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Pattern Recognition Neural Network for Improving the Performance of Iris Recognition System

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Abstract— This research employs pattern recognition neural networks for Iris recognition systems. The neural networks have a seven-layers architecture consisting of one input layer, five hidden layers, and one output layer. Ten different ANN optimization training algorithms were used separately to train this model to get best results for the iris recognition system. Many experiments were conducted to compare the results of this model with the results of other ANN models to identify the model which improves the performance of the iris recognition system. The performances were compared using mean square error (MSE), PSNR and recognition rate to identify the best model and algorithm. The best results were obtained from the patternNet model especially when it was trained with TrainLM. The results of this model were compared also with the results of other researches to show its efficiency.

Index Terms— Iris Recognition, Artificial Neural Networks, Feed forward neural network, Cascade forward, Function fitting, Pattern recognition and Learning vector quantization.

1 Introduction

A biometric system provides identification of persons based on their physical features such as fingerprints, voice, face, and iris [1]. Iris recognition can be regarded as the most reliable biometric identification system available that recognizes a person by iris pattern [2][3]. Biometric systems based on iris patterns play important role in security domains and high level security systems [4] because iris has unique patterns and no two iris patterns are the same. Iris recognition analyzes the iris pattern. Iris patterns are more unique, stable and reliable with age in comparison with other biometric features such as face and fingerprint [5].

Iris recognition system includes: localization of iris region; data set generation of iris images; and iris pattern recognition [4]. A biometric system consists of four parts: sensor module to take the biometric data; feature extraction to process the acquired data to extract feature vectors; matching part to compare the feature vectors are with those in the template; and decision making to establish the user's identity or a claimed identity is accepted or rejected [6].

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The literature related to iris biometrics is large and growing rapidly. Many literature surveys addressed the approaches and algorithms used for iris recognition.

Most researches were focused their contribution to one of the four parts of iris recognition system: image acquisition, iris segmentation, texture analysis and matching of texture representations. Other researches include experimental evaluations, image databases and applications [7].

Bowyer (2008) [7] covered in a survey the current state of image understanding for iris biometrics and suggested list of recommended readings related to iris biometric. And Richard (1997) [8] described details related to design and operation of iris recognition as a biometrically based technology for personal identification. And Kresimir and Mislav (2004) [6] presented overview of biometric methods such as uni modal and multimodal and their advantages and disadvantages.

Whereas Mayank, et. al (2004) [9] studied, implemented and compared well known algorithms for iris recognition on the CASIA iris image database. And Sheela and Vijaya (2008) [10] discussed techniques, products and databases related to iris recognition. They addressed methods such as phase-based method; texture-analysis based method; and approach based on intensity variations. While Bhalchandra, et. al (2008) [5] presented comparative study of iris recognition methods for feature extraction such as: Haar wavelet transform method; Binary coding scheme and matching; Log-Gabor filter method matching. And Lenina and Manesh (2009) [11] presented literature related to iris recognition systems. They described the general iris recognition system architecture. They focused on the need of new, fast and efficient methods for iris recognition.

Finally, Sajida and Sheikh (2012) [12] highlighted in a survey the current state and issues of iris based biometric authentication systems. They reviewed the current iris recognition methods.

From the above, we noted that there are few literature researches and studies which were related to surveys and the use of ANN in iris recognition systems. Therefore, this research reviews the literature researches related to ANN models in iris recognition system. The second objective is to construct an iris recognition system based on pattern recognition neural network (PatternNet) model with 7 layers architecture. This model was trained separately with 10 ANN training algorithms to improve the performance of iris recognition system. The remaining of this research is as follows: section 2 lists ANN models. Section 3 reviews the literature related iris recognition systems based ANN. Section 4 includes implementation of the suggested iris recognition system. Section 5 includes the experimental results and finally, section 6 concludes this work.

2 Artifitial Neural Networks Models

In recent years, ANNs models have been proposed for pattern recognition, image processing, speech recognition and forecasting. The most popular ANN model is the multi-layer feed forward networks FFBPNN which use backpropagation algorithm (BP) for training. When ANN architecture is chosen correctly, the BP is useful. Too small ANN cannot learn the problem well whereas too large ANN will lead to poor generalization performance [13]. The traditional BP algorithm used to train FFBPNN requires long time to convergence. Therefore, many models and training algorithms were described in details in Neural Network Toolbox™ User's Guide R2012a [14].

Feed forward ANN (FFBPNN) is the simplest model. FFBPNN consists of a series of layers and it is the same as BP. Many researches described in details the main steps of BP [15][16]. Cascade ANN (CFBPNN) it is similar to FFBPNN but include a connection from input and every previous layer to following layers. Additional connections might improve the speed at which ANN learns the desired relationship. And, Function fitting NN (FitNet) are also a type of FFBPNN, which is used to fit an input output relationship. Whereas learning vector quantization NN (LVQNet) consists of two layers. The first layer maps input vectors into clusters that are found by the network during training. The second layer maps merges groups of first layer clusters into the classes defined by the target data. The total number of first layer clusters is determined by the number of hidden neurons. The larger the hidden layer the more clusters the first layer can learn.

Finally, Pattern recognition NN (PatternNet) can be created for pattern recognition problems. It is a FFBPNN that can be trained to classify inputs according to target classes. The target data for PtternNet consist of vectors of all zero values except for a 1 in element i, where i is the class they are to represent.

3 ANN for Iris Recognition

Iris recognition is regarded as an emerging biometric recognition approach and it is receiving interest in research and practical applications. Iris is a kind of physiological biometric feature. It contains unique texture and is complex enough to be used as a biometric signature. Iris patterns are more stable and reliable than other biometric features such as face and fingerprint [17]. Successful iris recognition system require success and fast algorithm with less memory requirements especially for large programs and database [10]. Therefore, many literature researches were concerned on constructing iris recognition algorithms according to these specifications.

Abiyev and Altunkaya (2008) [4] proposed an algorithm for localization of inner and outer boundaries of iris region. Located iris is extracted from an eye image. After normalization and enhancement, it is represented by a data set. Using this data set ANN is used for the classification of iris patterns. The adaptive learning strategy is applied for ANN training. And Sarhan (2009) [18] presented an iris recognition system that produces low error rates based on discrete cosine transform for feature extraction and ANN for classification. And Araghi, et al, (2010) [19] proposed an iris recognition based on covariance of discrete wavelet using competitive ANN. They used a set of edge of iris profiles to build a covariance matrix by discrete wavelet transform using ANN.

While Gopikrishnan and Santhanam (2010) [20] illustrated an approach for biometric recognition of human iris patterns using ANN. Based on their approach, they extended this work for optimization for iris patterns recognition using two ANN models (CFBPNN and FFBPNN) for comparing the performance [21]. Their results showed that, the performance of CFBPNN model is better than FFBPNN model. Also based on their paper [20], they tried to reduce the size of templates from 20×480 to 10×480 in another work [22]. They concluded that this resulted in saving of computation effort with no loss in accuracy.

Erdinc and Novruz (2008) [23] proposed ANN based iris recognition approach by analyzing iris patterns. The iris recognition system consists of iris localization, feature extraction and classification of the iris images. Hough transforms were used for localizing the iris region. Cartesian to polar coordinate transform was used for transforming the ring shaped iris image to the rectangular shape. They made a comparison with other works.

At the same time, Wenbo, et. al (2008) [24] discussed whether and how we can make iris recognition easier. Firstly they analyzed the restricting factors of iris image acquisition and derived the optical formulas. They summarized the solutions of the iris recognition systems and finally they proposed iris recognition systems with good human computer interface. And Raghavi et al (2011) [25] built a system to deal with human iris recognition to overcome the shortcomings of other methods of personal identification. Their system deals with the localization of iris region using a fast algorithm.

The extraction is done using fuzzy ANN algorithm to extract the deterministic patterns in iris in the form of feature vectors. Then they are compared in terms of weighted hamming distance to verify the identity.

Whereas Sherline Jesie (2011) [26] presented a face and iris recognition system using ANN and principal component analysis (PCA). This is to enable detecting changes in face and iris image pattern of an individual to an appreciable extent. The recognition system can tolerate local variations in the face or iris image of an individual. The performance of both systems (face and iris recognition) is evaluated by comparing its recognition rate and accuracy. And Murugan and Savithiri (2011) [27] presented iris recognition system based on partial portion of iris patterns using BPNN. They compare their experimental results with the results of other methods.

And Rashad et al (2011) [28] proposed hybrid model for iris recognition based on local binary pattern and histogram properties as a statistical approaches for feature extraction. Their algorithm based also on combined LVQNet classifier for classification. Feature vectors results from LBP is applied to a combined LVQNet classifier with different classes to determine the minimum acceptable performance, and the result is based on majority voting among several LVQ classifier. They used iris datasets CASIA. Their proposed system gives a high recognition rate 99.87% compared with other methods.

And Sotir Sotirov (2011) [29] suggested a generalized ANN for iris recognition and described the process of scanning, preprocessing, learning and recognition of the iris. And Chaudhary and Mubarak (2012) [30] described the using of BPNN on classifying the iris patterns. They described in details image acquisition, image segmentation, feature extraction and pattern forming based on human iris imaging. Pair of iris recognition is very effective for person identification due to the iris unique features and the protection of the iris from the environment and aging.

Saminathan et al (2012) [31] presented a simple methodology for pre-processing pair of iris images by taking both left and right eye of human instead of either right or left eye. They presented the design and training of FFBPNN for iris recognition system.

Finally, Savita Sondhi, et. al (2012) [17] described an iris recognition system which composed of iris image acquisition, iris image preprocessing, ANN training process using self-organizing map (SOM) and pattern matching. They captured and reprocessed the iris image to remove the unwanted parts that are captured along with the iris image to prevent effects due to a change in camera to face distance. According to above, we note that many of literature researches have strengths and limitations in the case of performance and security related issues with existing techniques. For these purposes, we require an accurate and fast iris recognition algorithm for person identification system. At the same time many researches adopted different ANN models in iris recognition system. Therefore, we need to identify the best ANN model for iris recognition system.

4 IMPLEMENTATION OF IRIS RECOGNITION

In this research, we suggested an iris recognition system based on constructing PatternNet model with 7 layers architecture (input, 5 hidden layers and output layer) as shown in Fig.1. We selected 150 iris images for 50 persons each person with 3 images from CASIA Iris Image Database Ver. 1.0 (CASIA-IrisV1) which was provided by **C**hinese **A**cademy of **S**ciences **I**nstitute of **A**utomation [33].

All images are stored in CASIA-IrisV1 as BMP format with resolution 320×280. Fig.2 shows 9 samples of 3 persons (each with 3 images) which selected from CASIA-IrisV1. Each iris image is processed using many steps (eye image acquisition, segmentation, normalization, feature extraction and finally matching) to produce the same image but with dimension 200×170. Each one of the processed iris image (200×170) is then divided into sub blocks each with 10×10 dimension. This operation will result to 340 samples (image sub block) for each iris image. Therefore, the total number of training samples for the 150 iris images is equal 51000 [340×150=51000]. These samples are used in training process of iris recognition system.

At the same time, the input layer represents iris image that enter the system. The number of input layer neurons is equal to sub image dimension (10×10=100). Whereas, the output layer returns the output vectors and here, the number of output layer neurons is depends on number of classes (persons) used in iris recognition training process and it is equal 50.

As testing samples, 50 iris images (320×280) were selected randomly from CASIA-IrisV1 database [33]. Iris processing steps were applied on these images to obtain images with dimension 200×170. After that each image (200×170) is divided into blocks of dimension 10×10 to obtain 340 sub blocks for each iris image. Therefore, the total number of testing samples for the 50 randomly selected iris images is equal to 17000.

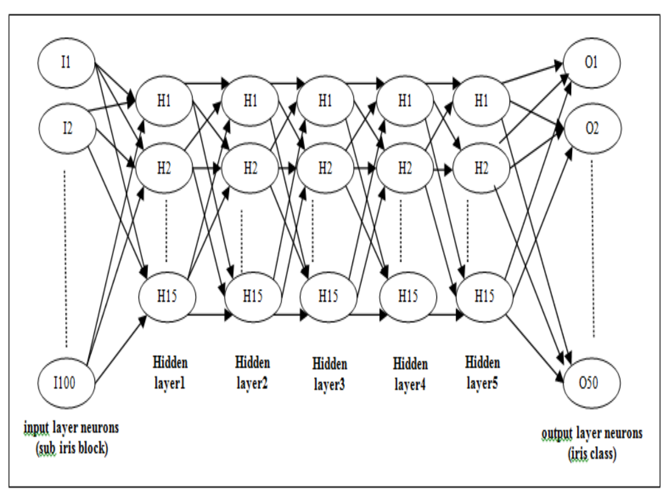

Fig.1. PatternNet ANN with 7Layers

4.1 Preprocessing of Iris Image

Human iris identification process consists of five steps: eye image acquisition, segmentation, normalization, feature extraction and matching.

We need normalization process because irises of different peoples may be captured in different size. For the same person also the size may vary because of the variation in illumination and other factors. We need feature extraction because iris provides sufficient texture information. A feature vector is formed to contain the ordered sequence of features extracted from the various representations of iris images. Finally, the feature vectors are classified using different ANN models in matching process [13]. Here, for ANN training and testing, we adopted the following iris preprocessing steps:

1. Localization
2. Segmentation from 320×280 to iris image=200×170,
3. Division =(200×170)/(10×10) to obtain 340 (10×10) blocks for each iris
4. Normalization

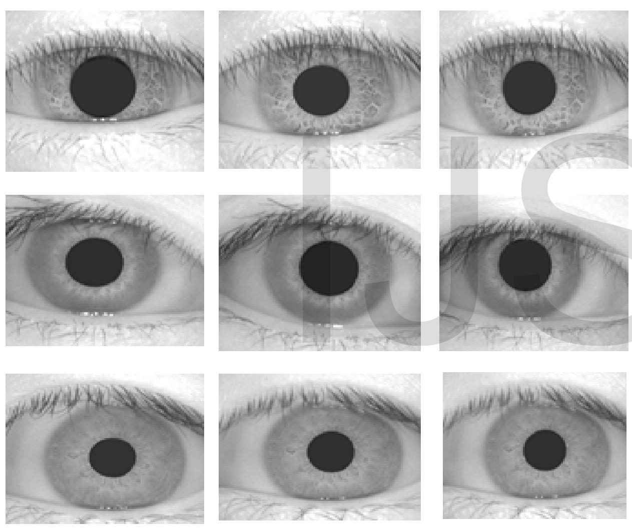

Fig. 2. Selected Nine Samples from CASIA-IrisV1 database (for 3 Persons each with 3 images)

4.2 ANN Training Algorithms

The optimization training algorithms adjusted the ANN weights and MSE is minimized during FFBPNN training. MSE represents the difference between ANN desired output and actual output. Ten training algorithms were used to train PatternNet model to identify algorithm with best results for iris recognition. These algorithms are [14][32]: Levenberg-Marquardt (TRAINLM); TRAINBFG; Bayesian regularization (TRAINBR); TRAINCGF; Gradient descent (TRAINGD); Gradient descent with momentum (TRAINGDM); TRAINGDA; Gradient descent momentum and an adaptive learning rate (TRAINGDX); TRAINOSS; and TRAINRP.

4.3 ANN Training for Iris Recognition

The steps required to train the PatternNet model for iris recognition system are as follows:

1. Initialize the ANN model weights and bias unit.
2. Initialize learning rate, momentum variable and threshold error with very small value let 0.0000001.
3. Initialize 50 classes: class for each person. Each class containing 3 irises images of one person.
4. Initialize 50 target (desired) vectors one vector for each iris class: vector = t1, t2, …………, t50. All bits of vector1 are 0 except the first bit is 1. All bits of vector2 are 0 except the second bit is 1, and so on for other vectors. This process is called iris images classification.
5. Initialize the target output vector for each input vector (iris sub block 10×10) of the 150 iris images. As example, the target output for iris image sub blocks related to the three iris images of the first person is equal to vector1. And, the target output for iris image sub blocks related to the three iris images of the second person is equal to vector2. And so on for each 3 iris images related to remaining 50 persons.
6. Apply steps of the selected training algorithm (LM, BFG, BR, CGF, GD, GDM, GDA, GDX, OSS and RP) to train the PatternNet model. Apply input vector; compute outputs of each layer to find the actual output vector. Calculate the ANN error and according to this error the training is stopped or repeated again by adjusting the ANN weights. These operations repeated until we get ANN total error equal to threshold error to stop training process.

4.4 ANN Testing on Iris Recognition

The steps required to test the PatternNet model for iris recognition system are as follows:

1. Apply one iris sub block 10×10 to input layer neurons.
2. Compute the output of all layers in the ANN according to the steps required by training algorithm which was used in ANN training process until finding the outputs of output layer neurons.
3. Check if output of output layer neurons (output vector) is the same as one of the 50 classes (it's computed MSE is too small), then ANN is recognized the sub block. Therefore. Otherwise (its computed MSE is large), ANN is not recognized this sub block. Therefore.

5 Experimental Results

MATLAB software is used to write simulation programs related to training and testing processes for ANN models. We use the Mean Square Error (MSE), peak signal to noise ratio (PSNR) and recognition rate (RR) to evaluate the performance of ANN model for iris recognition system.

To examine the ANN model with best results of training and testing processes for the iris recognition system, we constructed another 4 ANN models (FFBPNN, CFBPNN, FitNet, and LVQNet) each with the same 7 layers architecture (input layer, five hidden each with 15 hidden units and output layer).

Separately, we trained the five ANN models with 10 different ANN training algorithms. Experiments were conducted with different number of hidden units in each hidden layer.

Fig.3 shows MSE values when these models each was trained separately using 10 different algorithms. Lowest values of MSE were obtained when we increased the number of hidden layers neurons. Best results were obtained when we used 15 units in each hidden layer.

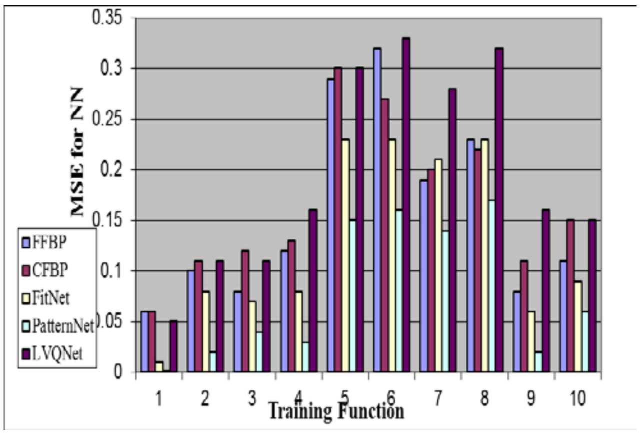

Fig.3. MSE for the 5 ANN models in training process

From Fig.3 we noted that lower values of MSE are obtained for these models when we used LM training algorithm and it is equal to 0.001. Also lowest MSE values were obtained when using PatternNet model.

We also calculated the number of iterations needed for training process for each experiment. The ANN model required more number of iterations when we increased the number of hidden layer neurons. Therefore we used only 15 hidden units in each hidden layer in each model. Fig.4 shows the number of iterations required to train the 5 ANN models with 10 algorithms.

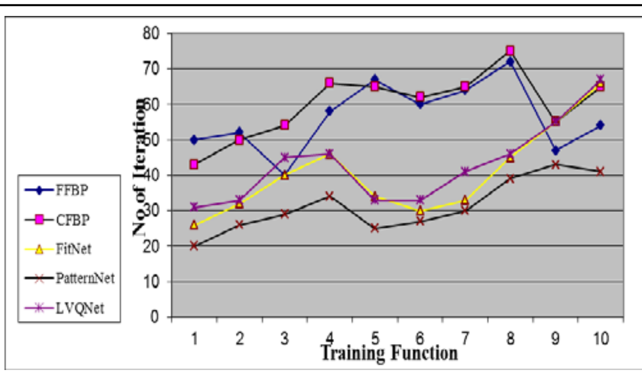

Fig.4. Number of iterations for 5 ANN models in training

From Fig.4, PatternNet required lowest number of iterations (20) for the training process especially when it was trained using LM algorithm.

But PatternNet required 43 and 41 iterations when it was trained using OSS and RP respectively. Whereas FFBPNN required 50 iteration, CFBPNN required 43 iterations, FitNet required 26 iterations and LVQNet required 31iterations for the same LM training algorithm.

5.1. ANN Testing Process

In testing process, we mentioned earlier in section 4 that the number of samples used in testing process is 50 iris images. Firstly, we tested the 5 constructed models with 50 iris images which were selected randomly from the training samples. The lowest values of MSE were obtained from PatternNet model with LM training algorithm as shown in Table (1).

TABLE 1
MSE for testing 50 trained images

Train Function	FFBP	CFBP	Fit Net	LVQ Net	Pattern Net
LM	0.04	0.03	0.02	0.02	0.002
BFG	0.09	0.09	0.07	0.09	0.01
BR	0.10	0.11	0.08	0.10	0.03
CGF	0.13	0.15	0.07	0.12	0.02
GD	0.25	0.26	0.21	0.25	0.12
GDM	0.23	0.24	0.25	0.28	0.14
GDA	0.17	0.19	0.22	0.25	0.13
GDX	0.21	0.20	0.26	0.27	0.15
OSS	0.08	0.10	0.05	0.14	0.01
RP	0.09	0.14	0.08	0.12	0.05

Table (2) shows the recognition rate for the testing process obtained from testing the 5 models using 50 randomly selected trained images. Best values of recognition rate were obtained from PatternNet model.

TABLE 2
Recognition rate for testing 50 trained images

Train Function	FFBP	CFBP	Fit Net	LVQ Net	Pattern Net
LM	98.6	98.5	98.4	98.4	98.9
BFG	96.7	96.7	96.8	96.7	98
BR	96.5	96.3	96.9	96.5	98.5
CGF	96.1	95.9	96.8	96.2	98.4
GD	94.5	94.2	95.1	94.5	96.2
GDM	94.9	94.7	94.5	94.3	96
GDA	95.5	95.3	95	94.5	96.1
GDX	95.1	95.2	94.2	94.4	95.9
OSS	96.8	96.5	98.4	96	98.4
RP	96.7	96	96.9	96.2	98.4

Also Table (3) shows the PSNR of the testing process related to the trained 5 models using 50 randomly selected trained images. Best values of PSNR were obtained from PatternNet model.

TABLE 3
PSNR FOR TESTING 50 TRAINED IMAGES

Train Function	FFBP	CFBP	Fit Net	LVQ Net	Pattern Net
LM	34.7	34.6	34.5	34.5	34.6
BFG	31.2	31.2	31.5	31.2	33.3
BR	31	30.8	31.7	31	34.6
CGF	30.5	30.3	31.5	30.7	34.5
GD	28.6	28.1	29.2	28.6	30.7
GDM	28.9	28.7	28.6	28.2	31.4
GDA	31	29.7	30.4	28.6	30.5
GDX	29.2	29.5	28.1	28.5	30.3
OSS	31.5	31	34.5	31.4	34.5
RP	31.2	31.4	31.7	30.7	34.5

Second, the five constructed ANN models is tested with 50 testing samples (i.e images which were not used in training process). The MSE values obtained from this testing were very high because the 5 ANN models where not recognized these testing images. The lowest MSE were obtained from using PatternNet ANN model which was trained using LM algorithm as shown in Table (4).

TABLE 4
MSE for testing 50 untrained images

Train Function	FFBP	CFBP	Fit Net	LVQ Net	Pattern Net
LM	0.81	0.79	0.75	0.76	0.66
BFG	0.86	0.85	0.84	0.88	0.82
BR	0.82	0.89	0.85	0.84	0.86
CGF	0.84	0.88	0.81	0.88	0.89
GD	0.91	0.92	0.90	0.93	0.91
GDM	0.93	0.94	0.93	0.92	0.91
GDA	0.91	0.92	0.93	0.91	0.94
GDX	0.89	0.91	0.92	0.95	0.91
OSS	0.91	0.88	0.86	0.82	0.83
RP	0.84	0.81	0.83	0.86	0.81

Finally, Table (5) shows the recognition rate for the testing process of the 5 models on untrained images.

TABLE 5
Recognition rate for testing 50 untrained images

Train Function	FFBP	CFBP	Fit Net	LVQ Net	Pattern Net
LM	25.6	25.4	25.3	25.3	25.7
BFG	22.4	22.4	22	21.9	25
BR	21.5	21.2	22.1	21.6	25.5
CGF	21.2	20.8	22	21.2	25.3
GD	19.9	19.6	19.4	19.7	25
GDM	20.1	19.8	19.3	19.3	21
GDA	20.7	20.5	20.2	19.4	21.2
GDX	20.3	20.4	19.3	19.2	20.8
OSS	22	21.6	25.3	21	25.3
RP	21.6	21	22.1	21.1	25.3

6 CONCLUSION

In this research, an iris recognition system was suggested based on PatternNet ANN model. This model is constructed with 7 layers architecture (input layer, 5 hidden layers each with 15 unitsand output layer). Ten different optimization training algorithms (LM, BFG, BR, CGF, GD, GDM, GDA, GDX, OSS and RP) were used to train this model separately.

The training and testing samples of the suggested iris recognition system was taken from the CASIA iris image database ver. 1.0 (CASIA-IrisV1) [20]. All images are stored in CASIA-IrisV1 as BMP format with resolution 320×280. The training samples consist of 150 iris images belong to 50 persons each person with three samples.

A set of experiments were conducted in this research to evaluate the performance of the suggested iris recognition system by calculating the MSE, PSNR and recognition rate. This is done by comparing the results of PatternNet model with the results of other constructed 4 ANN models (FFBPNN, CFBPNN, FitNet, and LVQNet).

From the training and testing results and according to MSE, no. of iterations, PSNR and recognition ratio values, we noticed that, the lowest MSE values, highest PSNR values and highest recognition ratio values were obtained from adopting PatternNet. At the same time, the best results for PatternNet model where obtained from using the Levenberg Marquardt training algorithm (LM).

For future work, we suggest to build an iris recognition system based on other different ANN models. Parallel computing may be used. Comparisons might be conducted with our current results and results of other researches.

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