A Design of the Fuzzy Neural Network Image Recognizer

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Abstact

Neural networks have become more popular recently and are now being applied to numerous fields. One of the major applications of neural networks is image recognition. Various image recognition systems have been proposed so far, but there is no definite solution yet.

In this paper, we propose a design of Fuzzy Neural Network Image Recognizer(FNNIR). Our model uses a fuzzy neural network model, named SONN[KIM90]. This model returns the information of the number of clusters and cluster and cluster center values for a given image data set. Unlike the well-known backpropagation technique, we do not need retraining for new data. Our newly designed image recognition system FNNIR that uses fuzzy merger is proposed and experimented for a sample color image.

I . Introduction

Neural networks often produce elegant or unexpected solutions to problems and they have a promise of solving problems that could not be solved vy conventional *Artificial Intelligence*. The primary motivation of the current neural network research is the realization of neural network system that has similar functions to that of the brain system. A lot of progresses have been made so far, but the current neural network models are still far away from real neuron systems.

Neural networks are widely being applied to numerous fields such as visual pattern recognition[CAR87, KIM90, KIM91a-c], image processing, vision, letter perception, and voice recognition.

Fuzzy theory was first introduced by Zadeh[ZAH65] in 1965. Fuzzy concepts can yield more accurate representation of data structures. Whereas hard partitioning has eithe '0' or '1' membership value, a fuzzy partitioning allows us any value in the closed interval 0 and 1. It makes it possible to have relative values instead of 'all or nothing' strategy.

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Bezdek[BEZ81] developed the fuzzy c-means algorithm in 1980 based on Dunn's[DUN74] fuzzy c-means clustering algorithm for iterative optimization of the least square error functional. This leads to infinite families of fuzzy clustering algorithms which have been developed and used by a number of investigators. The fuzzy c-means algorithm is broadly applied to optimal fuzzy partition[BEZ75], pattern classification[KIM91d, CAN86] and image segmentation [HUN85].

Recently, fusion technology combining neural networks and fuzzy logic got popularity and used in several fields[KIM92, AJJ89].

In this paper, we propose a design of fuzzy neural network image recognizer and experiment for a sample color image.

[] . Fuzzy Neural Network Model

SONN model[KIM90] is an unsupervised self-organizing neural network utilizing fuzzy membership equation. Therefore, this model does not need any external teacher. This model works

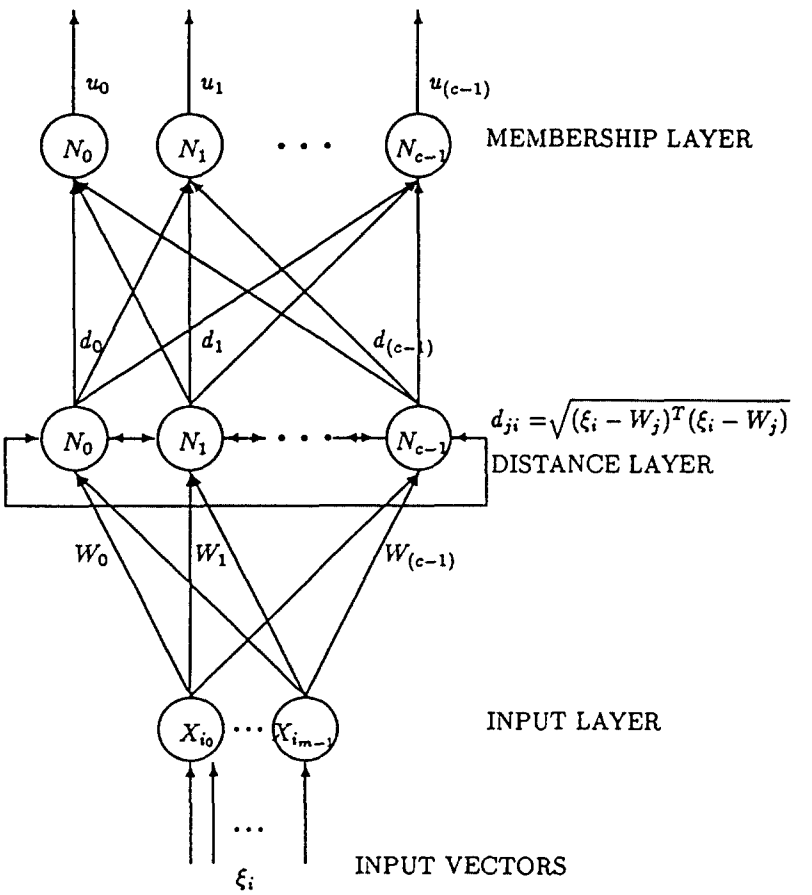

Figure 1. Structure of the SONN model

without any information about the number of clusters and cluster centers. It adjusts weights between the input layer and the distance layer until it is stabilized. Then it classifies each input according to the Bezdek's fuzzy equation[BEZ80].

This model consists of three layers as be shown in〈figure 1〉. Input vectors are feeded into the input layer and weights are adjusted between the input layer and the distance layer, and each distance membership value is calculated in the membership layer. Then that value is feedbacked to the weight adjustment. Since we don't know how many clusters for the given input data, sufficient number of neurons is nessary.

The block diagram of the SONN model for pattern recognition to get the cluster information and memebership values is in〈Figure 2〉.

We experimented with 15 output nodes. Another distinguished advantage of this model is

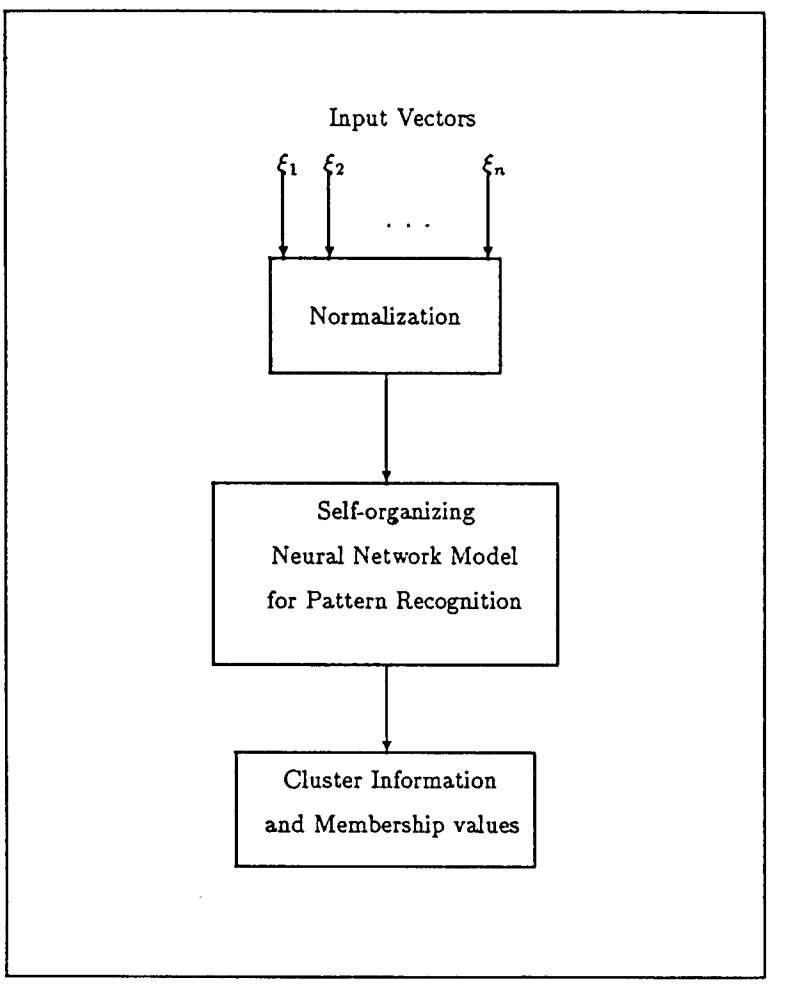

Figure 2. Block diagram of the SONN model for pattern recognition.

that it is independent of the number of neurons. It correctly classifies the given data whether the output neuron is 15 or even 20.

The salient feature of this model is self-organizing behavior. This model returns valuable information about the number of clusters and cluster center values for the given data.

Ⅲ. Fuzzy Neural Network Image Recognizer

Our newly designed fuzzy neural network image recognition(FNNIR)is illustrated in 〈figure 3〉. Images are comming through the input devices such as camera or scanner. Before the images are sent to the SONN model, it passes through through preprocessing steps such as normalization. The result of the SONN model shows the information for that input image. That information is the number of salient clusters, the number of elements for each cluster and cluster center values. By passsing through the fuzzy merger, nearby clusters are merged together.

The role of the fuzzy merger is very significant depending on the images. It merges different clusters whose cluster center values are very similar. The result of experiment in the next chapter shows that cluster 2 and cluster 3, cluster 7 and cluster 10 have similar cluster center respectively. Therefore each pair can be merged together and this color image has 13 clusters.

By repeating this process through the SONN model, all the information of the comparison image is obtained and stored in the storage system. For the image matching, we compare all the image information for i=1, 2, ···, n. Since we cannot expect exact matching when we use camera or scanner, we need approximate matching. In our experiments, there is about 10% error when we get the input through camera.

Ⅳ. Experimental Results

In our preliminary experiment, three dimensional 256×240 color image in 〈Figure 4〉 is used. That image is known to have 13 clusters.

In took about 2 hours in the SUN environment to extract clustering information for that color image through the SONN model, but the comparison steps can be done in real time. We need another design for combining clusters that have similar cluster centers. Fuzzy merger is used to compare clusters that have similar cluster centers. The detailed criteria for merging similar clusters are not set up yet.

The followings are partial result of our experiment. We set the number of cluster as 15, and set the limit value and learning rate as 0.05 and 0.1, respectively. The number of pixels that belongs to a cluster is as follows.

Cluster[1] : 1273 ;
Cluster[2] : 11348 ;
Cluster[3] : 4480 ;

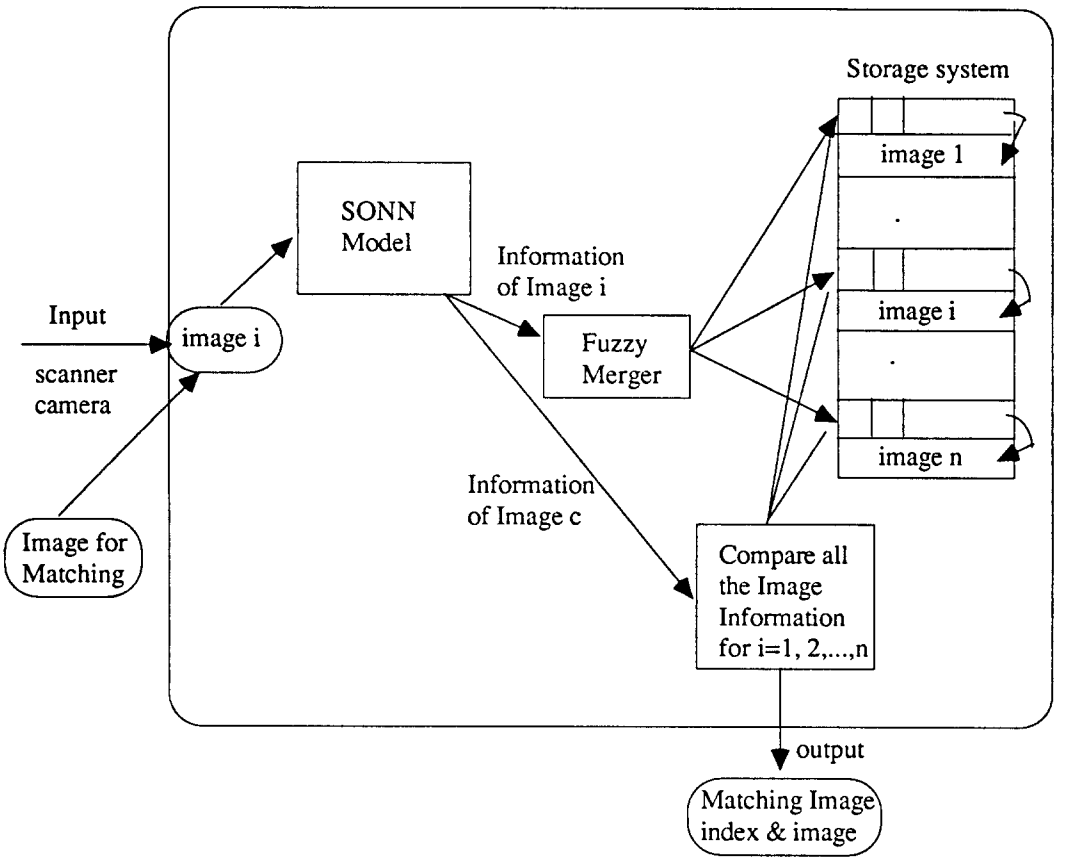

Figure 3. Diagram for the FNNIR

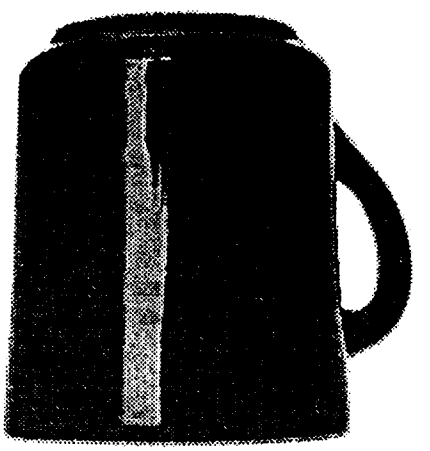

Figure 4. A Sample color image

Cluster[4] = 6994 ;
Cluster[5] = 1058 ;
Cluster[6] = 986 ;
Cluster[7] = 1295 ;
Cluster[8] = 5664 ;
Cluster[9] = 8330 ;
Cluster[10] = 6091 ;
Cluster[11] = 2700 ;
Cluster[12] = 1390 ;
Cluster[13] = 1421 ;
Cluster[14] = 4823 ;
Cluster[15] = 3587 ;

The corresponding cluster center values are as follows.

Cluster[1] = (0.27, 0.17, 0.07) ;
Cluster[2] = (0.06, 0.11, 0.08) ;
Cluster[3] = (0.06, 0.18, 0.08) ;
Cluster[4] = (0.14, 0.37, 0.16) ;
Cluster[5] = (0.42, 0.40, 0.12) ;
Cluster[6] = (0.54, 0.34, 0.09) ;
Cluster[7] = (0.54, 0.54, 0.17) ;
Cluster[8] = (0.26, 0.46, 0.19) ;
Cluster[9] = (0.37, 0.50, 0.20) ;
Cluster[10] = (0.47, 0.54, 0.21) ;
Cluster[11] = (0.58, 0.58, 0.22) ;
Cluster[12] = (0.64, 0.40, 0.13) ;
Cluster[13] = (0.75, 0.47, 0.15) ;
Cluster[14] = (0.99, 0.76, 0.35) ;
Cluster[15] = (0.84, 0.55, 0.18) ;

In this experiment, cluster 2 and cluster 3, cluster 7 and cluster 10 have similar cluster center values respectively. Therfore each pair can be merged together and this color image has 13 clusters.

Ⅴ. Conclusion

Fusion technology combining neural networks and fuzzy concept is wiedely applied in several fields.

In this paper, a new fuzzy neural network image recognizer that employs fuzzy merger is desined and experimented for a sample color image.

The very important supporting component is SONN model. This model is a hybrid of unsupervised neural network and fuzzy c-means clustering algorithm. It works without any information about the number of clusters and cluster centers. It returns cluster information and memberrship value for the given image.

Unlike the multilayer perceptron model that employs backpropagation algorithm, this model does not need training again and again whenever a new input is given. Therefore we can save considerable amount of time and keep flexibility in the database.

One disadvantage of this FNNIR model is time factor. Unlike character recognition that need some hundreds of data, this sample image consists of $61,440 \times 3$ number of data. The multiplying factor 3 is R, G, B information for each color image pixel. Considering this fact, the performance of FNNIR model is good so far.

Further work should be concentrated on the reduction of recognition time and the study of the fuzzy merger, The criteria for merging nearby clusters should be established and more experiments for numerous image data are desirous.

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