convolution neural network (CNN) which is capable of accurate iris segmentation in severely noisy environment of iris recognition. The work has been implemented on 3 datasets namely NICE-II, UBIRIS-V2, MICHE. Although their method showed up higher accuracies of iris segmentation, they had to use traditional image processing algorithm in stage 1.

MaryimOmran et al.[8] presented the robustness & effective structure of the iris recognition system. The system is named as IRISNet. The architecture of IRISNet consist of CNN Layer for feature extraction and SoftMax layer to classify features into N classes. Dataset used is IITD VI and obtained 97.32% & 96.43% for original and normalized images. However, the presented system worked well on only one dataset.

Naglaa et al.[9] proposed a Course-fine-algorithm to address computational cost problems, morphological processing to extract the initial Centre point and a refinement step is made using integro differential operator and ended up achieving 87% efficiency. They made their testing on CASIA v3 database. The database contains 249 subjects having a maximum of 5 images of the same eye, but he could only test on only 100 images of 16 subjects taking a maximum of 5 images for same eye.

Prateekvarma et al.[10] has used Daughman segmentation method for iris segmentation in his work. Iris images were selected from CASIA database. However, he could segment 3 out of 4 eye

image which corresponds to a success rate of 83% using integro differential equation & Hough transform method.

PrajayPodder et al.[11] proposed an improved noise reduction scheme based on radial suppression to reduce localised high frequency information from segmented iris regions for personal authentication. CASIA-v1 and CASIA-v3 are the datasets used for testing resulting FFR and FAR of 37.88% & 0.0001%.

Kuowang , Ajay Kumar et al.[12] investigated a new deep learning-based approach for iris recognition & attempts to improve the accuracy using a more simplified framework to more accurately recover the representative features. 7.14%, 10.7% & 27.4% are the error rates obtained which were been tested on three datasets: CASIA iris database, MMU, IITD.

From the above literature survey, we could conclude that certain authors worked on the conventional segmentation approaches without any observable changes, which led them to poor accuracies and one of the major processes in the system include the preprocessing which has a considerable impact on the performance of the system.

Additionally, it is clear that many authors have worked on a single database rather than on multiple databases, restricting their work to only certain datasets leading to failure on others. Whereas, few authors have worked on multiple datasets and have used the datasets only for comparison rather than having quality accuracies on all the datasets.

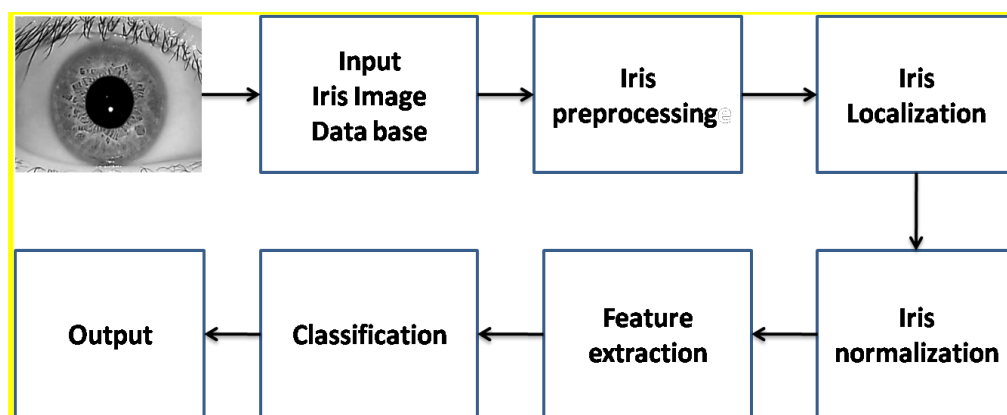


Fig.1 Iris recognition system implementation

3. PRE-PROCESSING

Database used in our project is CASIA v-1. The dataset has 756 images of iris in 108 folders with 7 images having dimensions 280X320 each.

In Preprocessing, the RGB input image is converted to grayscale, and morphological operations are performed using median blur filtering. In the preprocessing section basically there exists two simple methods. Firstly, the conversion of original image to gray scale and secondly, the filtering of original image using the median blur filter. Moreover, there are two other major filters known as Bilateral and Gaussian. The bilateral filter is a non - linear filter that smoothens a signal while preserving its sharp edges. It has proven to be extremely effective for a wide range of problems in computer vision and computer graphics . The result of blurring an image with a Gaussian function is a Gaussian blur . It's a common effect in graphics software, typically used to reduce image noise and detail. Gaussian smoothing is also used in computer vision algorithms as a pre-processing stage to improve image structures at different scales.

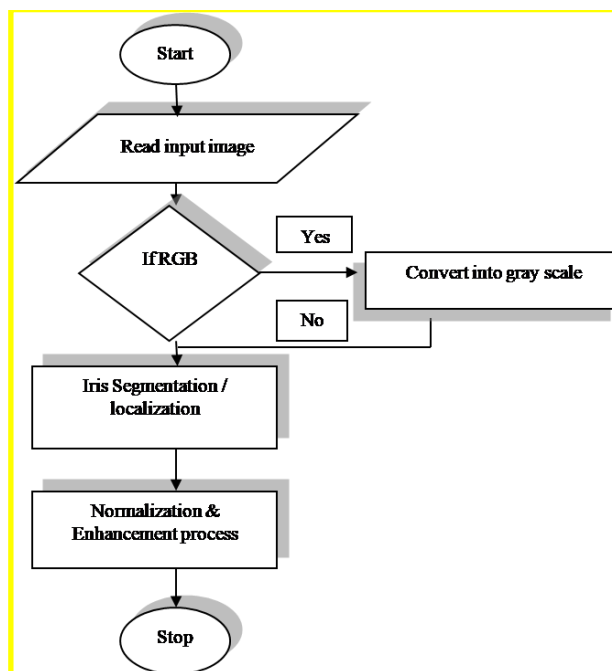
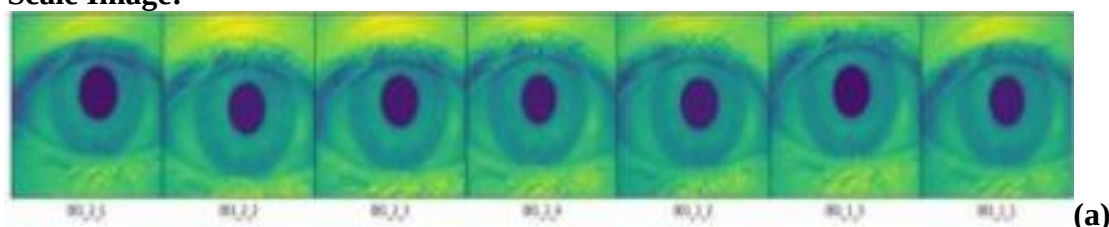


Fig.2 Steps involved in iris preprocessing

Grey Scale Image:



After Median Blur Filter:

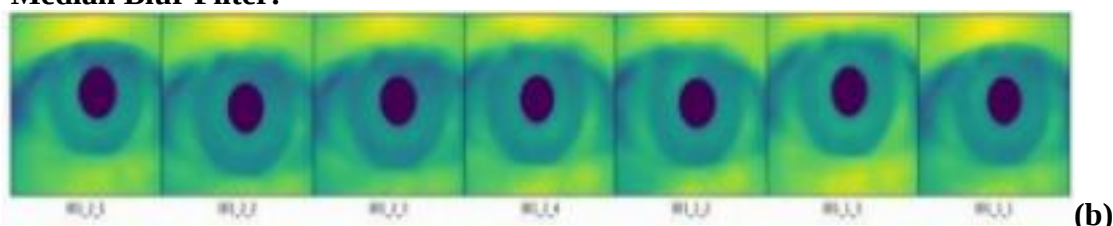


Fig.3 Preprocessed image

4.NORMALIZATION

Followed by the detection of pupil and iris circles by the localization process. The ROI, which is the angular part between the pupil and iris circles, is then extracted. As a result, during the normalization process, we extract this region and convert it to a rectangular image format with a size of (64,512). The key benefit of iris normalization is that it removes dimensional inconsistencies that can occur as a result of stretching of the iris region caused by pupil dilation with varying levels of illumination. Daughman's rubber sheet model is one of the most commonly used normalization technique. Using this technique we transform iris images from Cartesian coordinates to polar coordinates . Different people's irises can be captured in different proportions, and irises from the same eye can

also vary in scale due to light and other factors. Certain elastic deformation in the iris texture would influence the results of iris matching. By performing normalization, we are able to overcome this effect. The iris ring is reordered counterclockwise to form a rectangular block of a predetermined size.

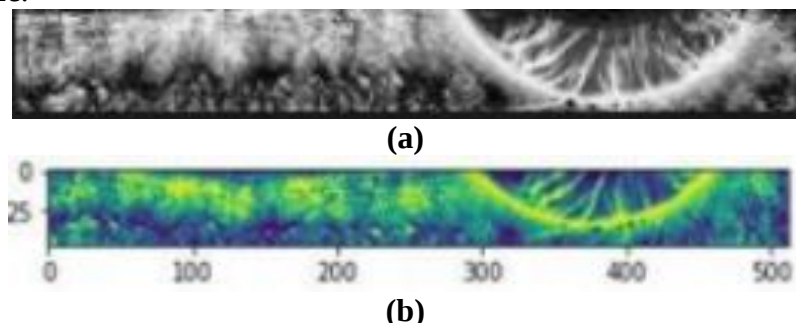


Fig4. Normalized images

5.CLASSIFICATION

Classification is a subset of categorization, which is the process of identifying, distinguishing, and analyzing things and objects. In our work we used Neural Network.

The term network in Neural Network refers to the interconnection of neurons in different layers of a system. The basic idea of a Neural Network is brought up in consideration with the human brain which contains the neurons. Collection of such neurons together is called a Network. Every system is composed of three layers: the input layer, the hidden layer, and the output layer. The input layer contains input neurons that send data to the hidden layer through synapses, and the hidden layer sends data to the output layer through more synapses. The synapses store values known as weights that allow them to manipulate the input and output to various layers. In Neural Networks, we typically use the SoftMax or sigmoid function for classification. When there are multiple class classifications, we use the SoftMax function at the end of the output layers. SoftMax returns the probabilities of each class ranging from zero to one for each output. For every Neural Network there exists a loss function, with the help of which it estimates the output to the closest requirement.

6.PROPOSED WORK

6.1 Iris Localization

Once the image is converting into gray scale, the next step is Iris localization. It is also known as segmentation process. The iris is first identified by assembling two circular outlines that correspond to the pupil and iris borders of the iris field. The main cause for doing this is to reduce the number of computation regions rather than having a complete image of the iris to CNN. Use of this method allows you to acquire only the areas of interest while discarding the rest. Hence, iris segmentation is always considered as an important step in the pre processing and can ensure greater efficiency. In our work Iris localization is done using DaughmanIntegro Differential operator.

Daugman's algorithm is based on operating an integro-differential operator to detect the iris and pupil contour.

The Daughmanintegro differential operator is a circular edge detector, which detects based on the illumination difference. As the name indicates it initially differentiates at maximum intensity difference points of the region of interest and obtains few points with their respective slopes and

finally integrates all the points to form a circle. In our work, we have set the thresholds for the illumination difference and the radius parameters in a peculiar manner to obtain an effective modified operator which detects the boundaries in precise manner.

$$\max_{(r_0, x_0, y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{(r_0, x_0, y_0)} \frac{I(x, y)}{2\pi r} ds \right|$$

The above mentioned equation is the Daughman integro differential equation. In the equation X_0, Y_0, r_0 are the centre & radius of course circle. $G_\sigma(r)$ is the smoothing function. The smoothed image is then scanned for a circle with the greatest gradient change, indicating an edge. $I(x, y)$ is the pixel intensity at coordinates (x, y) in an iris image. Symbol $(*)$ denotes the convolution.

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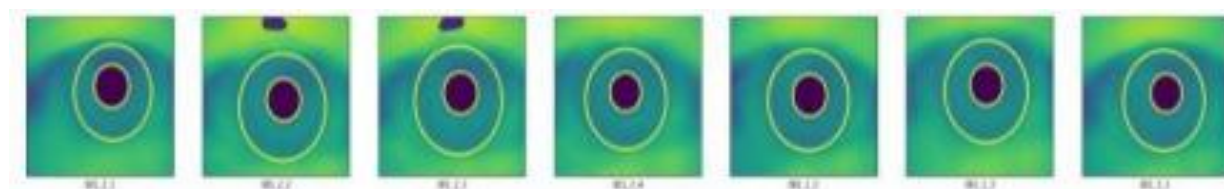


Fig.5 Segmented images

6.2 Feature Extraction

In the proposed work we have used Convolution Neural Network (CNN) for Feature extraction. Once the image has been normalized, it is now ready for the feature extraction process. Feature extraction is the process of extracting features from an image that are used to distinguish it from others. The distinct feature of CNN is that it can be used for both feature extraction and classification. It is made up of layers such as Convolutional layer, Pooling layer, Activation layer, Dense layer, and so on.

The primary reason for selecting CNN is that it has a wide range of applications and can perform accurately with a greater number of layers in the field of computer vision. Convolutional layers, pooling layers, dense layers, and dropout are all included in the proposed CNN work structure. We chose the following hyper parameters to improve the performance of the CNN.

CNN is fed to the normalized iris images. During the training phase, 80 percent is used for training, 20 percent for validation (from the training set), and 20 percent for testing. The model is evaluated for up to 100 epochs. After the first fully connected layer, a dropout method with a probability of 0.3 is used. It aids in preventing overfitting by deactivating or cutting off connections between layers of neurons.

Table(1) HYPER PARAMETERS IN THE PROPOSED CNN

Parameters	Values
Convolution & kernel size	32-3x3, 64-3x3, 128-3x3
Max-pooling	3-2x2
Activation	ReLU (In every layer)
Fully connected	512,256,109
Optimizer	SGD

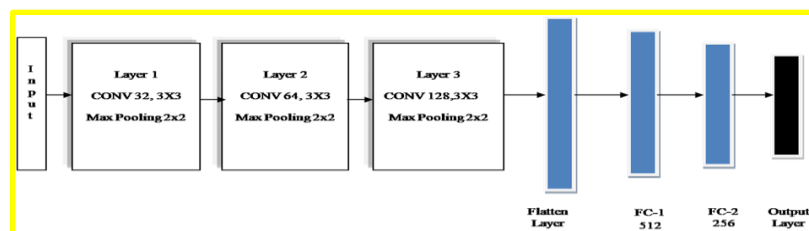


Fig.6 The Structure of proposed CNN model

7.RESULTS& DISCUSSION

In this section of the paper , we are going to discuss the experimental results of the proposed algorithms and comparison with the existing papers.

The model used in our experiment is CNN with appropriate hyper parameters tuning which has a capacity to attain high accuracy within lower epochs of time and result in the best accuracy at 100 epochs. The fig(8). States information about the training and testing accuracies of the built model. The fig(9). Shows us the final structure of the CNN built which suits best for the dataset utilized. Fig(7). details us about the values of accuracies and loss during the training and testing phase for each epoch. In TABLE(2) , we have also compared the result achieved by our model with the existing one [7] and are able to conclude that our model has attained better efficiency than the existing one.

Finally , the combination of CNN for feature extraction and NN for classification is considered to be the best combination because of the unique qualities exhibited by them individually and such consideration also helps us in being intact with the upcoming technology.

648/648 [=====]	- 1s 2ms/step - loss: 7.1388e-05 - accuracy: 1.0000 - val_loss: 0.1141 - val_accuracy: 0.9722
Epoch 88/100	
648/648 [=====]	- 1s 2ms/step - loss: 1.8186e-04 - accuracy: 1.0000 - val_loss: 0.1101 - val_accuracy: 0.9722
Epoch 89/100	
648/648 [=====]	- 1s 2ms/step - loss: 6.8358e-05 - accuracy: 1.0000 - val_loss: 0.1080 - val_accuracy: 0.9722
Epoch 90/100	
648/648 [=====]	- 1s 2ms/step - loss: 3.1218e-05 - accuracy: 1.0000 - val_loss: 0.1072 - val_accuracy: 0.9722
Epoch 91/100	
648/648 [=====]	- 1s 2ms/step - loss: 2.9932e-05 - accuracy: 1.0000 - val_loss: 0.1069 - val_accuracy: 0.9722
Epoch 92/100	
648/648 [=====]	- 1s 2ms/step - loss: 6.9700e-05 - accuracy: 1.0000 - val_loss: 0.1065 - val_accuracy: 0.9722
Epoch 93/100	
648/648 [=====]	- 1s 2ms/step - loss: 7.3481e-05 - accuracy: 1.0000 - val_loss: 0.1064 - val_accuracy: 0.9722
Epoch 94/100	
648/648 [=====]	- 1s 2ms/step - loss: 2.8372e-05 - accuracy: 1.0000 - val_loss: 0.1059 - val_accuracy: 0.9722
Epoch 95/100	
648/648 [=====]	- 1s 2ms/step - loss: 3.3508e-05 - accuracy: 1.0000 - val_loss: 0.1054 - val_accuracy: 0.9722
Epoch 96/100	
648/648 [=====]	- 1s 2ms/step - loss: 1.2603e-05 - accuracy: 1.0000 - val_loss: 0.1049 - val_accuracy: 0.9722
Epoch 97/100	
648/648 [=====]	- 1s 2ms/step - loss: 3.8558e-05 - accuracy: 1.0000 - val_loss: 0.1046 - val_accuracy: 0.9722
Epoch 98/100	
648/648 [=====]	- 1s 2ms/step - loss: 1.1010e-04 - accuracy: 1.0000 - val_loss: 0.1010 - val_accuracy: 0.9722
Epoch 99/100	
648/648 [=====]	- 1s 2ms/step - loss: 2.8314e-05 - accuracy: 1.0000 - val_loss: 0.1001 - val_accuracy: 0.9815
Epoch 100/100	
648/648 [=====]	- 1s 2ms/step - loss: 2.0411e-05 - accuracy: 1.0000 - val_loss: 0.0998 - val_accuracy: 0.9815

Fig.7

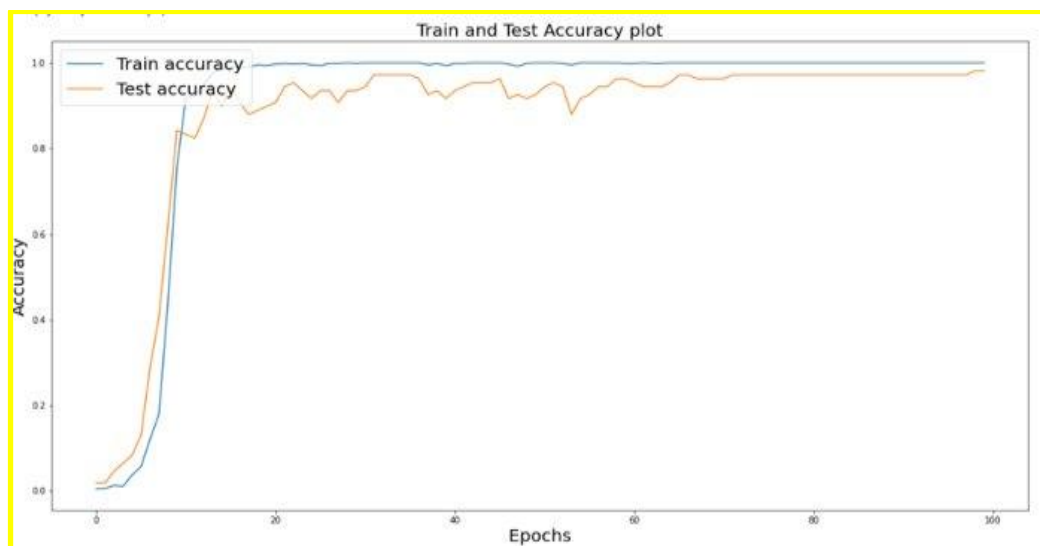


Fig.8

Model: "sequential_2"

Layer (type)	Output Shape	Param #
conv2d_4 (Conv2D)	(None, 200, 150, 32)	896
max_pooling2d_4 (MaxPooling2)	(None, 100, 75, 32)	0
conv2d_5 (Conv2D)	(None, 100, 75, 64)	18496
max_pooling2d_5 (MaxPooling2)	(None, 50, 37, 64)	0
conv2d_6 (Conv2D)	(None, 50, 37, 128)	73856
max_pooling2d_6 (MaxPooling2)	(None, 25, 18, 128)	0
flatten_2 (Flatten)	(None, 57600)	0
dense_4 (Dense)	(None, 512)	29491712
dropout_2 (Dropout)	(None, 512)	0
dense_5 (Dense)	(None, 256)	131328
dense_6 (Dense)	(None, 109)	28013
Total params: 29,744,301		
Trainable params: 29,744,301		
Non-trainable params: 0		

Fig.9

TABLE (2) - Comparison Table of accuracy of built model with the existing one.

Model comparison	Accuracy
PrateekVerma et.al[7](existing model)	83% (percentage)
Proposed model	98% (percentage)

CONCLUSION

In our work, we proposed a Iris based biometric identification algorithm which identifies an individual very precisely and accurately. Initially, we have pre-processed the input image and then used the modified segmentation technique to detect the inner and outer boundaries effectively. Then, we normalized the segmented images using the Daugman's Rubber Sheet

model and its output is sent into the newly built CNN(Convolutional Neural Networks) architecture and obtained efficient features and finally we sent the extracted features into the Neural Network (NN) classifier to obtain an accuracy of 98%(percentage). CASIA dataset v-1 consisting of 756 images in 108 folders containing 7 images each has been used for Experimentation. In our future work, we will be working on multiple databases and achieve higher accuracies in all of them with the existing built model.

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