Iris Identification Based on SVM-CNN Method

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***Abstract*—** *A person is automatically recognized in a biometric system by analyzing their distinct traits. Most people agree that iris recognition is the most accurate and dependable biometric identification method currently in use. The goal is to accurately and efficiently identify a person in real time by analyzing the sporadic patterns seen in the iris if an eye from some distance, by extracting strong features using deep learning technique. The extracting of significant features is important step that effect the overall accuracy of iris recognition system. In order to extract the iris characteristics, this research suggests a robust convolution neural network (CNN) structure. Then, an identity of the person is determine based on extracted features from his iris to support vector machine (SVM). The proposed system is examined on CASIA V. (1). Several parameters such as accuracy, precision, recall, and F-score are computed to evaluate the performance of the proposed system. The obtained result of the accuracy is about (99%). The proposed system results are compared with several previous methods and prove its effectiveness. A contemporary approach and the suggested method are contrasted and use deep learning for features extraction and the results depict our method outperforms other methods.*

***Keywords*— Recognition, Biometric, SVM, CNN, Identification, Segmentation**

INTRODUCTION

Biometrics are a very reliable way to make sure that transactions are safe and that people are who they say they are. The iris is the best biological and behavioral biometric device. Whether it's a person's age, twins, facial emotions, stance, or makeup, this clear internal organ has a physically structured data bank that is very reliable and safe, but also very unpredictable and variable [1]. Most iris systems don't work in places where people don't cooperate because of noise, off-axis movements, motion blur, and eyes that are only half open. These settings are typical of joint settings with a lot of rules. The eye recognition technology is accurate, but it is slow because the preprocessing and normalization steps take a long time. In many deep learning and object recognition tasks, getting the right features is the most important step, even when things are hard. One of the best ways to recognize someone [2] is by their iris, which makes them unique. We can say, "Begin with the iris" to talk about the iris. There are outside forces that can't reach the white lens and black pupil because of the iris [3]. A person's right and left eyes almost never have the same iris pattern, not even if they are identical twins. A lot of people think that the way someone's eyes look makes them special and unpredictable. Images of the iris show interesting designs made by its many different textures. Rings, ridges, crypts, furrows, freckles, and zigzags are some of these [4]. An individual can be automatically identified by a biometric system using a distinctive trait or attribute that they possess. The most reliable and accurate biometric identification system available is iris recognition. The scientific study of biological traits by statistical analysis is referred to as "biometrics". In this context, biometrics is the study of human traits for security. Biometric technology is concerned with recognizing the unique physical features or characteristics that determine the identity of individuals. The morphological features, including the vein, iris, face, fingerprint, retina, and hand geometry, as well as the behavioral traits, such as handwriting, that are unique to humans. Each person has a different gait, signature, and keyboarding style. Authentication uses consistent data on an individual [5].

The rapid advancements in information technology have led to significant developments in various applications. Advancements in technology have made it feasible to utilize biometrics in various applications. Applications where it's required to confirm or validate the accuracy of information about the identity of individuals [6]. A simple biometric system consists of four basic components as shown in Fig. 1 [7, 8]: • The biometric data is acquired by the sensor module. • The feature extraction module processes the collected data to extract vectors of interest. Attribute vectors are compared to template vectors via the matching module.. • module for making decisions where a user's identification is determined or a claimed identity is approved or denied.

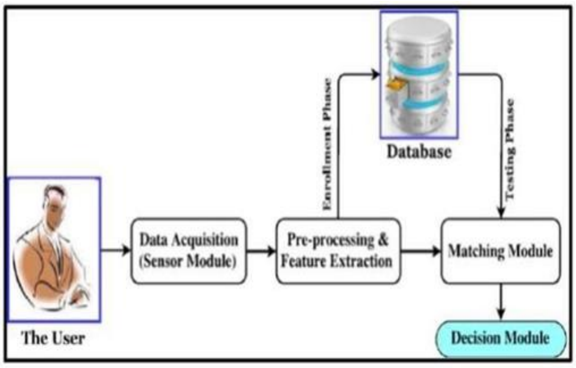

Figure (1): A general structure of a biometric system

Identifying a more effective feature representation technique with the aid of the most recent developments in Deep Learning is one such revolution. The features from the provided iris data will be automatically learned by Deep Learning. To attain a high degree of identification accuracy for the purpose of iris recognition, this will result in an ideal representation scheme that can be examined. Typically, feature representation schemes can be directly learned from data using deep learning networks. Deep Learning methods have dramatically changed many computer vision tasks these days. It follows that the convolutional neural network (CNN) is thought to illustrate Deep Learning approaches. Additionally, it can be applied to the iris recognition complexity to provide additional feature descriptors.[9]

This study explains the subsequent contribution towards an iris recognition approach where features are extracted using a unique convolution neural network model.

The structure of the paper is as follows. Section 2 describes related works. In Section 3, the theoretical background is described. Section 4 suggested iris recognition system is explained. Section 5 provides an explanation of the analysis of the experimental work and the findings. Section 6 provides a summary of the work that remains to be done.

RELATED WORKS

This section will display the most current algorithms employed in iris recognition systems, of which there have been several.

A Convolutional Neural Network (CNN) model-based iris identification system was suggested in 2018. Two cases are studied in the iris segmentation stage. In the first case, two regions of iris on each side of the pupil were cropped while in the second one the entire iris region is detected. The system skipped the normalization stage. Since the detected iris using one of the segmentation cases is fed to CNN modal to extract features and perform classification. The experimental tests are done on the CASIA-V1 dataset, the accuracy of recognition is about 98% using entire iris region and about 97.82% using cropped iris regions [10].

In 2019, Sue and Ahmed proposed method for iris identification based on deep learning. The proposed method using pretrained Alex Net network to extract deep features from iris image. In classification stage, the SVM is used. The CASIA-V1 dataset is used to test the approach. The overall obtained accuracy of the method was around 97.22%. in this system, Hardware with high computational power needed to be taken into account when training on a huge ConvNet network [11].

In 2019, iris recognition system is proposed based on using convolutional neural networks for transfer learning. In order to implement the suggested system, a pre-trained convolutional neural network (VGG-16) is fine-tuned for feature extraction and classification. Sixty participants from the public iris database CASIA-Iris-V1 are used to evaluate the effectiveness of the iris recognition system. Achieved accuracy was 91.6%[12] .

In 2020, Sheena and Mathew proposed a method for iris recognition based on deep learning. The iris region is segmented and then fed to the build CNN modal. iris features is obtained using several deep layers of CNN modal. Finally, SoftMax is used to perform the recognition process. The proposed method is tested on CASIA-V1 dataset. The accuracy was about 96%[9] .

In 2020, a method proposed by Shafiul and Humayan for iris recognition. In order to improve recognition efficiency, this research investigates an approach that employs support vector machines (SVM) and convolutional neural networks (CNNs) for feature extraction and classification, respectively. The CASIA-V1 dataset is used to test the suggested technique. There was almost 96.3% accuracy[13] .

The study proposes an approach for iris region localization in 2022. The histogram and median filter were utilized to extract iris information from iris images. Semi-discrete matrix decomposition (SDD), an algebraic technique, is used to extract iris information from iris images. The proposed algorithm used CNN for features extraction from SSD features map and classification. The method is tested on the CASIA-V1 dataset. The result of accuracy was about 95.5%[14] .

In 2024, Adegboye et al. introduced a method aims to develop an enhanced system based on a convolutional neural network to recognize the characteristics of the iris. The optimization was performed using Gravity Search Algorithm (GSA) due to its advantages over other algorithms. Four hundred and Fifty (450) iris images were obtained from the CASIA (vi) iris dataset. Operations such as iris segmentation, normalization, feature extraction and template matching were implemented within. The attained accuracy of GSA-CNN was about 95.00% [15].

Constraining conventional iris recognition systems to process iris images captured in unconstrained environments is difficult. Automatic iris recognition must confront unexpected variations in iris images in real-world applications. Finding a robust representation of iris features for a variety of images is challenge and can enhance recognition accuracy.

The primary goal of this paper is to improve the weak flexibility of traditional hand-crafted feature extraction method in the context of Iris Recognition System (IRS).

THEORETICAL BACKGROUND

The following sub sections explain the theoretical principles of the used methods in our system.

The Convolution Neural Network (CNN):

For image processing and recognition, CNN is a kind of Artificial Neural Network (ANN). To be more precise, it was made to handle pixel data, which is a component of deep learning methods that are frequently employed to examine visual images. CNN employs less preparation computation as compared to other image classification techniques, which means that the network picks up knowledge from the filters that are usually manually designed in other systems [16]. Fig. 2 shows the general structure of CNN.

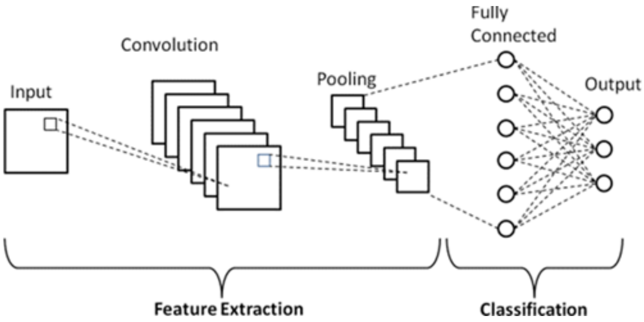

Figure (2): The general architecture of CNN

1. The Convolution Layer: Convolution layers are employed to extract features from the input images, and the Back-Propagation Algorithm is utilized to create random kernels for convolution operations (BPA).
2. The Maxpooling Layer: In order to simplify the information collected in the output through the convolutional layer, CNN also includes pooling layers, which are often utilized immediately after convolutional layers. To create a condensed feature map, the pooling layer uses each feature map's output from the convolutional layer. Next, every unit in the pooling layer can condense a section of the preceding layer's neurons [17].
3. The Fully Connected Layer: After the pooling layers, CNNs use the fully connected layers to provide the necessary classification for the images. Each value is given a vote across one or more completely linked layers after being flattened [18].
4. SoftMax Layer: The output makes use of this layer. The purpose of SoftMax is to develop a novel kind of neural network (NN) output layer, which is often utilized in categorical classification to provide output for k classes of input.

Support Vector Machines (SVMs):

a unique kind of binary classifier that aims to divide classes using a hyperplane as a linear decision boundary. The margin (of separation) is the length of time that separates the decision border from the closest data points, or support vectors. As such, it is a conceptually global model and a local model for real classification, using only the hyperplanes identified by these vectors for the purpose of classifying new points. Support vectors are the data that are most closely related to the hyperplane, as seen in Fig. 3. To increase the likelihood that any new data will be correctly classified, the hyperplane with the biggest margin between it and any point in the training data set should be selected [17].

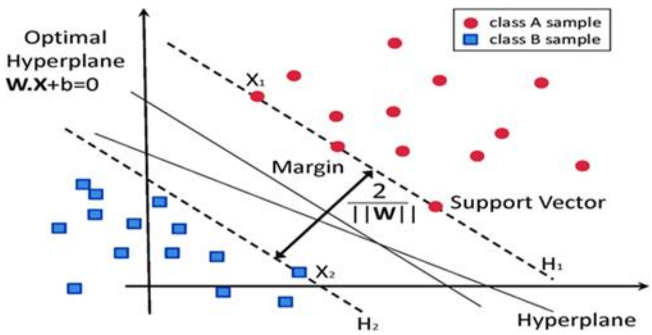

Figure (3): Support Vector Machines (SVM) [17]

THE PROPOSED SYSTEM

Individuals are identified using iris recognition systems, which analyze the unique patterns in their iris. The proposed system consists of the five steps which consist of capturing images, preparing them, splitting them, and extracting features, and provide a detailed description of the classification. These proposed system steps are depicted in Fig. 4.

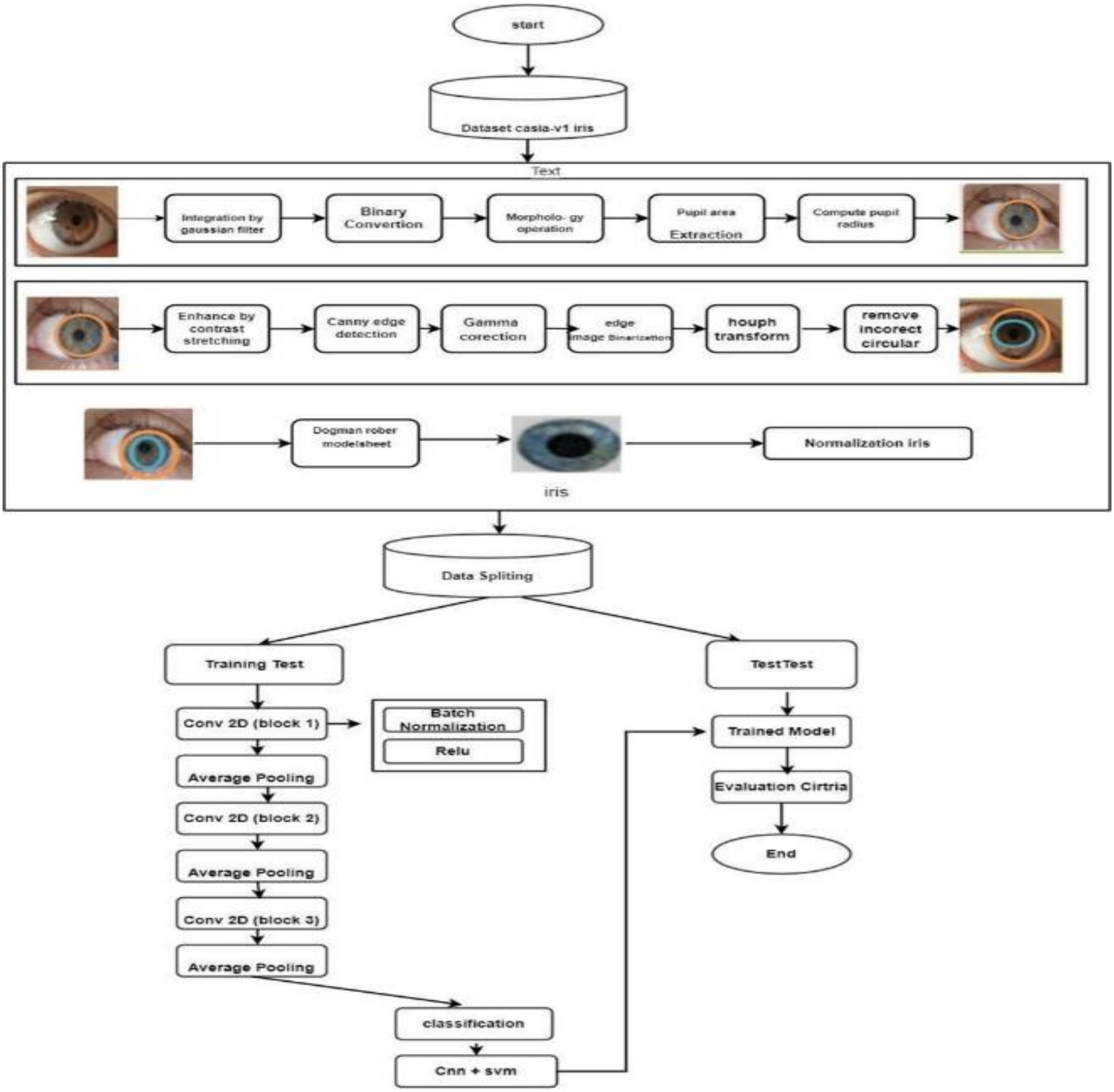

Figure (4): General diagram of the proposed system

IMAGE ACQUISITION

Iris recognition Acquiring images is the initial phase. Due to individual differences in iris size and color, this stage is extremely challenging. Obtaining high-quality images of the subject's iris using a camera and sensor is the first step in iris identification. CASIA-Iris-V1 is a dataset that collects photos that include the iris region of the eye, at least in part. The images are captured using 850nm, made-at-home iris cameras. It is common practice to use visible-light sensors to capture these photos. Both color and intensity images of the visible spectrum are possible to retain. An intensity image is the default format for storing near-infrared images. There are 756 iris images from 108 eyes in this Casia collection. In just two sessions, a device that the manufacturer created themselves can take seven images per eye. CASIA close-up iris camera, with a first session collecting three samples and a second session collecting four. The resolution of all the photographs is 320 × 280, and they are saved in BMP format. The iris is suitably and uniformly illuminated by the round near-infrared illuminators that surround the sensor. Depending on parameters like illumination, location, and distance, the same person may get various outcomes from the acquisition procedure. Before it was made public, CASIA-Iris-V1 detected pupil regions in all iris images and blocked NIR specular reflections with a constant-intensity circle [19]. The average capture distance is 2–3 feet and time is 1–2 seconds. As noted in Fig. 5, an image with high quality that has satisfactory resolution and precision can only be obtained within a distance of 3 meters [20].

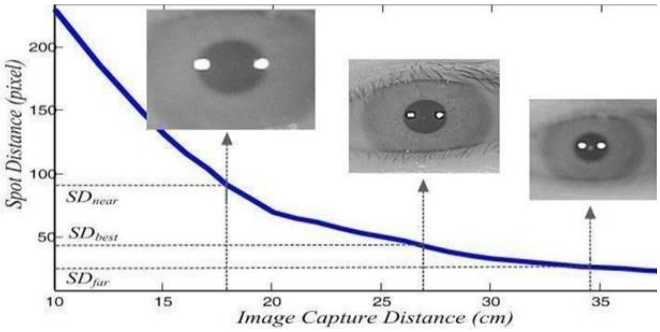

Figure (5): Proper Capture of Image [20]

IRIS SEGMENTATION

Iris segmentation precisely identifies the iris in eye photos. The eye will then identify its owner. Iris limitations must be accurately identified for identification. Separation is essential for iris identification. Iris detection is required for all future phases. Segmentation and localization are needed. The segmentation stage focuses on finding the iris's inner and outer margins as shown in Fig. 6.

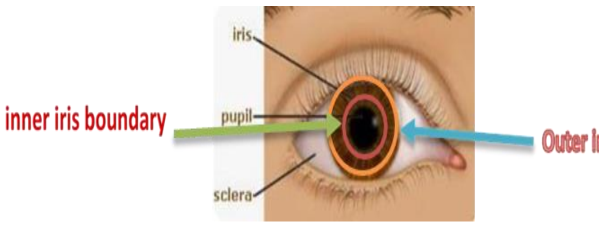

Figure (6): The iris's outer and inner boundaries

Iris segmentation method proposed by [21] is applied. Various methods are used to correctly detect the inner iris boundary. These methods involve Gaussian filtering, histogram thresholding on the binarized image, morphological procedures, and pupil radius determination. The process begins with these stages. Fig.7 shows the pupil region.

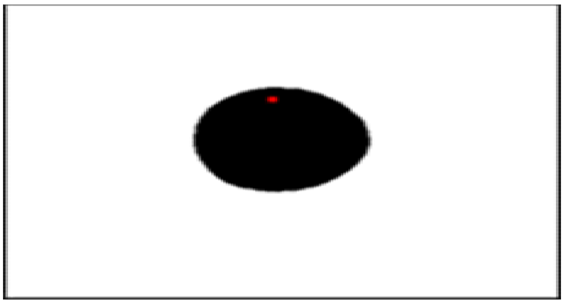

Figure (7): Pupil region detection

The radius of the pupil can be determined in four distinct directions from the provided point. Pick the first background pixel in each of four directions, starting at (xp, yp), to get the pupil's radius. From top to bottom, right to left, these are the directions. For the horizontal scan, these are the initial backdrop pixels located on the x- and y-axes, respectively. Obtain the horizontal radius (Ah) by applying this technique [22].

$$Rh = \frac{1}{2}(xr - x1) \qquad (1)$$

After a vertic$_{1}$al scan down the column (x = xp), determine the top and bottom starting background pixels as xb and xt. The vertically measured radius (Av) [23] is calculated as follows:

$$Rv = \frac{1}{2}(xb - xt) \qquad (2)$$

Then, the pupil radius Rp can be calculated as follows:

$$Rp = \frac{1}{2}(Rh + Rv) \qquad (3)$$

The second stage in determining the outer iris border involves boosting eye images, applying gamma correction, converting them to binary, using circular Hough transform, and using Canny edge detection. Fig. (8) shows the results of detection of inner and outer bounders.

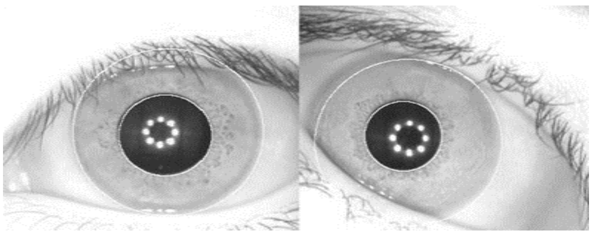

Figure (8): inner and outer boundaries localized for two eye images

IRIS NORMALIZATION

The next step is to change the iris area to have fixed dimensions so that comparisons may be made once it has been correctly segmented from an eye image. The primary reason of the iris's stretching as a result of pupil dilatation brought on by changes in light intensity is the dimensional discrepancies between ocular images. Variations in imaging distance, camera rotation, head tilt, and ocular rotation inside the eye socket are other sources of discrepancies. Two photos of the same iris taken under different circumstances will have distinctive characteristics at the same spatial position because the normalizing method will create iris regions with the same constant dimensions. The pupil area is not always concentric, which is another important observation [24].

Generally, somewhat nasal, and is located inside the iris area. Thus, the following equation must be used to normalize the iris region. As seen in Fig. 9, the fully detected iris is now transformed into a rectangular image using normalizing Equations (1) and (2).

$$x1 = x + r * \cos(F) \qquad (4)$$

$$y1 = y + r * \sin(F) \qquad (5)$$

where F is an angle that ranges from 0 to 360 degrees, r is the iris ring's radius that varies from the inner to the outer border of the iris image, and (x, y) are the coordinates of the ring's center and (x1, y1) are the coordinates of a pixel of the rectangle image[25].

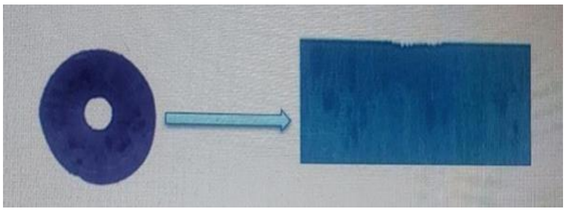

Figure (9): Iris Normalization Process

(a) Segmented iris (b) Normalized rectangular iris

FEATURE EXTRACTION TECHNIQUE:

The process of feature extraction involves taking an iris image and using a texture analysis approach to extract highly discriminative yet compact characteristics from the image[26], yet can still function accurately, which lowers the amount of features that need to be kept in the feature subset. The iris is predicted to function faster when the computational complexity decreases. These characteristics are taken out of the iris image for accurate authentication. The two types of algorithms—feature learning and hand-crafted algorithms—can be used to extract iris characteristics. The Deep Learning technique has two options: either create a model and train it on the researcher's database to extract features, or base it on pre-trained CNN models (e.g., VGG- 16). In the proposed method a deep learning modal is built to extract more compact features from iris region. To extract the necessary characteristics, a CNN was utilized. The following Table (1) displays the suggested network structure for the utilized system:

Table (1): CNN layers for the suggested approach

Layers	Parameter Settings-Hyper
Input Layer	Input Size = [64 100]
Convolution Layer 1	Filter size= (5×5),8, stride = (1,1), Padding=same.
Batch Normalization	-
Activation layer 1	Relu
Average Pooling Layer 1	Filter size= (2×2), stride= (2,2), Padding=same.
Convolution Layer 2	Filter size= (5×5),16, stride= (1,1),Padding=same.
Batch Normalization	-
Activation layer 2	Relu
Average Pooling Layer 2	Filter size= (2×2), stride=(2,2), Padding=same.
Convolution Layer 3	Filter size=(5×5),32, stride= (1,1), Padding=same).
Batch Normalization	-
Activation layer 3	Relu
Average Pooling Layer 3	Stride =(2,2), Padding=same.
Flatten layer	flatten results of Average-Pooling layer 2 to 1-D
FC-Dense layer 1	108 neuron nodes
Activation layer	Soft Max
FC-classification	

Classification Techniques

The recognition system's (RS) last phase is the classification phase. Measuring the degree of similarity between test samples and samples in the databases of iris images is the aim of classification. It is frequently impossible to match these samples completely. As a result, the recognition system uses the approximate rate of each sample to aid in person identification. In this work, the retrieved CNN characteristics from the previous step are utilized to determine each person's identification using the SVM approach.

THE EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

The suggested approach was put into practice using an Intel Core i7 PC with 20 GB of RAM and a MATLAB environment. dividing the data into two categories: training (80%) and testing (20%). The proposed method was implemented on the CASIA ver. 1 dataset.

Training mode

At the training stage, the accuracy and loss function are calculated. The train data is splitting into two group training and validation groups. The accuracy rate of 99.488 for the suggested network was shown in the findings, indicating a high degree of discrimination capacity. The training procedure for the dataset is depicted in (Fig. 10), where the blue color denotes the accuracy % of the rule's accurate diagnosis. The amount of mistake is shown by the red color.

Error and accuracy both begin at a level that is undesirable. They get better as the training goes on, reaching their maximum accuracy and smallest mistake conceivable.

Testing Mode

In the testing, the performance measures that are used to measure the performance and efficiency of classification algorithms are explained as follows: [27, 28].

1- Accuracy: the number of accurately identified cases, whether positive or negative, serves as a measure of accuracy.

$$Accuracy = \frac{TP+TN}{TP+TN+FP+FN} \quad (6)$$

2- Precision: testing the true positive from the expected positives yields information on the accuracy of the model's performance.

$$Precision = \frac{TP}{TP+FP} \quad (7)$$

3- Recall: Recall is the accuracy with which positive samples are correctly identified.

$$Recall = \frac{TP}{TP+FN} \quad (8)$$

4- F-score: for calculating a balanced mean output, the F1-score demonstrates the combination of precision and recall.

$$\text{F} - \text{score} = \frac{2*Recall*Precesion}{Recall+Precesion} \quad (9)$$

The last layer is where the features are taken from of the convolutional neural network (CNN), which is the (**Average Pooling Layer 3**) fed into the support vector machine (SVM). The attained accuracy of identification about 99.15%. Table (2) shows the calculation of system performance metrics on CASIA-Iris Dataset V1databases.

Table (2): The Performance Measure

Accuracy	Precision	Recall	F-score
0.9915	0.9814	0.97222	0.976829

COMPARISON OF PROPOSED SYSTEM AND PREVIOUS METHODS

A comparison of the suggested system with several Iris recognition techniques may be seen in Table (3). It should be mentioned that compared to the other systems, the recommended system performed better that are currently in place. The following are the primary causes of the attained results: Firstly, Figure (4) depicts the architecture of the Convolutional Neural Network. To capture discriminative characteristics, identical blocks of layers were stacked, and each convolutional layer was succeeded by a batch normalization layer to reduce over fitting and increase accuracy. Also, the early halting strategy is employed, which likewise avoids the over fitting condition.

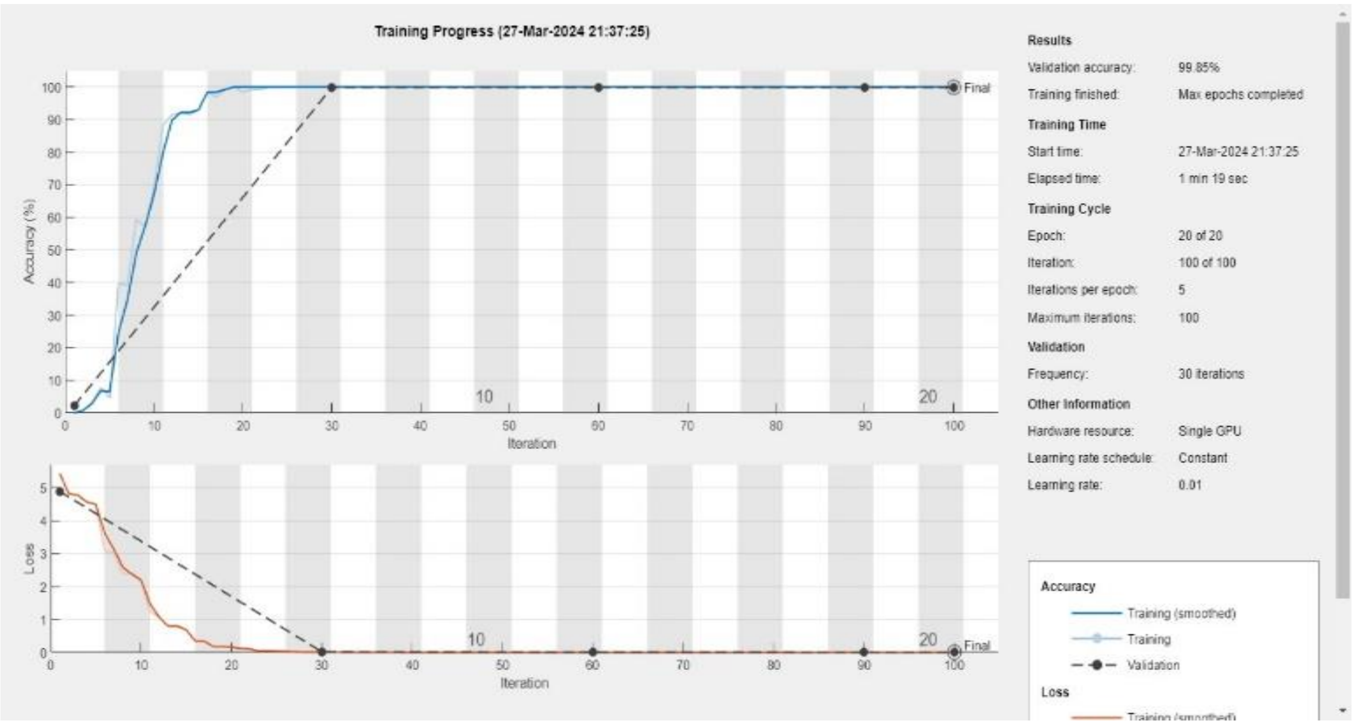

Figure (10): Accuracy and Loss Values results

Secondly, because the network primarily focused on the iris tissue, it produced results with improved precision because it was trained on segmented images as a region of interest (ROI).

Table (3): Comparison of the Proposed Method (CNN & Classification by SVM) with the previous Methods

References	CNN modal	Acc%
[10] 2018	CNN modal	97.83
[11] 2019	Alex Net network	97.22
[12]2019	VGG-16	91.6
[13] 2020	CNN Modal+SoftMax	96
[14]2020	CNN modal	96.3
[15]2022	SSD+CNN	95.5
Our proposed method	Proposed CNN+SVM	99.15

CONCLUSIONS

The suggested technique was used with a CNN deep learning network and accurate segmentation to address iris recognition systems. The first pupil border detection is part of the segmentation process. Next, the center and border of the iris are identified. Different forms of pupil and iris centers may be seen in many of the photographs utilized in the collection. Including the test and training photos, a total of 756 images were utilized. The segmentation accuracy of the suggested system was 97.21%. By building a CNN model and training it on the data used, it was found that adjusting the hyper-parameters such as the number of epochs, the number of filters and their size have a role in increasing the accuracy of the CNN. By experimenting with other classification methods, it was noted that the SVM classifier outperformed other used methods such as SoftMax classifier.

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