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Optimization of Radial Basis Neural Network by Mean of Amended Fruit Fly Optimization Algorithm

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ABSTRACT

This paper presents the optimization of radial basis function (RBF) neural network by means of aFOA and establishment of network model, adopting it with the combination of the evaluation of the mean impact value (MIV) to select variables. The form of amended fruit fly optimization algorithm (aFOA) is easy to learn and has the characteristics of quick convergence and not readily dropping into local optimum. The validity of model is tested by two actual examples, furthermore, it is simpler to learn, more stable and practical.

Keywords: aFOA, RBF neural network, MIV.

INTRODUCTION

Our aim is to find a variable function based on such a large number of experimental data in many scientific experiments such as Near Infrared Spectral data[1,2] and Atlas data[3,4]. But this kind of function is often highly uncertain, nonlinear dynamic model. When we perform on the data regression analysis, this requires choosing appropriate independent variables to establish the independent variables on the dependent variables regression model. Generally, experiments often get more variables, some variables affecting the results may be smaller or no influence at all, even some variable acquisition need to pay a large cost. If drawing unimportant variables into model, we can reduce the precision of the model, but cannot reach the ideal result[5]. At the same time, a large number of variables may also exist in multicollinearity. Therefore, the independent variable screening before modeling is very necessary[6].

Because the fruit fly optimization algorithm has concise form, is easy to learn, and have fault tolerant ability, besides algorithm realizes time shorter, and the iterative optimization is difficult to fall into the local extreme value. And radiate basis function (RBF) neural network's structure is simple, training concise and fasting speed of convergence by learning, can approximate any nonlinear function, having a "local perception field" reputation. For this reason, this paper puts forward a method of making use of the amended fruit flies optimization algorithm to optimize RBF neural network (aFOA-RBF algorithm) using for variable selection.

aFOA ALGORITHM:

Drosophila melanogaster is a species of Fly (the taxonomic order Diptera) in the family Drosophilidae. The species is known generally as the common fruit fly or vinegar fly. Starting with Charles W. Woodworth's proposal of the use of this species as a model organism, *D. melanogaster* continues to be widely used for biological research in studies of genetics, physiology, microbial pathogenesis and life history evolution. Fruit Fly Optimization Algorithm, refers to FOA, is the latest of evolutionary computation technology, put forward by Pan Wenchao of Taiwan in 2011. FOA algorithm is a new method of swarm intelligence of global optimization performance, basing on fruit flies foraging behavior. Because fruit flies in the sensory and perception is superior to other species, especially in the vision and the sense of smell. Fruit flies olfactory organs can be a very good collection of various air smell, can even smell food source about 40 km away. When flying close to the food, Fruit flies use the keen vision and companions gathers to the position to find the food position, and then fly to the direction[7].

Algorithm:

Step 1 Start:

Start the algorithm to resolve the set-streaming stream-shop schedules.

Step 2 Parameter Initializations:

The main parameters of aFOA are maximum iteration number, the population size.

Step 3 Population Initializations:

Randomly initialize the population size is NP. Randomly produce solution, half blending and un-blending.

Step 4 Neighborhood Generations and Find Best Neighborhood:

NN neighborhoods are randomly generated. NN neighborhoods are produced by three kinds of neighborhood search. Find out the best neighbor.

Step 5 Replacements of Neighbor:

If the best neighbor is better than the fly then replace the fly with the best neighbor and go to next step, else go to next step without replacing.

Step 6 Local Neighborhood Loop Search:

If the loop termination is reached then sort the population else go back to step 4.

Step 7 Crossovers:

In global cooperation search each flies in the poor half crossover it with the corresponding one. If new fly is better than poor fly then replace the poor fly with new one and go to next step, else go to next step without replacing.

Step 8 Termination Criterions:

If termination standard is reached then provide result, else go back to step 3.

Step 9 End:

End the algorithm with solution of set-streaming stream-shop schedules.

THE RADIAL BASIS NEURAL NETWORK:

Radial basis neural network is also called RBF neural network, belongs to the forward type neural network. The network's structure is similar to the multilayer feed forward network, only has a hidden layer of three layer forward network. The first layer is input layer, which composed by signal node; The second is hidden layer, the layer's node decided by apparent problem, the layer neuron transformation function that radial basis function is the local response of the Gaussian function; The third layer is output layer.

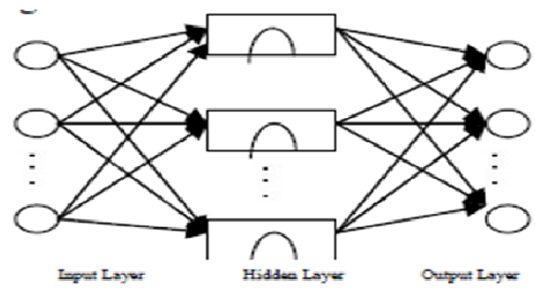

Figure 1: Radial basis neural network

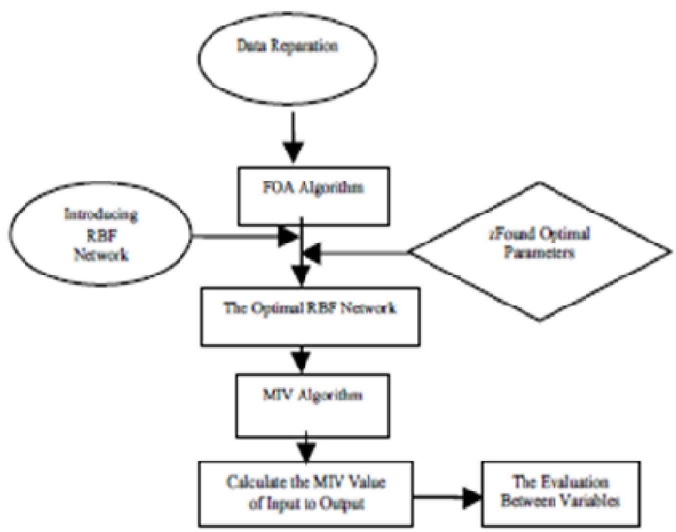

Figure 2: Variable Selection

RBF network use radial basis as hidden unit "base" to form a hidden layer, which transforms the input vector, the low dimensional model of input data converse into a high dimensional space inside, this will change a low dimensional space in linear inseparable problem into a high dimensional space in linear separable, and the problems are solved. RBF neural network has a variety of learning methods. This paper is based on the self-organizing selection center learning method. This learning process is divided into two steps: the first step is self-organization learning stage, which solves hidden layers' center and variance of the basis function; The second step solve weights between hidden layer and output layer. In the training process, determining the number of hidden layer neurons is a key issue, the basic training principle starts from zero neurons, through checking output error whether meet the requirements, or else using in each cycle by automatic increasing neurons, so that network generates maximum error corresponding input vector as weight vector, produce a new neurons, then check the new network error, repeat this process until error requirements or maximum number of hidden layer neurons. Thus it can be seen, RBF neural network has simple structure, adaptive, output and initial weights of the independent characteristics, and the independent learning convergence speed, can approximate any nonlinear function[9].

aFOA-RBF ALGORITHM USED TO IMPLEMENT VARIABLE SELECTION:

Parameter DISTRIBUTE is radial basis function's expansion speed. Building good RBF neural network, DISTRIBUTE value directly affect network fitting (prediction) accuracy when the network learning training, choice reasonable DISTRIBUTE value is very important. The greater DISTRIBUTE value, can make the radial basis neurons covered to input vector space which has response, but also do not need all the radial basis neurons has response, as long as part of the response is enough, and too big DISTRIBUTE value can also lead to the difficulty of computing. In the design of network often try different DISTRIBUTE value, has certain subjectivity and uncertainty, is not easy to get the optimal model[10].

In order to seek the optimal model, RBF neural network can be drawn into aFOA algorithm iterative optimization process, taste concentration decision value($S=1/Dist>0$) as DISTRIBUTE value directly, the network absolute value of prediction error's sum as tasting concentration decision function Smell value. In order to prevent the RBF network over fitting and influence network promotion ability, we divide it into two groups of experimental data cross validation, calculate the each network's training error, find that iterations and the corresponding Smell value and DISTRIBUTE value when network absolute value of prediction error's sum achieved minimum, so as to find the best DISTRIBUTE value. Then use this DISTRIBUTE value and all input and output samples to establish optimal RBF network. After that we draw the mean influence value (MIV) into the optimal RBF neural network for main variable screening. MIV is one of the important indexes which is used to evaluate the affects of each independent variable to the dependent variables. MIV led into neural network is an index, which can reflect the network weight matrix, changes of the input neurons, and evaluation of the size of the output neurons influence. At present, the MIV is considered one of the best indexes in the neural network evaluate variables in the correlation. MIV's symbol stands for input to output related direction, its absolute size represents the relative importance of the influence. After training in established optimal RBF network, each independent variable of the training samples ±10% in the original basis, constitute two new training sample K1 and K2, I set them as the new training sample substitution into established optimal RBF network ,then simulate them respectively, get two output respectively S1 and S2, calculate the difference value of S1 and S2, treat the outcome as a changed independent variable to output variable value(IV) ,finally according to the training sample size calculate IV's average value, get the MIV conclusion that independent variables to output variable (dependent variable).

According this method, calculating each independent variable MIV, arranging each independent variable order according to the absolute value of the MIV, getting relative important sequence from each variable to dependent variable, so we can realize the variable selection[5].

EXAMPLES:

A. Data preparation

1) Generate five hundred x1, x2 and x3 value randomly and respectively in region [-2, 2], produce Y1 value in according with the three dimensional nonlinear function

$$Y=x_1^2 + 2x_2^2 + 5x_3^2 + 2x_1 x_2 + 6x_2 x_3 + 2x_1x_3 \quad (1)$$

We still randomly generated five hundred x4 and x5 value as interference variables, and then store the data for Data1.

2). Generate five hundred x1 and x2 value randomly and respectively in the region [-4, 4], produce Y1 value which is in according with two dimensional nonlinear functions

$$Y =(x_1 + x_2^2 + 2x_2)\, e^{x1 +x2}. \quad (2)$$

We still random generated five hundred x3, x4 and x5 value as interference variables, then store the data for Data2. x1, x2, x3, x4, x5 and Y1 are regarded as the training sample. x_i, i = 1, 2, 3, 4, is regarded as network input (independent variables). Y1 is regarded as the network output (dependent variable). The FOA - RBF algorithm combining with MIV method to screen out the output results are mainly on the effects of the variables. The experiment selects the suitable variables which have main affection to output Y through the aFOA-RBF algorithm combining MIV method.

B. Constructing model

We have 200 sample data normalization processing. The results are divided into two groups, each has 50 sample data as a set of training samples. Amended Fruit flies optimization algorithm's iteration number are set to 25, population scale are set to 5, the 'I' fly's initial position (X, Y) set to X(i)=X_axis+2*rand()-1; X-axis = rand(); Y(i) =Y_axis+2*rand()-1; Y-axis= rand(). Taste concentration decision value is S(i)=1/sqrt(D(i)); DISTRIBUTE value is DISTRIBUTE = S (i).By using the DISTRIBUTE value and 'newrb()' function create a approximation radial basis RBF network, , one group of the two for learning, another is used to predict (iterative when cross validation), in the network's learning process we try to increase the number of hidden layer neurons constantly until the network output error can satisfy the present value so far. We consider the prediction error's absolute value sum as taste density smell value. And find the minimum value of the population Smell, record the corresponding iterations, taste density (DISTRIBUTE value) and the fruit fly individual position. Then we find the best DISTRIBUTE value during the iterative optimization process, and establish the optimal RBF network. Finally, we count the MIV value of each input variables to output variable by MIV algorithm.

C. Experimental results and analysis

aFOA - RBF algorithm for data Data1's operation result is shown from Figure. 3 to Figure. 5. Algorithm's running time is 54.217590 s.

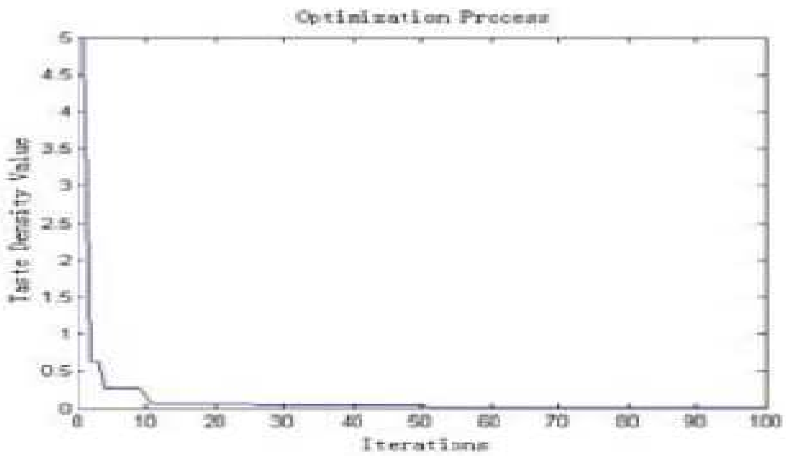

Figure 3: aFOA-RBF algorithm's iterative optimization process for data "Data1"

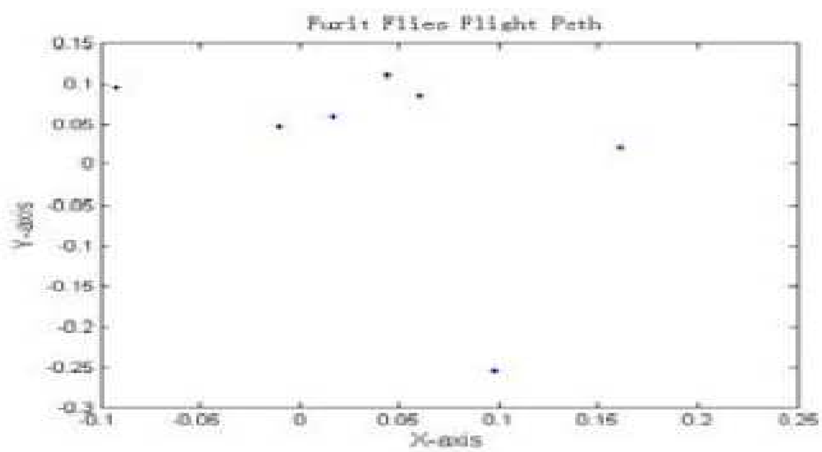

Figure 4: Flies optimal path for data "Data1"

Elapsed time is 54-217590 seconds -

Best_spread =

1-5228

MIV = [MIV_x1 MIV_x2 MIV_x3 MIV_x4 MIV_x5]

MIV =

5.2526 9.3426 22.5181 0.0693 -0.0028

Figure 5: aFOA RBF result for data "Data1"

TABLE I. THE RESULTS OF CONTINUOUS OPERATION 5 TIMES ABOUT 'DATA1' BY aFOA-RBF ALGORITHM

S. No.	Algorithm Running Time (sec.)	Best DISTRIBUTE Value	MIV Value (MIV_x1------,MIV_x5)
1	54.2176	1.523	5.2526, 9.3426, 22.5181, 0.0693, -0.0028
2	52.2643	0.864	5.6064, 11.4374, 24.2477, 1.1267, 1.5267
3	52.9663	1.107	5.0192, 11.3304, 26.73134, 0.1542. 0.1904
4	52.2264	1.062	4.1845,10.7414,25.8335, -1.0246, -0.9056
5	52.0592	1.054	4.9435, 9.4303, 27.4075, 0.2438, 0.2521

The best DISTRIBUTE value is 1.5228. The corresponding fruit flies' coordinates of this group is (0.0476, 0.1159). MIV_Xi value is in accordance with MIV value and the independent variable xi to network's output Y1,which is 5.2526, 9.3426,22.5181, 0.0693 and -0.0028 respectively. MIV's symbol stands for the related direction of input to output; its absolute size represents the relative importance of the influence. The algorithm continuously operates ten times (sample data is randomly generated each time). All results see in table 1.

This shows that the first three variables' MIV value of x1, x2, and x3 are bigger. These values are calculated by x1, x2, and x3, has nothing to do with x4 and x5. Therefore, the results of the main effect to dependent variable Y1 which selected out by this algorithm are real conditions consistent. Also, the operation results for data 'Data2' seen from Figure. 6 to Figure. 8 by use of aFOA - RBF algorithm. Algorithm running time is 52.070761s. The best DISTRIBUTE value is 0.3585, the group of fruit flies position coordinates for (2.2335, 1.2353) eventually. MIV_ Xi's value is

127.6204, 169.4325, 41.3302, 37.2808, 19.3070. The algorithm also continuous ten times (sample data is random generated each time), the results see table 2.

TABLE II. THE RESULTS OF CONTINUOUS OPERATION 5 TIMES ABOUT 'DATA2' BY aFOA-RBF ALGORITHM

S. No.	Algorithm Running Time (sec.)	Best DISTRIBUTE Value	MIV Value (MIV_x1------,MIV_x5)
1	52.0708	0.359	127.0204, 169.4326,-41.3304, -37.2809, -19.3070
2	56.9123	0.495	142.1258, 156.5311, -65.8890. -76.5729. -59.8165
3	52.9560	0.439	71.5886,115.8796, -2.9341, -7.4295, -14.3774
4	58.3003	0.239	416.9257, 531.0809,130.2046, 97.7198, 164.7629
5	57.3003	0.744	416.9257, 531.0809,130.2046, 97.7198, 164.7629

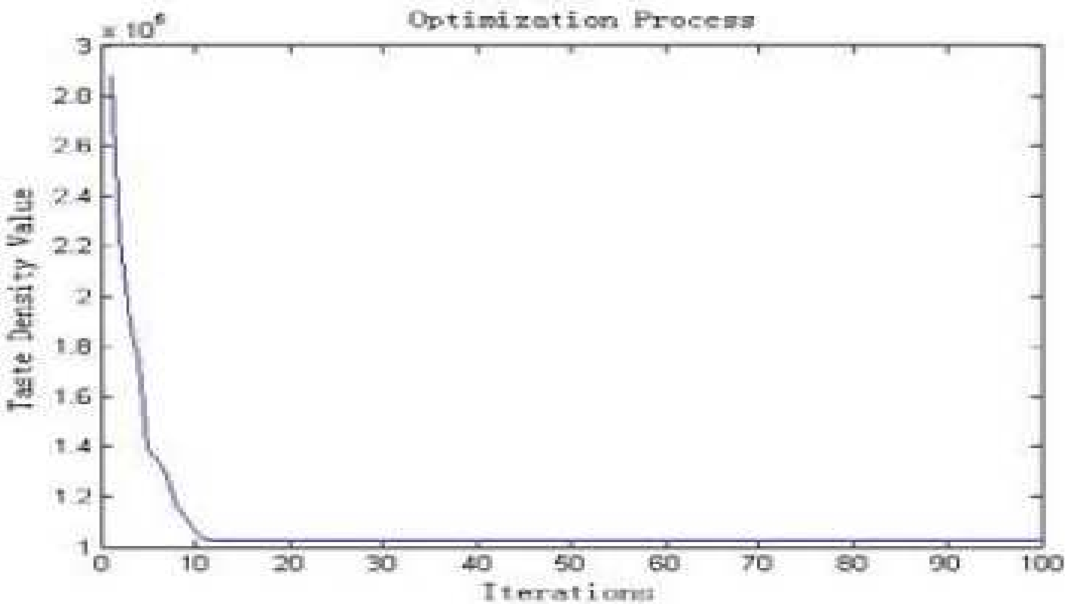

Figure 6: aFOA-RBF algorithm's iterative optimization process for data "Data2"

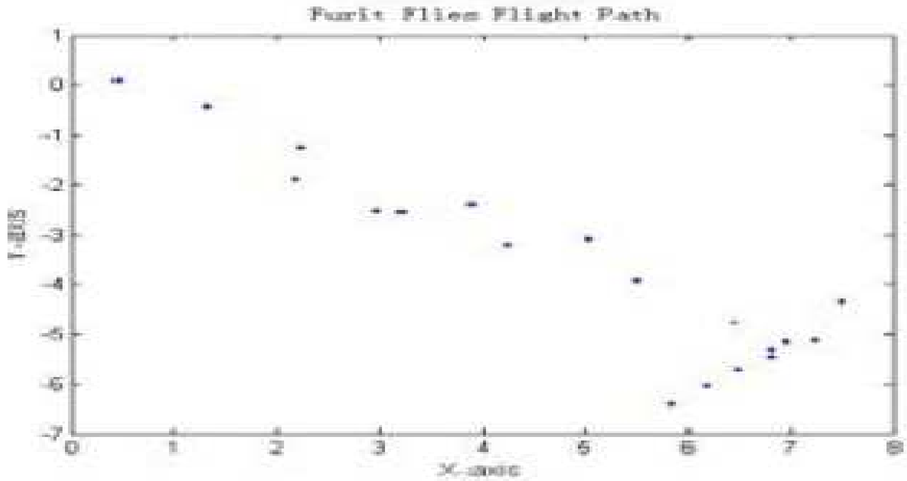

Figure 7: Flies optimal path for data "Data2"

Elapsed time is 52.070761 seconds –

desired_spread =

0.3585

MIV = [MIV_x1 MIV_x2 MIV_x3 MIV_x4 MIV_x5]

MIV =

127.6204 169.4325 -41.3302 -37.2808 -19.3070

Figure 8; aFOA RBF result for data "Data2"

Table 2 shows that the first two variables' MIV value of x1 and x2 are bigger. These values are calculated by x1 and x2, which has nothing to do with x3, x4 and x5. Therefore, the results of the main effect to dependent variable Y2 which selected out by this algorithm are also consistently real conditions.

CONCLUSION

RBF net has the following advantage over back propagation net: small quantity adjustable parameter, simple structure, self adapting, and the loading results have no business with original value etc. The Training results of RBF net has much relations with the value of only parameter distribute, this article using aFOA to optimizing RBF neural network, get the best distribute value by aFOA Iterative optimization, then build the best RBF net. Finally, combine with the average impact value evaluation, get the MIV (the value of importance that independent variable to dependent variable). Try to bring in 2 or 3 disturbing variable by two examples, aFOA-RBF algorithm can successfully, the percentage merely match 100%. Which means it is workable to analyze master variable for aFOA simulated algorithm by optimizing the RBF net and combine with the MIV algorithm[11]. Compare with least square method[1], Combined with the genetic algorithm of least squares[3,4] etc, in addition simulated algorithm is more simple, and easily learned, Convergence fast and not easy to trap in the local extremism , which make aFOA-RBF has better stability and usability. In addition, the Optimization ability of aFOA simulated algorithm restricted by group size, iterations , Progress value etc, but has small effect after writer's many times testing, Cannot show it one by one for article length reason. So, aFOA-RBF algorithm is another good way to realize the variable selection.

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