Face Recognition Using Supervised vs Unsupervised Learning Techniques

Abhjeet Sekhon*
Department of Computer Science & Engineering,
Mewar University, Chittorgharh,
Rajasthan, India
*abhisekhonkalsi@gmail.com

Received: *20.09.2017,* ***Accepted****: 28.10.2017*

Abstract

This paper presents face recognition task using various supervised and unsupervised learning techniques of artificial neural network. In this proposed work back propagation, self-organizing map, radial basis function with particle swam optimization, KNN classifier and k-means with radial basis function networks were investigated. We worked on AT & T database which fuses 400 pictures of 40 people. The basic objective of this proposed work is to understand the suitability and precision of all these neural network techniques in face recognition errand (on same database). Some critical results and perceptions are given.

Keywords - Face recognition, Supervised, Unsupervised, AT & T, Database.

Introduction

Face recognition is a task in which any individual can recognize by a computer framework. An individual can without much of a stretch perceive a man from a great many individuals, in this undertaking PC framework responds as being human. The Framework can perceive a man from a picture put away in the database and a few pictures which are not put away in the database. Recognition of face from a picture is an exceptionally troublesome assignment in light of the fact that there are such a large number of varieties in the photos, some lighting conditions, distance from the camera, diverse groups and so forth.

Face recognition framework is a sort of biometric framework. It can be utilized for security purposes. Face recognition can be possible by using distinctive artificial neural system procedures. Following are the supervised and unsupervised ANN techniques which are implemented in this research work.

Supervised:
- Back propagation neural network
- Radial basis function network
- KNN classifier

Unsupervised:
- Self-organizing map
- K-Means

The central focus of this proposed work is to understand the limit and capacity of these artificial neural framework techniques for face recognition errand. Three basic steps are followed in this proposed system:

- Feature detection
- Feature extraction (with HOG feature extraction strategy)
- Face recognition (with ANN Techniques)

Related Word

A research on "face recognition using back propagation neural network" was carried out by Agarwal *et al.*, (2010). They had been tried their proposed framework on 400 pictures. They watched that their framework was 97% accurate. They compared their results with k-means and fuzzy c-means. They presumed that their proposed framework gave better outcomes when contrasted with these two. Another research on "face recognition using radial basis function network" was carried out by Meng *et al.*, (2002). They had been used ORL database and extracted features by using principle component analysis. They watched that their framework accomplished phenomenal execution both as far as error rate and learning efficiency.

Kashem *et al.*, (2011), carried out a research on "face recognition using PCA with back propagation". They observed that their proposed system was more than 90% accurate. They had utilized face database with various wellsprings of varieties like lighting, foundation, extras and so forth. Linga *et al.*, (2008), carried out a research on "face recognition using back propagation neural network and radial basis function network". Their proposed system was tested on FERET database. They have used 120 faces for training and 80 faces for testing. They concluded that both the techniques were accurate for face recognition.

A research on “neural network for face recognition using SOM” was carried out by Santaji *et al.*, (2010). They had created and shown a face recognition framework for human faces utilizing SOM. Their framework was 96.2% exact for 400 pictures. Jain *et al.*, (2012), carried out a research on “design of face recognition system by using neural network with discrete cosine transform and principle component analysis”. They had looked at 2D-DCT for picture pressure and SOM for image recognition with PCA for picture pressure and SOM for recognition. According to them PCA with SOM was better technique.

Pooja *et al.*, (2015), carried out a research on “face recognition using SOM network”. DCT and DWT were implemented for feature extraction with SOM. They had used 30 face images database containing 6 subjects and each subject having 5 images with different facial expressions. They discovered their framework was 100% exact for face recognition and DWT highlight extraction was superior than DCT feature extraction.

A research on "Face detection and recognition using k- means and neural network methods" was carried out by Ashoka, (2014). He had actualized k-means with BPNN procedure for unraveling face recognition errand. He had utilized k-means for face classification and BPNN method for face recognition. He watched that his face detection framework was 82.8% viable and his face recognition framework was 72.35% productive.

A research on "k-means clustering for detection of human faces in database" was carried out by Smith, (2009). In this research, she had used k-means to segment eye and mouth candidates within the face candidates. She had used principle components eigen vectors for training the system. She had trained the

system for three components: one to classify faces, one to classify eyes, one to classify mouth. She watched the achievement rate of characterization was 88.9%, 85.4%, 97.8%. In her examination, 20% of the pictures neglected to produce any legitimate eye or mouth applicants. She observed that k-means algorithm was able to segment valid candidates in 97% of the cases.

A research on "face recognition based on radial basis function and clustering algorithm" was carried out by Yuanfeng, (2008). In his exploration he had executed RBFN utilizing K-means. He had proposed another strategy for characterizing faces on the premise of subtractive grouping calculation. He had tried his framework on ORL database and he watched that RBFN utilizing SCA was superior than RBFN utilizing K-means. Pal *et al.*, (2014), carried out a research on "facial expression recognition based on basic expressions and intensities using K-means clustering". In their framework, cohn kanade picture database was utilized with K-means technique. They had used facial expressions like happy, angry, fear, natural, sad and surprise. They had actualized k-means for face classification and BPNN for recognizing the faces and their framework was 98% precise.

A research on "face image retrieval using facial attributes by k-means" was carried out by Sudha *et al.*, (2014). They had proposed an approach to achieve immediate retrieval in a large-scale dataset. They had utilized k-means for grouping of pictures on the premise of their properties and proposed a novel system for face recognition. They watched that their proposed framework was precise for face recognition errand. Parveen *et al.*, (2006) carried out a research on face recognition using multiple classifiers. They had executed LDA, KNN and SVM strategies for settling face recognition errand. For speedup KNN they had actualized PCA in highlight lessening. They had presumed that SVM and KNN are viable strategies for face recognition.

A research on "A color face recognition using PCA and KNN classifier " was carried out by Maheswari *et al.*, (2015). They had used 700 images as training data and 350 images as testing data. They had watched that from training information, framework accurately perceived 654 pictures and from testing information, framework effectively perceived 317 pictures. Their framework was 92.47% exact.

Dhriti and Kaur, (2012), carried out a research on k nearest neighbor classification approach for face and fingerprint at feature level fusion. In their research Gabor channel was used. They had used PCA for face classification and KNN for recognizing the face from an image and fingerprint recognition. Add up to the number of pictures in training dataset was 40. They watched that KNN classifier with city square separation gave most elevated combination esteem when contrasted with Euclidean, cosine and correlation.

Proposed System

Database

In this proposed work, a face picture database was made with the true objective of benchmarking the face recognition system. AT & T database is used for face recognition task. It has finish 400 pictures, 10 one of a kind pictures of each of 40 individuals with assortments in face focuses, outward appearances are considered. The picture database is isolated into two subsets, for training and testing purposes. Figure1 illustrates few face images from the database.

Figure 1: Few face images from AT & T database

Techniques

Artificial neural network methods are looked into in this proposed work.

- These are:
- Self-organizing map
- K-means
- Radial basis function
- KNN classifier
- Back propagation neural network

Self-organizing map and k-means are unsupervised learning techniques, radial basis function, KNN and back propagation are supervised learning techniques.

Self-organizing map

In this proposed work, SOM technique was executed. The guideline objective of self-organizing map changes an approaching example of self-assertive measurement into a maybe a couple dimensional discrete guide and to play out this change adaptively in a topologically requested fashion's figure out how to perceive gathering of comparable info vectors in a manner that neurons physically close to each other in the neuron layer react to comparative information vectors. They give quantization of picture test into a topological space where inputs that are close-by in the first space are likewise close-by in the yield space, accordingly giving dimensionality diminishment and invariance to minor changes in the picture test.

Algorithm

The algorithm for self organizing map is as follows:

- Firstly, We introduced learning rate and weight values parameter,
- Euclidean distance was calculated. (1)

$$D(j) = \sum(wij - xi)^2$$

Here i= 1 to n and j=1 to m
D is for squared Euclidean distance.
w is for weight values and x for inputs.

- Then winning unit was found.
- Weights were updated by using the following formula:

$$wij\ (new) = wij\ (old) + \alpha\ [xi - wij\ (\text{old})] \quad (2)$$

- Learning rate was also updated.
- Until the system found its stopping condition we need to update the weights and again perform previous steps.

In figure2, there are X qualities and Y values. X for data sources and Y for yields of the system. In the system all information hubs are straightforwardly associated with the yield hubs on the grounds that there are just two layers (input layer and output layer) in the SOM. Input layer acknowledges the contribution to the type of face highlight values. The framework handled these qualities and creates yield of the system in type of face qualities. During the time spent SOM, the champ unit was figured by Euclidean distance strategy. In this strategy the framework ascertains squared Euclidean distance between information vector and weight vector and picks the unit whose weight vector has littlest Euclidean distance from the information vector. At that point the triumphant and neighboring units up graded their weights.

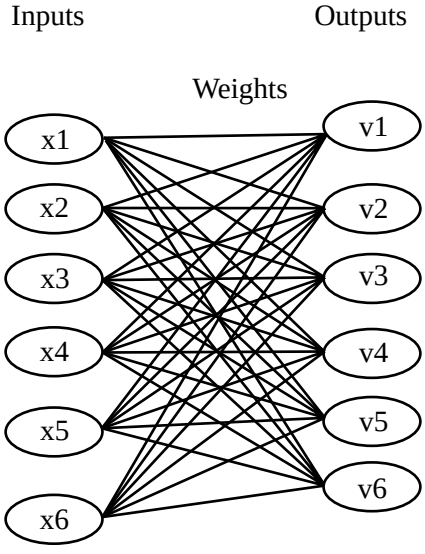

Figure 2 : SOM

We can increment or diminishing the quantity of hubs in the system according to framework's prerequisite.

Back propagation neural network technique

In this proposed work BPNN were implemented. BPNN system learning calculation is among the best ways to deal with machine realizing when the information incorporates complex tactile information, for example, pictures [1]. Back propagation is essentially an expression for the halfway subsidiary of the cost work as for any weight or bias in the system. The expression infers how rapidly the cost changes with the change in weights and bias. Every component in back propagation system has a characteristic, instinctive translation that makes it a quick calculation for learning. There are "classic" systems which are generally utilized and on which numerous others are based.

Algorithm

Algorithm for back propagation neural network is as follows:

1. Weight values were initialized.
2. Shrouded hub results were found by using following formula:

$$z = voj \sum + xivij \quad (1)$$

Z is output of concealed layer. x represents to inputs and v represents to weights.

3. Outputs of the framework:

$$yink = wok + \sum zjwjk \quad (2)$$

Yink represents outputs. W represents to weight values and Z represents to contributions of concealed layer.

4. Back propagate errors

$$\delta inj = \delta iwjk \quad (3)$$

5. Until the system found its stopping condition we need to update the weights and predisposition values and again implement previous steps.
6. Update weight values.

$$wjk(new) = wjk(old) + \delta wjk \quad (4)$$

W represents weight values.

Figure3 is network topology of back propagation. We have one input layer, three hidden layers and one output layer in this network. Every one of the hubs in the system is associated with each other. Hubs in the input layer rely on the component estimations of the face. Input layer accepts input to the type of feature values. Hidden layer prepares these values and create yield to the following level layer. Yield layer produces the last yield of the framework as picture values. Training procedure of the framework begins from the input layer to yield(output) layer all through the concealed layers. At the point when training procedure is finished, then our framework is prepared for perceiving the appearances.

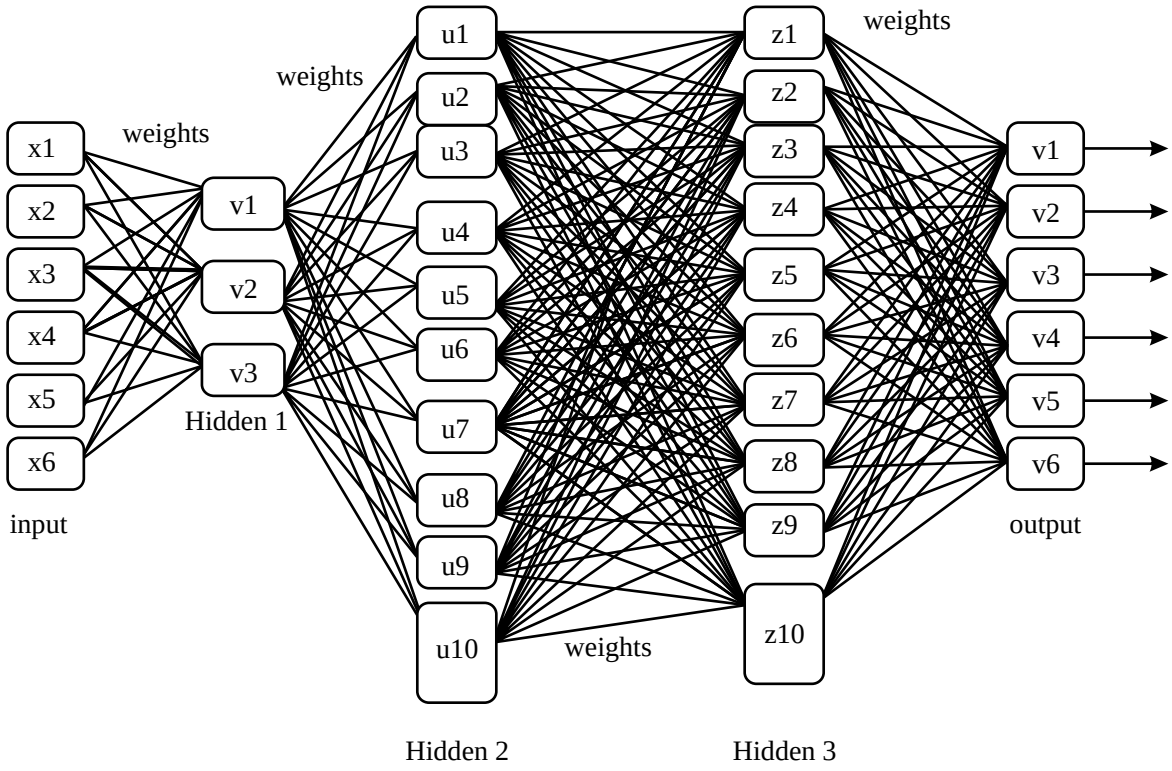

Figure 3: BPNN

k-means with RBFN

In this proposed work, two techniques were actualized for solving face recognition task. These are K-means with RBFN. The K-Means is a straightforward grouping calculation used to partition an arrangement of articles which depends on their qualities or components, into the k bundles in which the k is a predefined or customer portrayed enduring. Portraying k centroids, one for each group is the essential thought. The centroid of a cluster is molded in a way that it is solidly related (the extent that similarity limit) to all objects of that gathering. Since we know the quantities of clusters to be framed, the articles which are in the information rundown are at first separated into arbitrary gatherings, that is, every single protest is appointed to an irregular bundle. K-means packing arrangements to bundle n discernments into k aggregates in which each recognition has a place with the gathering with the mean which is the nearest, filling in as a fundamental model of each gathering.

K-means is an unsupervised learning method. We have just two layers input and output layer in the k-means calculation. In figure4, we have six contributions to the type of face highlight values from x1 to x6 and we have picked five number of centroids. With the goal that framework made five number of bunches (c1 - c5)of the face values in the database. These group values additionally utilized by RBFN for face recognition errand. Figure5 demonstrates the system topology of RBFN. It is a supervised learning technique. It has three layers. To begin with is input layer, second is clusters layer and third is yield layer. In input layer, we have six number of contributions as face highlight values from x1 to x6. We picked five number of centroids so five number of bunches were utilized as a part of the concealed layer from c1 to c5

by utilizing k-means. In concealed layer, we use two things one is width and second is group values. For figuring yield of the framework we utilize weights for yield layer. y1 to y6 are the yields of the framework.

Algorithm

The algorithm for K-means with RBFN is as follows:

- Weights were initialized.
- Centroid was browsed the arrangement of contributions with the help of k-means calculation.
- Output of the shrouded layer was calculated.

$$vi(xi) = e\left(- \sum \frac{[xji - xji]^2}{\sigma^2} \right) \quad (1)$$

xji was jth variable of information example.

- Outputs of yield layer were calculated.

$$ynet = wimvi(xi) + wo \quad (2)$$

Here w for weight, ynet for yield of system.

- Errors were calculated and found stopping condition.

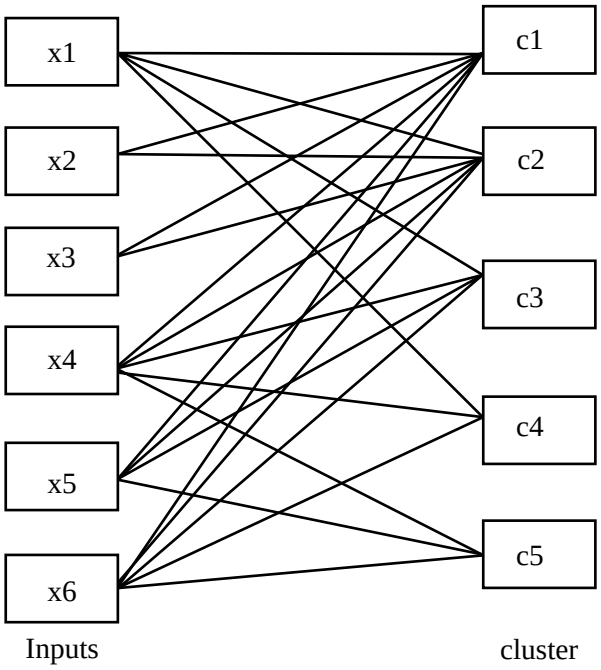

Figure 4: k-means

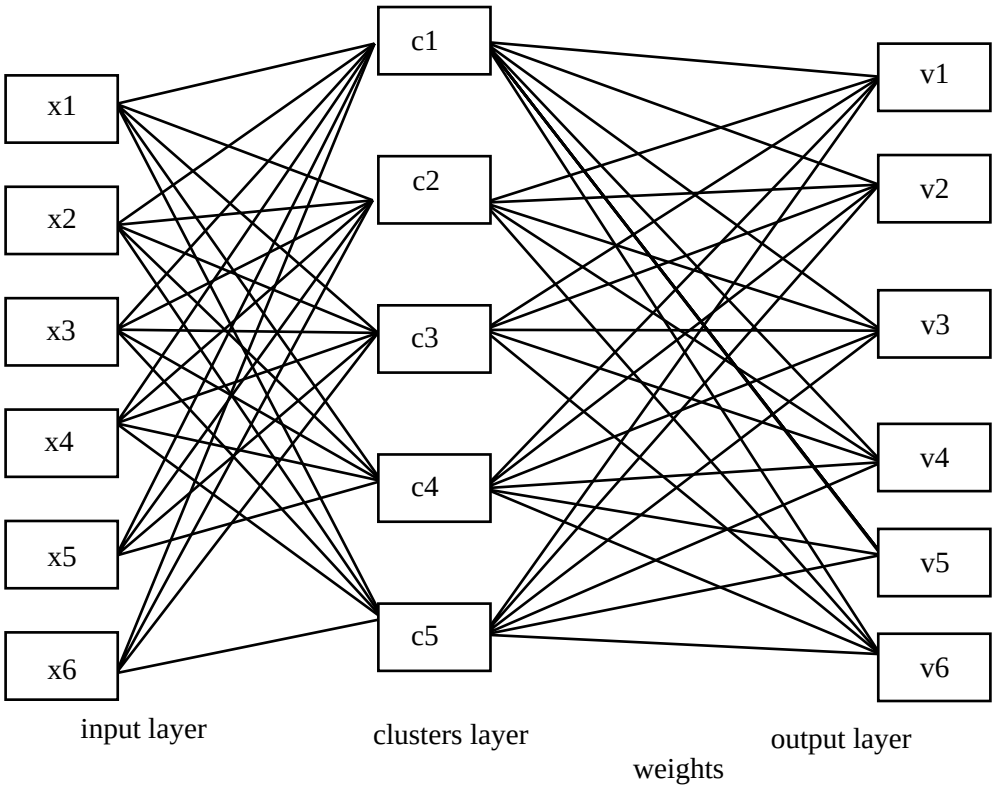

Figure 5: RBFN with k-means

Radial basis function network with Particle swam optimization

Radial basis function with particle swam optimization, these two procedures were actualized in this proposed framework. PSO is utilized for the preparation of the system. RBFN is utilized for the estimation for creating a yield of the framework. It has two layers in this system.

PSO is a procedure that is approximately demonstrated on the organized conduct of gatherings, for example, groups of feathered creatures and schools of fish. Every molecule has a virtual position that speaks to a conceivable answer for some minimization issue. On account of a neural system, a molecule's position speaks to the qualities for the system's weights and bias. The objective is to discover a position/weights so that the system produces figured yields that match the yields of the training data.

PSO used for amassing the particles and is an iterative strategy. In every emphasis, each molecule moves to another position which, ideally, speaks to a superior issue arrangement. A molecule's development depends on the molecule's present speed and bearing (speed), the best position found by the molecule whenever and the best position found by any of alternate particles in the swarm.

Algorithm

Following is the algorithm for RBFN using PSO.

1. Reservoir sampling was used for calculating Centroids.

For computing centroid:

- Random picked clustered included into the array. Distance (d) was calculated between all adjacent face values from array.
- We have calculated Average distance A by using following formula:

$$A = \frac{\sum d}{N} \quad (1)$$

N is number of hubs in input layer, d represents calculated distance of every single face in exhibit.
System will rehash this procedure and again until we make best centroid in the database/dataset.
(By using this calculation, system will make centroid which has highest average distance.)

2. Width was calculated.
   - For Calculating width in the first place, we need to calculate Euclidean distance D between centroids.

$$D = (v1i - v2i) * (v1i - v2i) \quad (2)$$

   - Following formula was used for calculating width W.

$$W = \frac{\sum D}{C} \quad (3)$$

W represents width, D represents to Euclidean distance, and C represents to Number of mixes.

3. After making centroid and calculating width, the following stage is training of RBFN by using PSO:
4. The measurements in the system

$$\sum w = \frac{H}{O} \quad (4)$$

$$M = H * O + b \quad (5)$$

Here w is for weights, H for number of hidden hubs and O for number of output hubs.
M represents measurements and b represents predisposition.

5. Random weight values were introduced for system.
6. Mean Square Error was calculated.
7. Euclidean distance was calculated between appearances of dataset and centroid of system.

$$D = \sum(v1 - c1)^2 + - - + (vn - cn)^2 \quad (6)$$

8. Outputs of Hidden layer:

$$r = 1.0 * \frac{D^2}{2} * w^2 \quad (7)$$

$$G = \exp(r) \quad (8)$$

9. "D" was distance between all values of dataset and all the centroid of the framework.
10. Final outputs of the system:

$$Y = \sum(h1 * w1) + - - - - - + (hn * wn) + b \quad (9)$$

11. Softmax Function was implemented.

$$S = \sum (v - t)^2 \quad (10)$$

12. By using softmax function Mean Square Error was calculated for all the face values.
Now average mean square error:

$$AM = \frac{\sum Ms1 + - - - - + Msn}{NN} \quad (11)$$

NN represents training length and Ms Represents mean square error.

13. Until the system found its stopping condition we need to update the weights and bias values and again implement previous steps.
Method for weight updating and bias updating is:

$$NW = (w * v) + (c1 * r1 * (b - p) + (c2 * r2 * bg - cp) \quad (12)$$

$$bias = bias + newv \quad (13)$$

Here v represents velocity, which brings up next position in the particle.

Figure6 is a system topology of radial basis function network with particle swam optimization. We have one info layer, one group layer and one yield layer in our structure. X1 to X4 are four contributions to the system since we utilize the four elements removed estimations of the face as a contribution to the system. There are five hidden nodes and each hidden node includes two parameters: clusters value and value of width on the grounds that these parameters were utilized as a part of figuring the yields of concealed hubs. Y0 to Y2 are yields of the system. These were ascertained with the assistance of radial basis function network. Everyone of the hubs in the system is associated with each other.

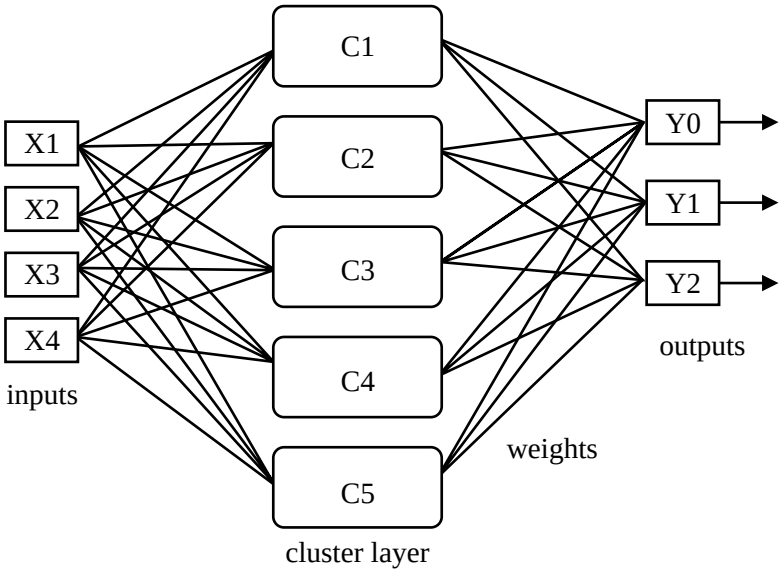

Figure 6 : RBFN with PSO

- K- nearest neighbor classifier

KNN classier also implemented in this proposed work. The KNN classifier is an extension of the essential nearest neighbor (NN) classifier system. The closest neighbor classifier works in perspective of an essential nonparametric decision. Each question picture is examined in perspective of the partition of its segments from the components of various pictures in the training database. The nearest neighbor is the picture which has the base division from the question picture in the part space. The distance between two segments can be measured in light of one of the separation capacity, for instance:

City block distance:

$$d1(x, y) = \sum_{i=1}^{n} | xi - yi | \quad (1)$$

Euclidean Distance:

$$d2(x, y) = \sqrt{\sum_{i=1}^{n} | xi - yi |} \quad (2)$$

Cosine Distance:

$$dcos(x, y) = 1 - \frac{x, y}{|x|, |y|} \quad (3)$$

Algorithm

Following is the algorithm for KNN classifier:

- Each face include values inside the informational index has a class mark in the set.
- The data centers', k-nearest neighbors (k is the number of neighbors) are then found by calculating the distance by using:

$$d2(x, y) = \sqrt{\sum_{i=1}^{n} | xi - yi |} \quad (4)$$

- The k-nearest data centers are then analyzed to make sense of which class name is the most common among the set.
- The most consistent class name is then assigned to the data point being analyzed.

KNN algorithm uses K nearest tests to the inquiry picture. In this proposed work Eq.2 (Euclidean distance) technique was implemented for performing the face recognition task.

In figure7, there are two layers input layer and yield layer. In input layer, we have six number of face feature esteems for the structure from x1 to x6. KNN separated these face esteems and existing face esteems in the dataset (by handling Euclidean distance) and organized a gathering of equivalent appearances from g1 to g6 and give labels. On the commence of this get-together, the system will see the appearances with learning partition values. When we enter testing set of countenances for recognition

then the system will figure isolate estimation of the testing appearances and complexity these partition values and existing faces in the database and find which stand up to has a place with which assemble. At that point, framework perceive the countenances.

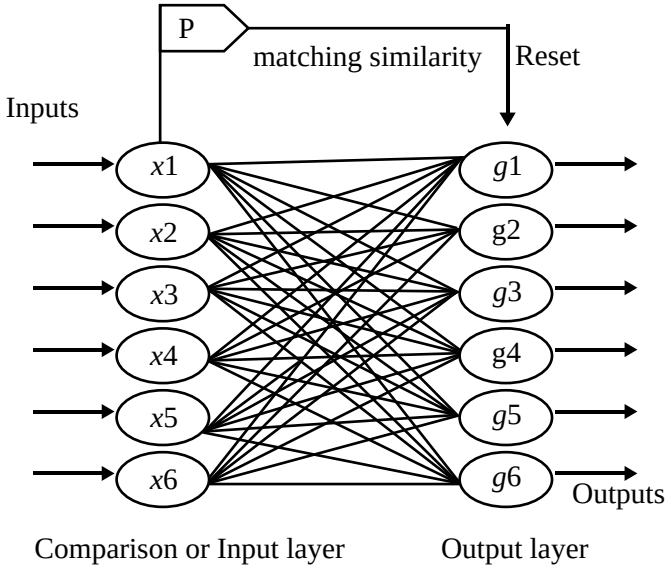

Figure 7: KNN

Results and Observations

On the commence of this proposed work, we have construed some basic outcomes and observations. Two unsupervised learning frameworks and three supervised learning frameworks are considered in this proposed work. Everyone of the strategies are exact for face recognition system, however, each of the five methods has their own particular constraints and focal points. We can comprehend the pertinence and precision of every one of these strategies on the premise of taking after outcomes.

Table 1: Accuracy of all the techniques for face recognition

Training ratio	BPNN	RBFN	K Means with RBFN	KNN	SOM
40-60	78%	72.2%	82%	81.7%	63.3%
60-40	81%	75%	85%	87.5%	72.5%
80-20	91%	83%	90%	95%	75%

In table1, when we have training ratio 40-60, we can see BPNN is 78%, RBFN is 72.2%, K-Means with RBFN is 82%, KNN classifier is 81.7% and SOM is 63.3% accurate. But when we increase the training ratio to 80-20 BPNN is 91%, RBFN is 83%, K Means with RBFN is 90%, KNN classifier is 95% and SOM is 75% accurate. It means when we increase the database then it increases the accuracy of all techniques.

We have observed that some techniques are more accurate and some are less accurate in face recognition task.

- The technique which is more accurate between all these techniques is KNN classifier.
- The technique which is less accurate between all these techniques is SOM.
- K Means technique only is used for face classification but recognition task cannot be possible without the help of any other technique.
- Large number of centroids can increase the efficiency of K Means.
- In the case of BPNN, we can increase the accuracy of the system with the help of parameters of this technique like Learning rate, Error rate etc. It is accurate for face recognition task on still images.
- BPNN and RBFN both techniques are accurate in face recognition task but BPNN is more accurate as compared to RBFN in the case of large database.
- RBFN is fast as compared to BPNN because it has taken less time in the execution of this task.
- Supervised learning techniques are more accurate in face recognition task as compared to unsupervised learning techniques.

Conclusion

In this proposed work different Artificial neural network methods have been reviewed like BPNN, RBFN, SOM, K-Means and KNN classifier. These all systems are precise for face recognition errand. KNN classifier is more precise from every one of these methods on still pictures. But SOM method is less precise as contrast to other systems. At the point when database expanded then the precision of the considerable number of strategies were additionally expanded. Every one of the strategies is exact for face recognition on still pictures but supervised learning techniques are much better as contrast to unsupervised learning techniques.

References

Agarwal, M., Jain, N., Kumar, M., and Agrawal, H. 2010. Face recognition using Eigen faces and artificial neural network. *International Journal of Computer Theory and Engineering,* 2 (4): 1793-8201.

Ashoka, S. B. 2014. Face Detection and Recognition Using K-means and Neural Network Methods. *Advanced Research in Electrical and Electronic Engineering,* 1(5): 9-14.

Dhriti and Kaur, M. 2012. K-Nearest Neighbor Classification Approach for Face and Fingerprint at Feature Level Fusion. *International Journal of Computer Applications* 60(14):13-17.

Joo, Er, M., Wu, S., Lu, J., and Toh, H. L. 2002. Face recognition with radial basis function (RBF) neural networks. *IEEE Transactions on Neural Networks,* 13(3): 697-710.

Gao, Y. 2008. Face Recognition based on Radial Basis Function and Clustering Algorithm.

Ghorpade, S., Ghorpade, J., Mantri, S., Ghorpade, D. 2010. Neural Networks for face recognition Using SOM. *International Journal of Computer Science and Technology*, 1(2): 65-67.

Jack, R.E., Garrod, O.G., Yu, H., Caldara, R., Schyns, P.G. 2012. Facial expressions of emotion are not culturally universal. *Proceedings of the National Academy of Sciences,* 109(19): 7241-7244.

Jain, R., and Rajshree T. 2012. Design of Face Recognition System by Using Neural Network with Discrete Cosine Transform and Principal Component Analysis. *International Journal of Advanced Computer Research,* 2(4):66-69.

Kashem, Mohammod Abul, et al. 2011. Face recognition system based on principal component analysis (PCA) with back propagation neural networks (BPNN). *Canadian Journal on Image Processing and Computer Vision,* 2 (4): 36-45.

Maheswari, K.S., and Harinath, B.C. 2015. A Color Face Recognition using PCA and KNN Classifier. *International Journal & Magazine of Engineering, Technology, Management and Research,* 2(9): 1110-1116.

Pallabi, P., Bhavani, T. 2006. Face recognition using multiple classifiers. *Tools with Artificial Intelligence, ICTAI'06. 18th IEEE International Conference on*. IEEE.

Reddy, L., Babu, G.R., Kishore, L., Maanasa, M. 2008. Multiscale Feature and Single Neural Network Based Face Recognition. *Journal of Theoretical & Applied Information Technology,* 4:7.

Smith, N. 2009. K-Means Clustering For Detection of Human Faces in Databases. Dissertation, *Graduate School of Computer and Information Sciences Nova Southeastern University.*

Sudha, I., Saradha, V., Tamilselvi, M., Vennila, D. 2014. Face image retrieval using facial attributes By K-means. *International Journal of Computer Science and Information Technologies,* 5(2): 1622-1625.