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Iris Recognition using Daugman's Algorithm and ANN

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Abstract:

There are several different techniques for biometric authentication. Iris recognition happens to be one of the most sophisticated and effective among them. It is mainly based on the pattern recognition method where in it identifies sharp and distinct patterns of the Iris that can accurately recognize the intended user. This recognition system is quite accurate and also gives improved performances. With the rise in the security breaches and other forms of authentication frauds, it is very important to have a stringent biometric system in place. In the proposed work, iris localization has been performed by using the Daugman's algorithm which is an integro-differential operator capable of separating or segmenting out regular shapes. The Daugman's algorithm also has a noise smoothening capability. Both these attributes make the Daugman's algorithm a preferred choice for iris localization. Subsequent to the iris localization, feature extraction is carried out to compute the relatively non-varying and unique parameters of an iris image. The features computed in the work are Contrast, Correlation, Energy, Homogeneity, Mean, Standard Deviation, Entropy, RMS, Variance, Smoothness, Kurtosis and Skewness. The features tend to behave uniquely for different iris images. However, overlapping values are possible. The features are then fed to a neural network using the Levenberg-Marquardt back propagation training rule. After training the neural network with feature values of authorized images, the subsequent step is testing the neural network for accuracy. The standard MMU database has been used for design of the system. It has been found that the proposed system attains an accuracy of 99.7% which is higher compared to the previously existing system using the same database.

Keywords: Iris Recognition, Daugman's Algorithm, Segmentation, Feature Extraction, Artificial Neural Network, Accuracy.

I. INTRODUCTION

The user Authentication is one of the key concern areas that form the part of secured access to data. Iris authentication and recognition approach that helps in authenticating the intended user utilizing the characteristic features of the iris. It has several other applications such as it is used in ATM's, and biometric recognition systems. This system typically contains different phases of functioning. The figure below shows the process involved for the iris recognition system. It happens to be a very useful approach in most cases. Figure 1 shows the process of Iris Recognition system and its different steps. Iris recognition is a form of bio metric authentication system that uses high end mathematical techniques and processes on the digital image of the Iris of the eye. It is mainly based on the pattern recognition method where in it identifies sharp and distinct patterns of the Iris that can accurately recognize the intended user. This recognition system is quite accurate and also gives improved performances. With the rise in the security breaches and other forms of authentication frauds, it is very important to have a stringent biometric system in place. Especially in places of high importance like the banks and ATMs, it is useful. Different algorithms are employed to encode the different set of patterns that exist in the iris localization scheme. It is useful to know the user is the real person or someone else impersonating the intended person. The system maintains a database. The database is usually big and consists of large number of templates of the iris features. This is then matched by the search engine of the model for the recognition purpose.

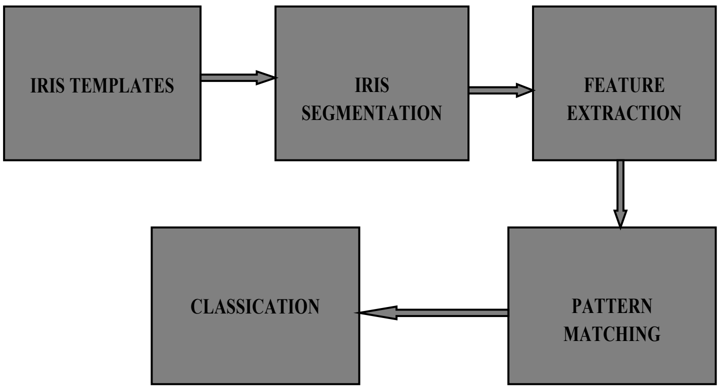

Fig.1 Iris Recognition based Model

So many people all over the world have resorted to these iris authentication mechanisms to safeguard their authenticity. Its extensive proliferation can be seen in places that are of national importance and financial and confidential institutions. In airports also this system is incorporated. National level exams where any person can take the exam illegally have also implemented this scheme. A really useful characteristic of this system is that it has a very robust and accurate matching process for the pattern recognition and also the incidence of false matches is extremely rare. Also as the Iris is a stable internal part of the human eye, it is quite reliable and useful for this purpose.

II. PREVIOUS WORK

The previous work explains the various appraoches that were undertaken and researched in this context of work approach.

The **In Springer 2018 [1], Alaa S. Al-Waisy et al.,** presented a multi-biometric iris recognition system based on a deep learning approach. The authors put forth a really innovative approach on the Multimodal biometric systems. The biometric systems have been widely used for various purposes all around the world and henceforth the authors put their focus on the multi biometric system of Iris recognition using the deep learning concept. The various image templates of Iris collected are then used for the segmentation purpose. This is one of the most important phases of the entire process. Third comes the feature extraction phase. In this the useful features and useful Iris image templates are extracted and the redundant ones are discarded. This proved to be a very useful approach in the biometric recognition domain.

In IEEE 2018, Cunjian Chen et al. in [2] put forth a Multi-task Convolutional Neural Network for Joint Iris Detection and Presentation Attack Detection. In this work the authors presented a scheme that consisted of a convolutional neural network that could detect the iris as well as perform PAD. It suggested a novel concept that could be used widely. It is inspired by an object detection scheme that could suppress the parameters needed for the optimal functioning. There re sensors at work that carry out the sensing and recognition mechanisms. The classification needs to be highly accurate. This is followed by pattern matching step. This is yet another very important part of the entire system. . Many a times, the facial features are so complex and detailed that the classification and feature extraction might fail to accurately identify the Iris. Also in cases of slight facial modifications like use of expressions etc, the system might not work properly.

In IEEE Shabab Bazrafkan et al. IN [3], proposed nhancing iris authentication on handheld devices using deep learning derived segmentation techniques**.** The authors in the paper proposed a novel approach based on the improving the Iris authentication method in hand held devices and it would also employ the deep learning methods of segmentation. The iris segmentation and localization features are so widespread that it actually does not provide proper outcomes. As the number of users and data keeps on increasing, the number of frauds and illegal and unauthorized attempts to breach the systems also are taking place. So to handle such instances, proper and effective biometric authorization systems need to be ready. So this approach was sought after immensely.

In IEEE 2017, Ritesh Vyas et al. in [4] explained about Co-occurrence Features and Neural Network Classification Approach for Iris Recognition. In this paper, an approach for iris recognition was proposed based on co-occurrence features and neural network classification. It was shown that he proposed approach with gray co-occurrence features prove to be highly effective in separating iris based images. The evaluation of the proposed method was checked based on the accuracy of classification. The data base used was the MMU iris database. The best accuracy is achieved with the proposed scheme is 97.83% which is at par with state- of-the-art approaches.

[4]In 2017 IEEE, Kien Nguyen et al. presented a paper **Iris Recognition With Off-the-Shelf CNN Features: A Deep Learning Perspective**.

In IEEE 2017, R. Raghavendra et al. in [5] presented ContlensNet: Robust Iris Contact Lens Detection Using Deep Convolutional Neural Networks. In many cases, many people resort to use of contact lenses. In such cases the method of Iris recognition approach has to be a little bit different. As the Iris recognition is a little difficult as the contact lenses covers the real iris part of the ye so the iris sensor is not able to detect it easily. Hence in this work, a model of Contlens is proposed for effective Iris contact lens detection using the convolutional neural network mechanism. It is built with nearly 15 layers and has a very solid detection method in place. There are cases where many Iris images have similar pixel attributes and values and it is hard to decipher the unique Iris.

In IEEE 2016, Nianfeng Liu et al. in [6] has provided accurate iris segmentation in non-cooperative environments using fully convolutional networks. In favorable conditions , the iris recognition methods work in a particular way. With high user cooperation and also cooperative set of conditions, it is a relatively easy task. Whereas for non cooperative environments such as incidence of blur, disturbances, less user cooperation nd other unforeseen circumstances, it becomes an arduous task. So this paper focuses on the accurate iris authentication in non cooperative environments. It utilizes the concept of fully conventional neural networks. Noisy iris images are a big problem. Also people on the move perform a lot of movements. In such cases this approach is used.

In IEEE 2016, MariaDe Marsico et al. in [7] have provided Iris recognition through machine learning techniques: A survey. Machine learning's mechanisms are being harnessed at a very fast pace. With automation and the artificial intelligence technology, many work processes are being reinvented. The machine learning is being used as a broad area of research for various domains. In this very work, the study is taken for the recognition purpose. The impact and use of machine learning for recognition systems is researched. The performance of the approach to handle the complexity of the recognition scheme is taken into account. . So a high end mechanism that can accurately pin point the details is need of the hour.

In IEEE 2016, Sushilkumar et al. in [8] presented a paper Iris recognition using SVM and ANN. This paper uses the method of ANN and Support vector machine for the iris recognition objective. Hough transform is also applied to separate out the region for the iris segmentation. the Iris extracted images are classified on the basis of the images which match and images which don't match. Based on which the system decides whether the user is authenticated user or not. The classification needs to be highly accurate. This is followed by pattern matching step. It performs relatively well with use of the two methods in combination.

In IEEE 2016, Shervin Minaee et al. IN [9], describes about An experimental study of deep convolutional features for iris recognition. The researchers presented a study on the depp convolutional traits for the recognition of the Iris. The features of the Iris are a important part with respect to the iris identification. Different iris of different people consists of some similar and some different attributes. So, proper analysis of the Iris of the eye is a big task. Many of the such process used manual tasks in the past. The database has to accurate and large so that there are all possible images of the Iris and gives every kind of probable user identification. The next step is the Iris segmentation. The various image templates of Iris collected are then used for the segmentation purpose. This is one of the most important phases of the entire process. Third comes the feature extraction phase. So this study provided insight into the research..

In IEEE 2015 IEEE Shervin Minaee et al. IN [10] have **provided Iris recognition using scattering transform and textural features.** The authors put forth the use of scattering transform and textual features in this study. The iris has been a subject of extensive research since a long time. Specifically for biometric systems, it has been widely researched. Principle component analysis is also used in the extraction phase of the system. The proposed method achieves a 99% accuracy and high throughput. Many a times, the facial features are so complex and detailed that the classification and feature extraction might fail to accurately identify the Iris. Also in cases of slight facial modifications like use of expressions etc, the system might not work properly.

III PROPOSED METHODOLOGY

Blood The proposed system is based in improvement in iris recognition based on the Dugman's algorithm for iris localization and the use of neural networks for classification. The proposed method detects pupil using Daugman's integro differential operator (IDO) and subsequently trains a neural network classifier for the final classification.

The Daugman's Algorithm

The Daugman's algorithm is by far one of the most effective classifiers as far as iris recognition is concerned. It relies on the fact that regular shapes with distinctive boundaries can be easily segmented by the Daugman's algorithm. There are several steps involved in the IDO which re explained below..

Histogram Equalization:- This process generally improves the contrast of the irs thereby increasing the possibility of better segmentation.

Binarization:- The image Binarization technique is extremely effective in ehnacing or amplifying the differences between the pupil and the iris section. The Binarization technique also is responsible for removal of interfering objects that may mar the separation performance.. Moreover, the binarization is based on applying an integro-differential operator to find the iris and pupil contour. The mathematical expression for the Daugman's algorithm is given below:

$$Z = max(r, x_0, y_0)|G_\sigma(r)\frac{\partial}{\partial r}\oint_{r,x_0,y_0}^{r,x_f,y_f}\frac{I(x,y)}{2\pi r}ds| \qquad (1)$$

Where

I(x, y) is the input eye image,

r being the radius that is to be searched for,

Gσ is a Gaussian function used for smoothing and s is the circle contour given by r,x0 and y0.

The operator can be understood to carry out a pixel wise search throughout the entire image as on a partial derivative (blurred) of the integral over circular contours which are in the process normalized in different contours. [3]-[5]The boundaries of the pupil separating the pupil form the iris makes contour integral derivative maximum, the point where there will be a sudden change in the values of intensity over the circular borders. The two dimensional Gaussian Filter that is used in the Daugman's algorithm is defined by:

$$g(x) = \sqrt{\frac{a}{\pi}}e^{-x^2} \qquad (2)$$

Where,

'a' denotes the peak of the distribution curve of intensity and its given by the formulation of a two dimensional intensity function. [6] In two dimensions, it is the product of two such Gaussians, one per direction we have:

$$g(x) = \frac{1}{2\pi\sigma^2}e^{\frac{-(x^2+y^2)}{2\sigma^2}} \qquad (3)$$

Here,

x and y are the spatial coordinates

σ^2 represents the variance of the random process

The algorithm is effective enough for the localization of regular images owing to the fact that regular shapes exhibit a sudden peak in intensity at the contours and hence make the contour derivative maximum shapes. In the case pertaining to the iris segmentation, the relation for the segmentation in-equation is governed by R1<s<R2

Here,
R1 is the inner radius of the iris
R2 is the outer radius of the iris
s is the region of the iris lying within the region bounded by R1 and R2

The above inequality separates the iris as a strip and results in iris localization. The segmented part is a circular ring patch enclosed by the region of R1 and R2.

Introduction to Artificial Neural Networks:

Artificial neural networks multi-domain and multi faceted applications especially in the fields of pattern recognition and classification problems. ANN is typically used for applications where the data is:

1) Large

2) Complex

Or

3) Both Large and complex

The mathematical structure of the ANN is shown in the figure below:

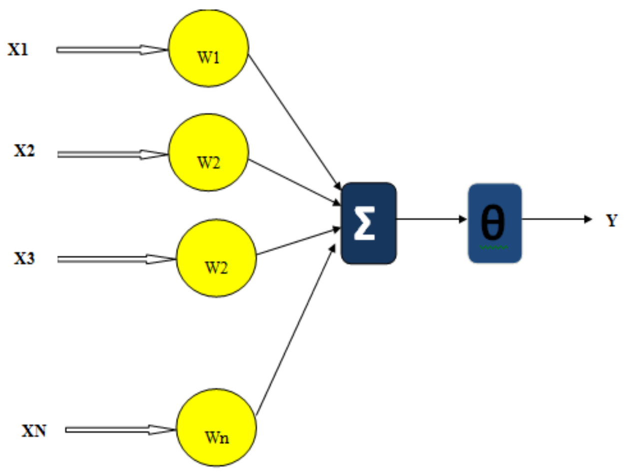

Fig.2 Mathematical Counterpart of ANN Structure

Here,

X are the inputs

Y is the output of ANN

W is weight

θ represents the logic for analysis or bias.

The mathematical model of the ANN gives us the empirical relation between the inputs, weights and the output:

$$y = \sum_{i=1}^{i=n} X_i W_i \tag{4}$$

The learning capability of the ANN structure is based on the temporal learning capability governed by the relation:

$$w(i) = f(i, e) \tag{5}$$

Here,

w (i) represents the instantaneous weights

i is the iteration

e is the prediction error

The ANN has the following 3 stages of layers:

1) Input Layer: This section receives the inputs (X) as a parallel stream.

2) Hidden Layer: This layer is responsible for the data analysis and pattern recognition such as iris recognition applications critically depend upon the training algorithm used to train the ANN and the weights saved subsequently.

The weight changes dynamically and is given by:

$$W_k \xrightarrow{e,i} W_{k+1} \tag{6}$$

Here,

W_k is the weight of the current iteration.

W_{k+1} is the weight of the subsequent iteration.

3) Output Layer: The output layer simply renders the output of te composite ANN mechanism. The structure is shown below:

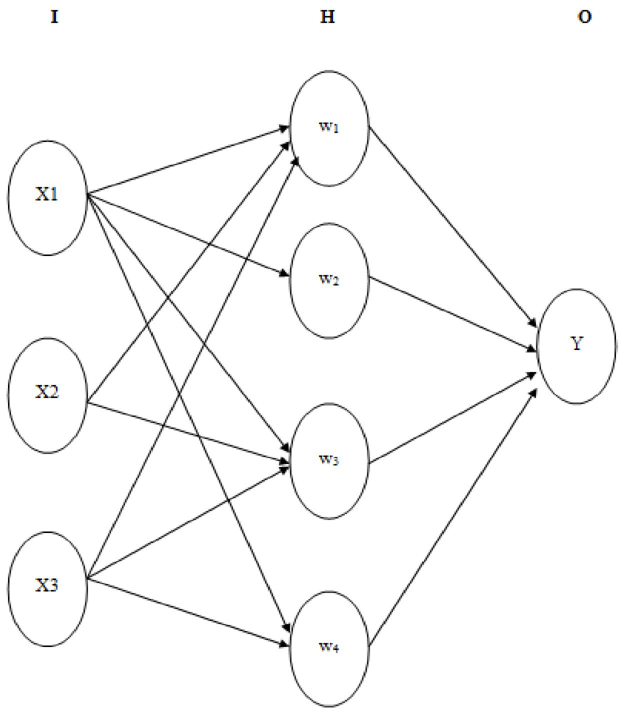

Fig.3 Conceptual Internal Configuration of ANN

Here,

I represents input layer

H represents hidden layer

O represents output layer

Design of Neural Network Based on Levenberg-Marquardt Algorithm

This algorithm bears its name on the names of Kenneth Levenberg and Donald Marquardt. The major essence of the algorithm is its speed and its stability.. The flowchart of the LM algorithm is given below.

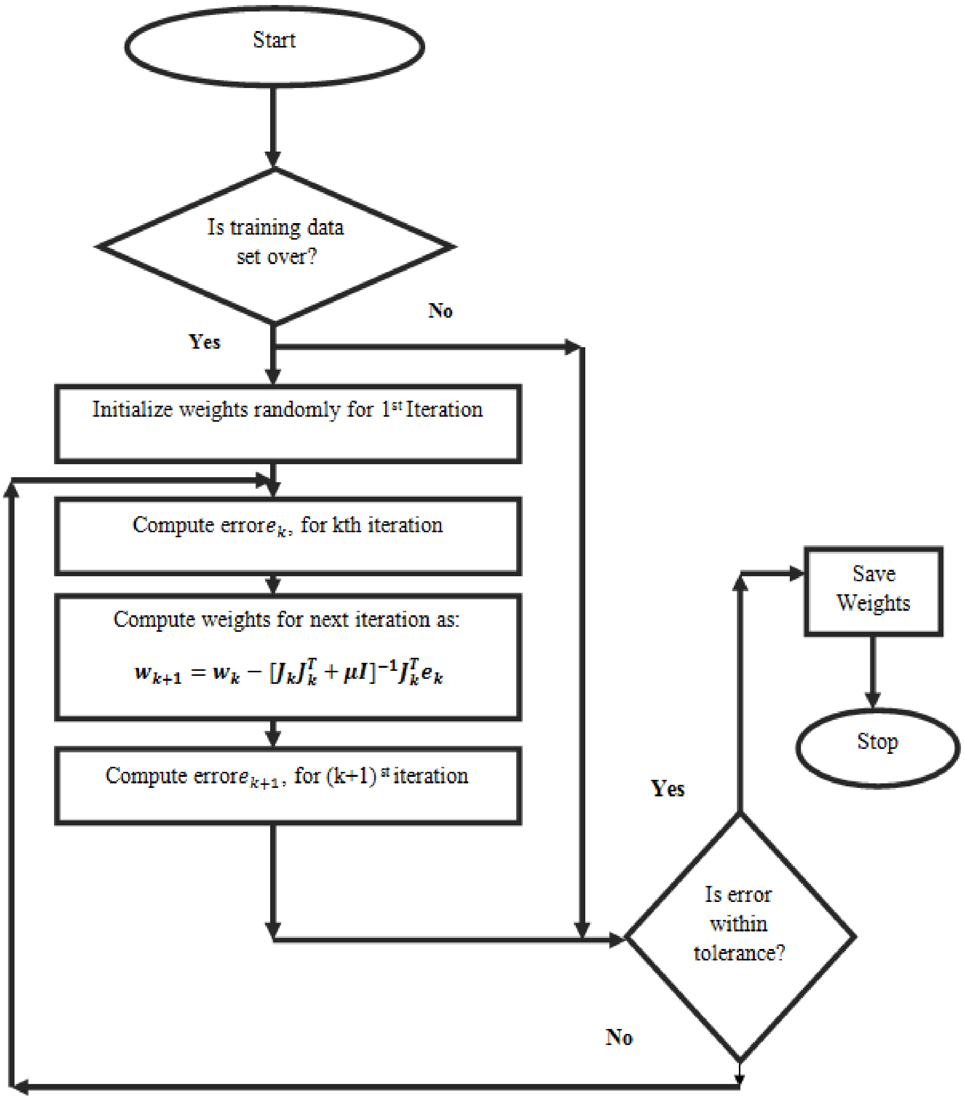

Fig.4 Flow diagram of Levenberg Marquardt training algorithm.

$$H = J_k^T J_k \quad (7)$$

$$g = J_k^T e \quad (8)$$

Where

J_k is the Jacobian matrix for k[th] input data stream,

g is the gradient vector

e is the error

T is the transpose operation

k is the iteration number

The training rule for the algorithm is mathematically given by:

$$W_{k+1} = W_k - [J_K^T J_k + \mu I]^{-1} J_K^T e_k \quad (9)$$

Where,

I represents an identity matrix,

W_k is present iteration weight,

W_{k+1} is the subsequent iteration weight and

e_k is the error evaluated in the previous iteration

μ is called the step size for weight variation

H the Hessian Matrix, which is the second order derivative of errors with respect to weights.

The Hessian Matrix is given by:

$$H = \begin{bmatrix} \frac{\partial^2 e}{\partial x1 \partial w1} & \cdots & \frac{\partial^2 e}{\partial x1 \partial wn} \\ \vdots & \ddots & \vdots \\ \frac{\partial^2 e}{\partial xn \partial w1} & \cdots & \frac{\partial^2 e}{\partial x1 \partial wn} \end{bmatrix} \quad (10)$$

The significance of the LM training rule is that it computes the Hessian Matrix (H) indirectly as a function of the Jacobian matrix. This reduces the time complexity of the algorithm.

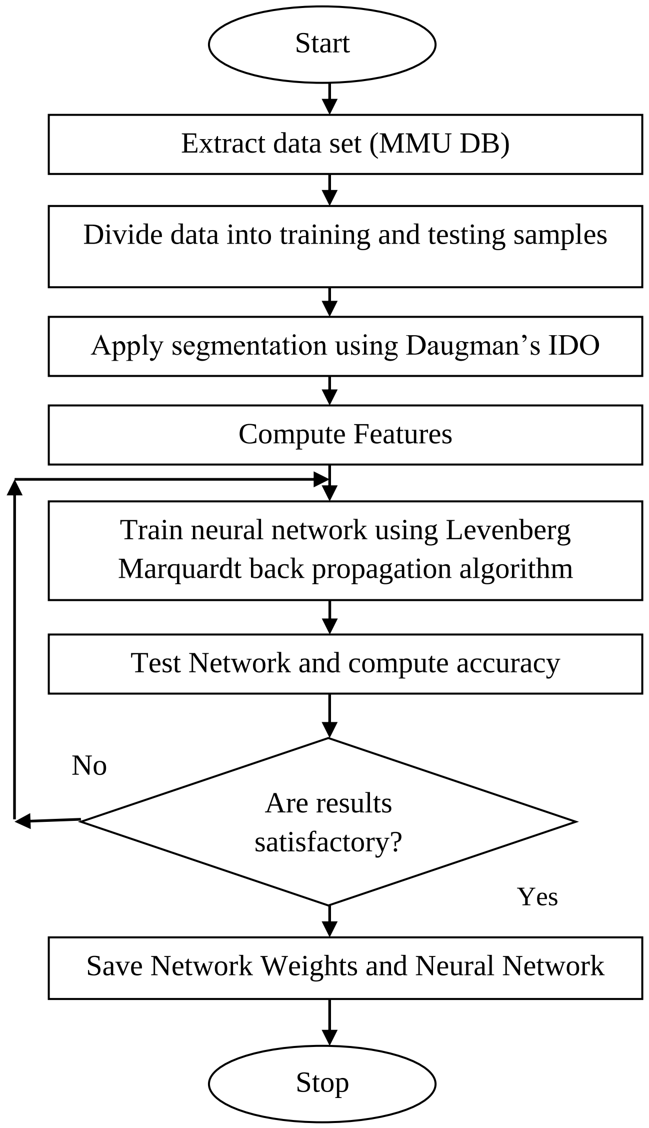

Fig.5 Flowchart of Proposed System

IV. RESULTS

The The results of the proposed work is the design of a technique that is capable to attain the classification of iris recognition with the following attributes

1) Lesser error in classification
2) Higher accuracy
3) Low or moderate time complexity (low number of iterations)

A sequential approach in all the steps involved is given below:

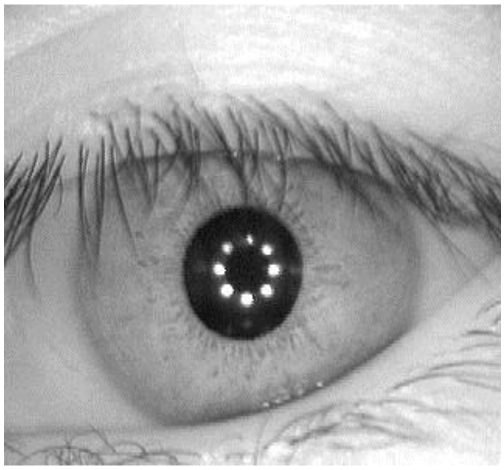

Fig.6 Composite image of the iris before segmentation [MMU Database]

The figure above depicts the captured image of the eye. It is worth noting that the image has the reflections of the camera and is a composite image which needs segmentation for the iris.

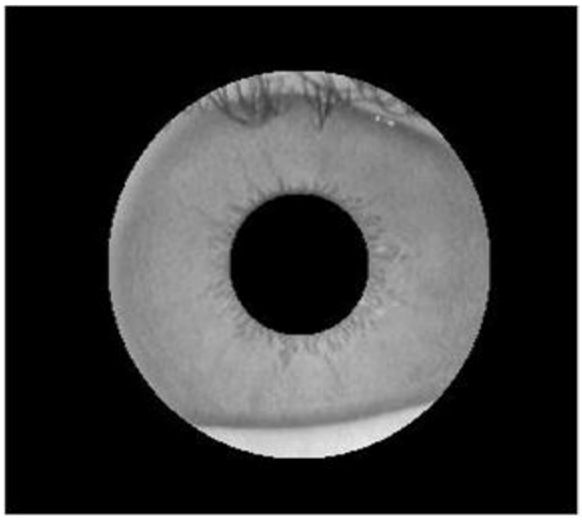

Fig.7 Segmentation of the IRIS using Daugman's IDO algorithm

The algorithm is effective enough for the localization of regular images owing to the fact that regular shapes exhibit a sudden peak in intensity at the contours and hence make the contour derivative maximum shapes. In the case pertaining to the iris segmentation, the relation for the segmentation in-equation is governed by:

$$R_1 \leq R \leq R_2 \quad (11)$$

Here,
R1 is the inner radius of the iris
R2 is the outer radius of the iris
R is the region of the iris lying within the region bounded by R1 and R2

The above inequality separates the iris as a strip and results in iris localization. The segmented part is a circular ring patch enclosed by the region of R1 and R2.

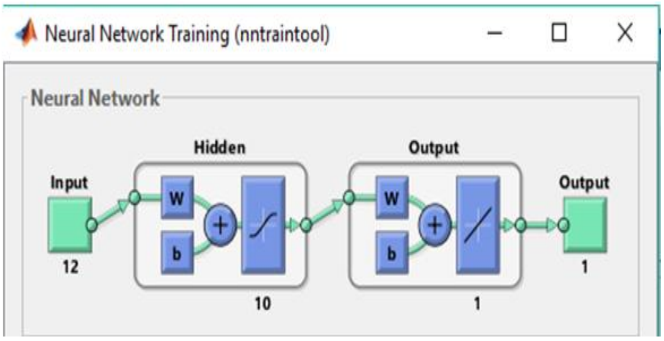

Fig.8 Designed Neural Network

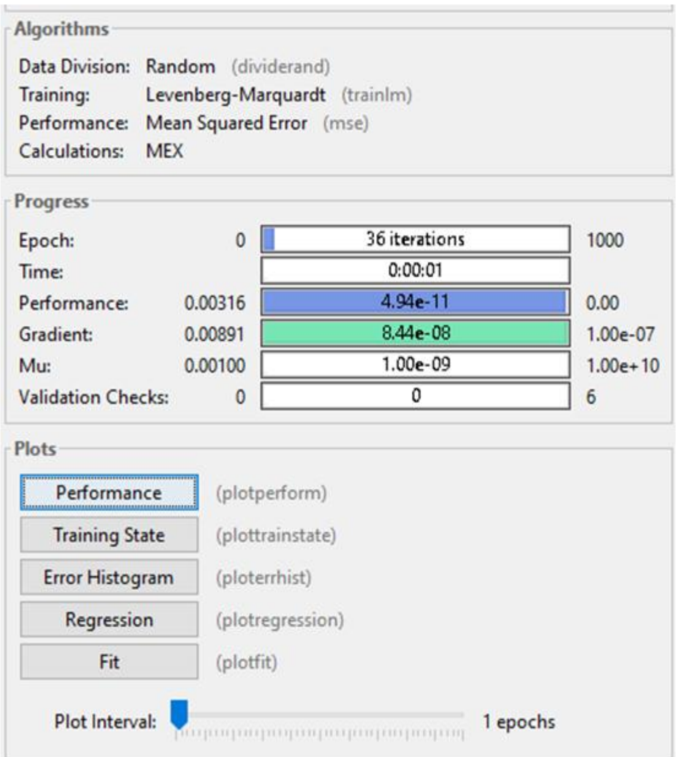

Fig.9 Training Parameters for Neural Network

The evaluation parameters for the neural network are explained below:

Accuracy (Ac): It is mathematically defined as:

$$Ac = \frac{TP+TN}{TP+TN+FP+FN} \qquad (12)$$

1. True Positive (TP): It is the case when a sample belongs to category and the test also predicts its belongingness.
2. True Negative (TN): It is the case when a sample does not belong to category and the test also predicts its non-belongingness.
3. False Positive (FP): It is the case when a sample does not belong to category and the test predicts its belongingness.
4. False Negative (FN): It is the case when a sample belongs to category and the test predicts its non-belongingness.

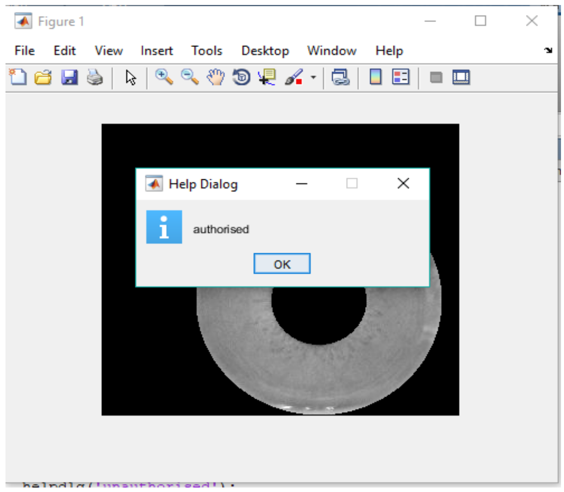

Fig.10 Authorized IRIS

It can be seen that the iris part has been separated using the Daugman's algorithm and then the classification has been done as authorized.

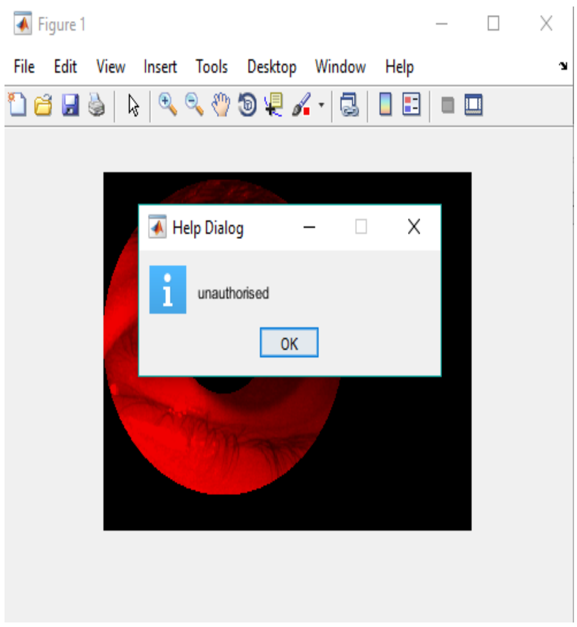

Fig.11 Unauthorized IRIS

It can be seen that the iris part has been separated using the Daugman's algorithm and then the classification has been done as unauthorized.

The computation of accuracy can be given by:

700 images have been training.

300 images have been used for testing.

3 Images have been classified inaccurately.

error =3/1000=0.3%

Hence accuracy is 99.7%

The database used is the MMU database, and the proposed technique attains an accuracy of 99.7%, which is higher than the previously proposed techniques (98.73%) . A comparative analysis with the previous approach (Co-occurrence Features and Neural Network

Classification Approach for Iris Recognition by Vyas et al. IEEE 2017) is given:

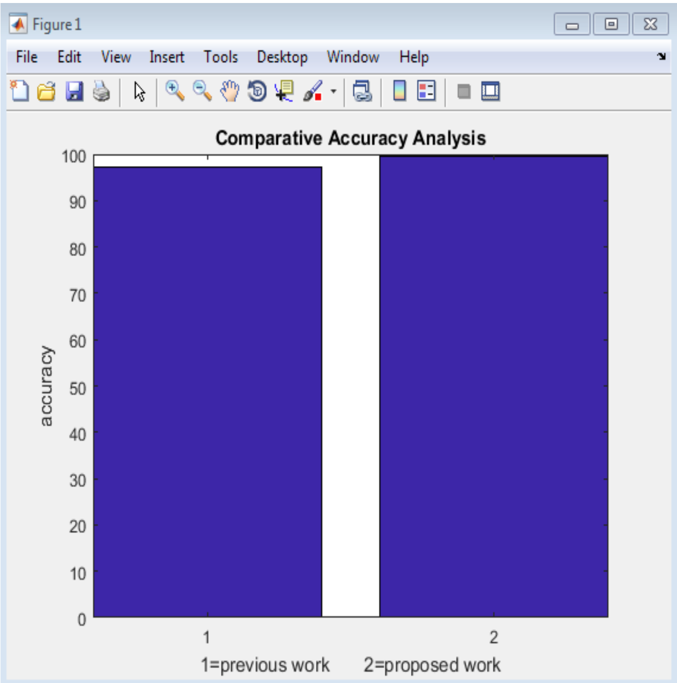

Fig.12 Comparative Accuracy Analysis

CONCLUSION:

It can be concluded from the previous discussions, it can be concluded that highly classified and secure applications need reliable security systems to prevent unauthorized trespassing. Iris recognition is a form of bio metric authentication system that uses high end mathematical techniques and processes on the digital image of the Iris of the eye. It is mainly based on the pattern recognition method where in it identifies sharp and distinct patterns of the Iris that can accurately recognize the intended user. In the proposed work, iris localization has been performed by using the Daugman's algorithm which is an integro-differential operator capable of separating or segmenting out regular shapes. The Daugman's algorithm also has a noise smoothening capability. The features computed in the work are Contrast, Correlation, Energy, Homogeneity, Mean, Standard Deviation, Entropy, RMS, Variance, Smoothness, Kurtosis and Skewness. The features tend to behave uniquely for different iris images. However, overlapping values are possible. The features are then fed to a neural network using the Levenberg-Marquardt back propagation training rule. After training the neural network with feature values of authorized images, the subsequent step is testing the neural network for accuracy. The standard MMU database has been used for design of the system. It has been found that the proposed system attains an accuracy of 99.7% which is higher compared to the previously existing system using the same database.

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