A Novel Genetic Algorithm with Improved Fuzzy Neuron Network for Digital Image Processing

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Summary
It is a difficult problem to get rid of the distorted points and to keep the detail of the image at same time when processing of image. So the fuzzy neuron network (FNN) is introduced to fuse the result of filter of the multilevel FIR-median hybrid (MFMHF) and the result of the median filter with a specified window. The selection of appropriate parameters for the FNN is still a challenge. Thus, an improved FNN based on genetic algorithm (GA) is proposed to solve the problems of choosing the parameters of the FNN system. Simulation results show that after the parameters of the FNN being optimized with GA, the performance of the FNN on image fusion is much better than the performance of the FNN system.

Key words:
Image processing, fuzzy neuron network, genetic algorithm, denoising.

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 [1], Center weighted median filters [2], Detail preserving median based filters[3], recursive minimum–maximum method[4], the filter of the multilevel FIR-median hybrid (MFMHF) [7]. The MFMHF filter can preserve the detail of the image, but it can not 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 backpropagation (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.

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 figure (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 Equa. (1).

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

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*

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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 below.

$$m_1, m_2, m_3, m_4, m_5 = -1, -0.5, 0, 0.5, 1$$
$$s_1, s_2, s_3, s_4, s_5 = 0.2, 0.2, 0.2, 0.2, 0.2 \quad (2)$$

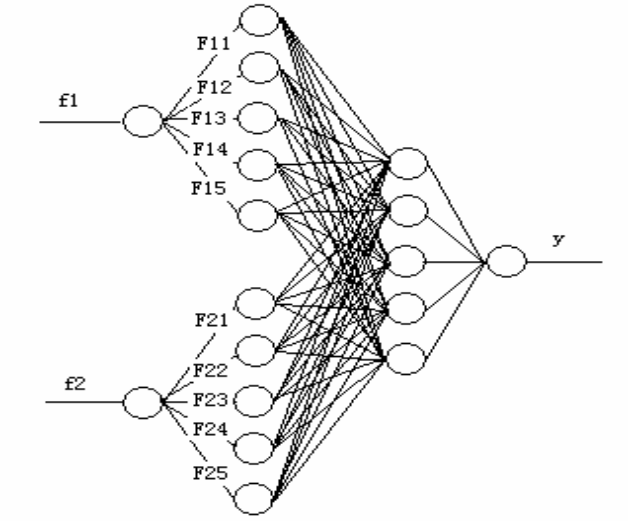

Figure 1 The structure of the FNN

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 *pure-linear* (Linear transfer function).

3. The Structure of the GAFNN

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 figure below is the structure of the GAFNN.

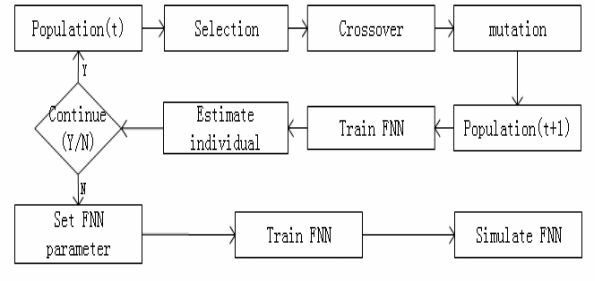

Figure 2: the structure of the GANN

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.

4. Simulation Results

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

An image of the Lena, size of 512*512, has 256 grays. 10% impulse noise is added into the image. 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 20 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.

(a) Original Image

(b) Distorted Image

(c) MFMHF Filter

(d) Median Filter

(e) FNN

(f) GAFNN

Figure 3: Compare of the four filters.

Table 1 : Comparison of the Four Filters.

	MFMHF filter	Median filter	FNN	GAFNN
PSNR	25.8634	30.7191	31.1724	33.8538
MSE	168.5550	55.1026	49.6415	26.7735
MAE	2.0841	3.5715	2.8325	1.7178

From the Figure 3 and the Table 1, we can get the conclusion. The MFMHF Filter can reserve the detail of the image, but in the 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.

5. Conclusion

An improved FNN based on genetic algorithm (GA) is presented to solve the problems of selecting the parameters of the FNN. Simulation results indicate that the MFMHF filter cannot get rid of all the distorted points and the Median filter makes the image fuzzy. The FNN fuses the result of MFMHF filter and the result of the Median filter. After the parameters of the FNN being optimized with GA, the performance of the FNN on image fusion is much better than the performance of the common FNN. **T**he FNN provides us the good result for image denoising. The GAFNN significantly improves the FNN on the problem of the parameters determination and the GAFNN is the best of the four filters.

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