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A New Method for Noise Elimination Using Fuzzy Neural Network Optimized by Genetic Algorithm

Sajjad Ghatei[1]

[1]Department of Computer Engineering, Ahar Branch, Islamic Azad University, Ahar, Iran

ABSTRACT

In common applications source of image information are required for analyzing and description. When applied image changes from special form in to another such as: storage, digitalizing, some distortion may occur in image. So, output image needs optimization. For this purpose, there are some algorithms and different techniques with special advantages, disadvantages and restrictions. In this paper, different types of classic spatial filters like: median filter, Multilevel FIR-Median Hybrid Filter and fuzzy neuron networks filters have been discussed and suggested a new fuzzy neuron network optimized by genetic algorithm to improve missing point of image. For better result, we trained fuzzy neuron network with an artificial image. The results showed fuzzy neuron network filter optimized by genetic algorithm (PSNR=32.5697, 28.9043, 31.0041) had better results in comparison with another techniques.
KEY WORDS: median filter, Multilevel FIR-Median Hybrid Filter, Fuzzy Neuron Network, Fuzzy Neural Network optimized by Genetic Algorithm.

1. INTRODUCTION

When dealing with something on the image creating, transmitting and decoding, the image is always distorted by the impulse noise. So it is necessary and important to preprocess the image before the next operation. The traditional method of decreasing the impulse noise is based on the median filter. But the median filter makes the image fuzzy, and some details of the image are lost too. There are many improved median filters such as the weighted median filter [4], Center weighted median filters, Detail preserving median based filters, recursive minimum–maximum method, the filter of the multilevel FIR-median hybrid (MFMHF) [1, 2, 3]. The MFMHF filter can preserve the detail of the image, but it can't get rid of all distorted points. By fusing the images, a good balance can be achieved between the noise attenuation and the detail preservation. In this article, the result of the MFMHF filter and the result of the median filter are fused by the neural network. The back propagation (BP) network is good at function approaching. The fuzzy neuron network (FNN) is much better than the BP network, because FNN can map the low dimension to the high dimension [8]. But the problem is that if there aren't suitable parameters for the FNN we can't get the better result from the FNN. In this article, a new method is put forward to optimize the FNN parameters with GA. The FNN is designed to fuse the result of the MFMHF and the result of the median filter with a specified window. Fusion images can obtain the advantages of the two methods. The FNN optimized by the GA (GAFNN) has a better performance than that of the FNN system.

This paper totally divided into 5 main part. Part II discussed fuzzy neural network. In part III, suggested technique has been illustrated. Part IV referred to the results of experiments with explained methods and part V is conclusion.

2. DESCRIPTION OF FNN

As we known, the BP network is good at function approaching. We can use the BP network to simulate any kinds of curves. The BP network has two shortcomings. One is that it takes a long time to train a BP network; the other is that the BP network is weak in globe searching [8, 9]. When it comes to a complex nonlinear system, the disadvantages of the BP network become obvious. The FNN improves the BP network. In this article, a fuzzy layer is added between the input layer and the hidden layer of the BP network. The low dimension inputs are mapped to the high dimension. The complexity of the problem is reduced. The FNN is used to fuse result of the MFMHF filter and result of the median filter. The structure of the FNN can be seen in fig. 1. The FNN has four layers, the input layer, the fuzzy layer, the hidden layer, and the output layer. In the input layer there are two neurons the f_1 and the f_2. The f_1 is the value of one point of the MFMHF filter's result. The f_2 is the value of the parallel point of the median filter's result. Each neuron is mapped to five neurons with the membership function as given in Eq. (1).

***Corresponding Author** : Sajjad Ghatei, Department of Computer Engineering, Ahar Branch, Islamic Azad University, Ahar, Iran. Email: s.ghatei@iau-ahar.ac.ir

$$F_{ij} = \exp(-(\frac{f_i - m_j}{s_j})^2); \quad i = 1,\ 2; \quad j = 1,\ \ldots,\ 5 \qquad 1$$

The f_i is the input of the number ***i*** neuron. The F_{ij} is the result of the number j fuzzy neuron fusing the number i input neuron. The m_j and the s_j are the parameters of the FNN. The values of the m_j and the s_j are given Eq. (2).

$$m_1, m_2, m_3, m_4, m_5 = -1, -0.5, 0, 0.5, 1 \qquad 2$$

The hidden layer has five neurons. The transfer function is "*tansig*" (Hyperbolic tangent sigmoid transfer function). The output layer has one neuron. The transfer function is "*purelinear*" (Linear transfer function) [3].

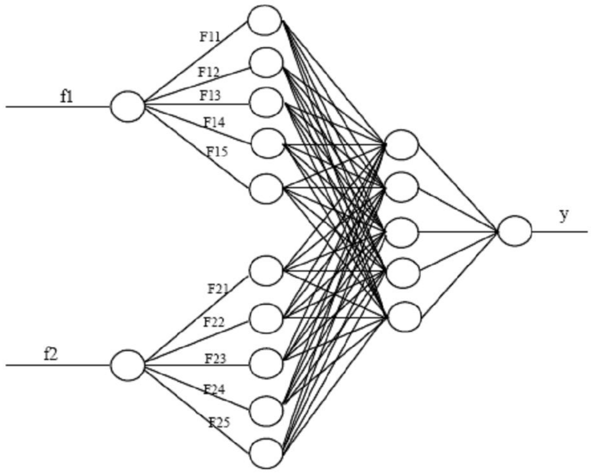

FIGURE 1 The structure of the FNN

3. THE STRUCTURE OF THE GAFNN (SUGGESTED METHOD)

The membership function is the only method to describe the image data in the fuzzy world. But the selection of membership function's parameters is subjective. In this article, the membership function has two kinds of parameters. One is the function center m_j, the other is function width s_j. For the image data, these two parameters have no experienced values. The genetic algorithm (GA) is the method which simulates the evolution of biology. The GA is a globe, adapt searching algorithm. So the genetic algorithm is the right method to search the best values of the parameter for the FNN. The fig. 2 below is the structure of the GAFNN [3, 5].
Firstly, the parameters to be optimized should be selected, and the fitness function should be mounted. Secondly, the first population is evaluated with the fitness function. After selection, crossover and mutation, the next generation is obtained. When the one of the population achieves the request of the fitness function, the optimized parameters are selected to train the FNN. Finally, the optimized FNN system is used for simulations.

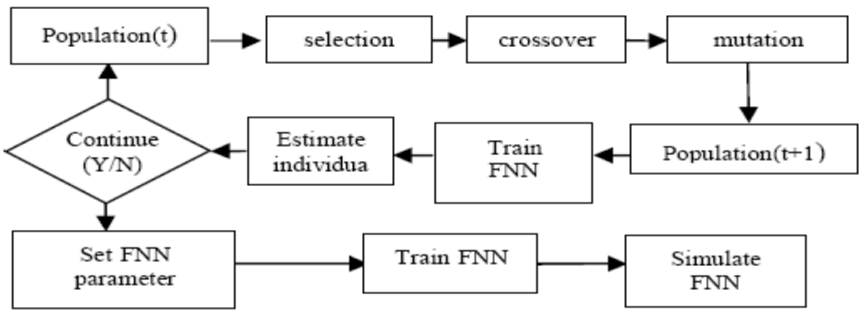

FIGURE 2 The structure of the GAFNN

4. SIMULATION RESULTS

Image used for trained of fuzzy neuron network is an artificial image involved a 64*64 matrix that divided into a 16*16 network and put the color of each part an integer number between 0 to 255 (for gray images). Obtained matrix was named artificial image (a-3). After that, we add pulsed noise to artificial image, this new image was named input noisy image [6, 7].
In fig. 3 an example of artificial and noisy image has been showed.
After formation of artificial images, we give (b-3) image to FNN and will expect (a-3) image.

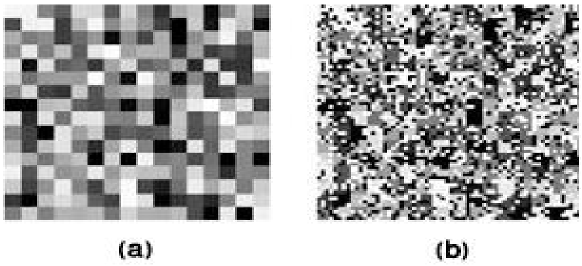

FIGURE 3 Applied images for trained of fuzzy neuron network. (a) main image (b) input noise image

In order to test the validity of the method, we have done some experiments.

Tree images of the Lena, Boats and Cameraman size of 512*512, have 256 grays. 20% impulse noise is added into images. The MFMHF filter, the median filter, the FNN and the GAFNN are used to filter the distorted image separately. In the training of the FNN, we select a zone in the image as the sample. The result of MFMHF filter and the result of the median filter are the input data of the FNN, the parallel zone of the original image is the output data of the FNN. In the GAFNN, the total population is 30, and the FNN parameter is one individual of the initial population. After 30 generations, the best individual is picked out to training the FNN system.

The Power Signal-to-Noise Ratio (PSNR), the Mean Square Error (MSE) and the Mean Average Error (MAE) are used to estimate the filtering result.

The results have been shown in Table 1 and fig. 4. The MFMHF Filter can reserve the detail of the images, but in a zone where the distorted points are crowded the MFMHF Filter reserve the distorted points too, especially where the distorted points are connected. The Median filter has the advantage of removing the distorted points, but the Median filter makes the image fuzzy. The result of FNN is better than that of the MFMHF Filter and the Median filter. And the result of GAFNN is better than that of the FNN. In the FNN, the membership function centers are at the same intervals and the width is same too. But the input samples are not being evenly distributed. Also, the different distances between the center and the sample have different contribution to the net. The GA gets an optimized parameter for the FNN, so the GAFNN has the best result in the four filters.

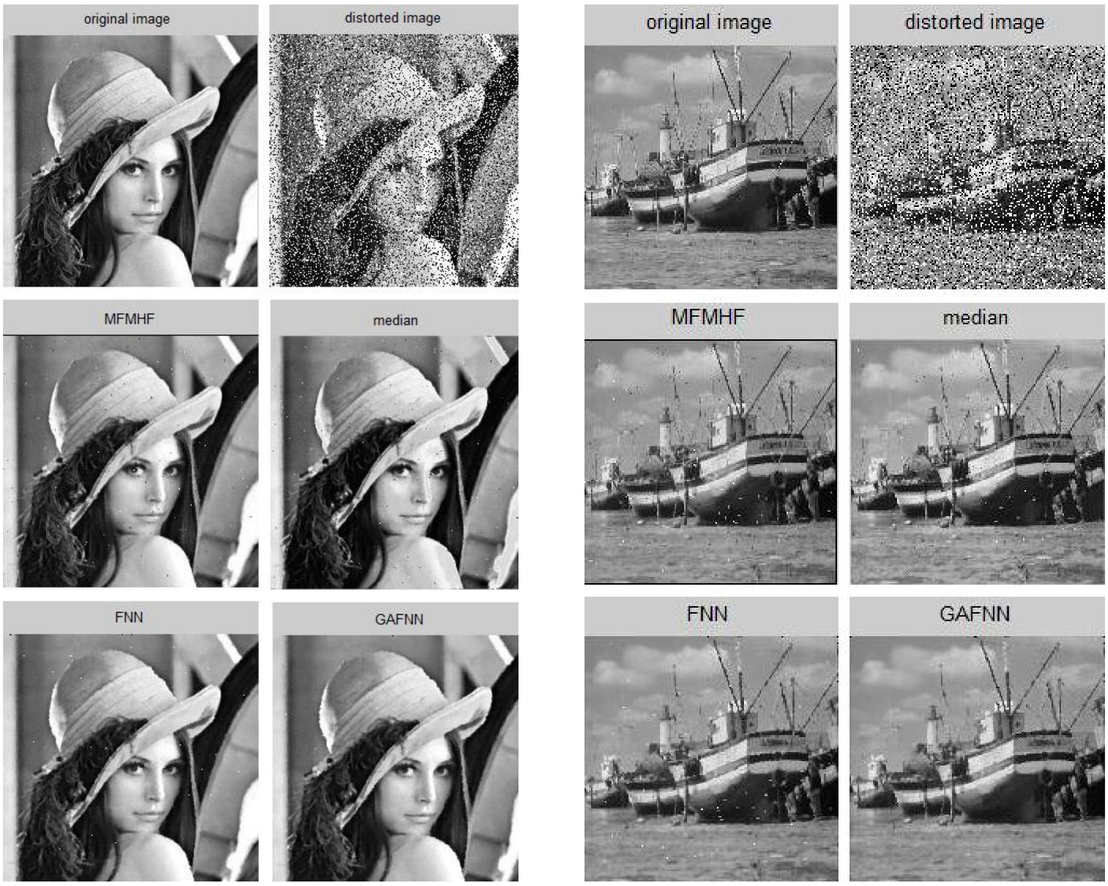

FIGURE 4 Comparison the filters on Lena and Boats images

Table 1. The results of applied filters on Lena and Boats images

		MFMHF	Median	FNN	GAFNN (suggested method)
Lena	PSNR	28.5002	29.2889	31.5437	32.5698
Lena	MSE	63.5641	58.8230	44.7846	29.5231
Lena	MAE	3.7576	3.7259	2.0256	1.8930
Boats	PSNR	24.5490	26.1260	27.6257	28.9043
Boats	MSE	69.5609	62.6541	47.7354	30.2231
Boats	MAE	5.7822	4.7009	3.9011	2.0030

5. CONCLUSION

In this paper, we proposed methods and techniques applied to digital image noise elimination. Median filter despite of its ability in suitable elimination of the pulsed noise seems impotent in the presence of high noise levels. In order to contain the problem, we introduced techniques capable of recovering in the presence of the high pulsed noise levels. Experiments demonstrate that multilayer fuzzy neuron network based on back propagation and descent gradient method, generate a solution in the proximity of the main image in the high noise levels. Fuzzy neuron network applied in this paper reached to a satisfying result after 200 epochs. Through applying genetic algorithm, higher efficiency obtained in comparison with conventional fuzzy neuron network. These techniques can give hopeful results in analyzing images and identifying the models.

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