An Evaluation Method of Combat Service Operation Performance for Surface-to-Air Missile Based on FNN

Gang Li, Dapeng Li, Yanyan Zhou, Linwei Xu
School of air defense and anti-missile
Air Force Engineering University
Xi'an, 710051, China
ligangbs@yahoo.com.cn,lidapengkgd@126.com,zhouyanyan122@yahoo.com.cn, xulinwei2009@163.com

Jifeng He
Military Agent Room
The 23rd Research Institute
Beijing, 100854, China
hejifeng@yahoo.com.cn

Abstract—**Firstly, the implication and purpose of the Combat Service Performance Evaluation for Air Defense Missile was elaborated in this paper. Then the Fuzzy Neural Network (FNN) Evaluating Method was put forward to apply to the combat service performance evaluation. Secondly, an evaluation index system was built on the basis of the characteristics of the combat service operator and the combat service process. At last, the correctness and validity were approved though the simulation results.**

Keywords- ***Air Defense Missile, Combat Service Operation, Performance Evaluation, Fuzzy Neural Network.***

I INTRODUCTION

Surface-to-Air missile combat service operation performance evaluation, points to the activities that combat service personnel in the Surface-to-Air missile after the chronicle or simulation combat service operation training, the military instructor to the operation of weapons and equipment proficiency and combat effect of evaluation activities. The combat service operation performance evaluation method is aim at improving training efficiency and combat effect, to the evaluation activity carries on the quantification scoring method. However, because of Surface-to-Air missile weapon system composition structure complicated, combat service operation personnel involved, single evaluation method has been unable to combat service operation achievements of scientific and objective evaluation, so this paper puts forward a method based on fuzzy neural network of comprehensive evaluation method.

II EVALUATION INDEX SYSTEM

The establishment of the evaluation index system is the foundation of Surface-to-Air missile weapon system combat service operation performance objective evaluation and is also one of the difficult problems needed to be break through. Whether the index's determination is reasonable or not will directly affect the reliability of evaluation results, the index system scale and specific index difference will affect the complexity of evaluation process. Based on such analysis, this paper establishes the Surface-to-Air missile weapon system combat service operation performance evaluation index system, based on the improved Delphi method and AHP method as shown in figure 1:

As shown in figure 1, the index system is divided into 5 layers, including qualitative and quantitative indexes. The first layer is the target layer, i.e. combat service operation performance. The second layer is criterion layer, including 4 indicators, i.e. commander score, command and control vehicle operator achievement, search vehicle operator performance and emission vehicle operator result. The third layer is factor layer, including 15 indicators, i.e. theoretical knowledge, practical experience, operation ability and so on. The fourth and fifth layer indexes are respectively extend and decomposed from the third and fourth layer, and serve as the foundation of combat service operation performance evaluation. Only by the acquisition of the fourth layer and fifth layer of the underlying index evaluation data can we get the final evaluation result, i.e. combat service operation performance. The underlying qualitative index quantification and data normalization method is no longer detailed here due to the limited space.

III FUZZY NEURAL NETWORK COMPREHENSIVE EVALUATION METHOD

Fuzzy neural network comprehensive evaluation method (FNN) combines the fuzzy comprehensive evaluation method and neural network evaluation. Fuzzy comprehensive evaluation method can solve the problem of quantitative and qualitative evaluation of mutual transformation, while neural network evaluation method has fast speed. So the combination can effectively overcome the disadvantages of each method alone, make the combat service operation performance evaluation be more objective and receivable, evaluation speed be faster. Considering that the BP neural network algorithm is mature and more distinguished, we select BP fuzzy neural network for combat service operation performance evaluation. On the other hand, the neural network of the large input layer neuron number will affect network evaluation speed, and has the potential to cause network training divergent. Therefore, we take the criterion layer 2 as an input indicator of the fuzzy neural network that is $\{U_1, U_2, U_3, U_4\}$, with membership evaluation set {excellent, good, poor} representing membership degree vector as the network output, the evaluation algorithm for the specific implementation steps are as follows:

A. The Establishment of BP Fuzzy Neural Network Evaluation Model

as shown in figure 2:

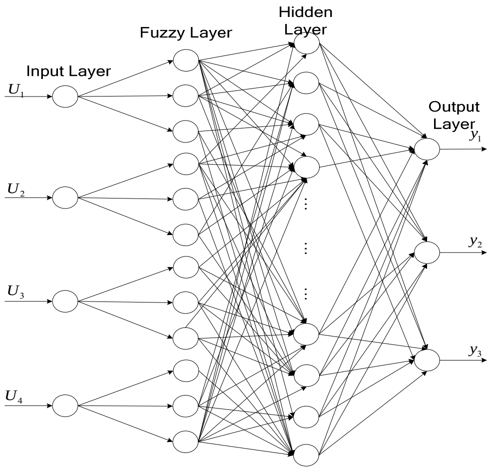

Figure 2 BP fuzzy neural network model

The figure 2 shows, the first layer is network input layer, with 4 neurons, U_1, U_2, U_3 *and* U_4. the evaluation data of four indicators is acquired from the bottom layer, by means of AHP.

The second layer is fuzzy quantization layer, the number of layer neuron node depends on the input layer nodes and comments of the concentration together, and the calculation formula is showed as follows:

$$L = M \times N \qquad (1)$$

Where the L represents the fuzzy quantitative layer neuron number, M represents the input layer neuron number, and N is the number of comments. We select the said set {excellent, good, poor}, namely N equal to 3, so $L = 4 \times 3 = 12$.

The third layer is hidden layer, also known as fuzzy rule layer, and stores fuzzy rules. In general, the layer neuron number can be obtained by empirical formula 2:

$$K = \prod_{i=1}^{M} C_N^1 = N^M \qquad (2)$$

Similarly, where M represents the number of neurons in input layer, N is the number of comments. However, in general it's usual that multiple rules correspond to the same output, thus the fuzzy rule layer neuron number should be less than or equals to the theoretical calculation value. The fuzzy rule layer neuron number of theoretical calculation value should be 81 here, but only a few samples are selected and the network actual output corresponds to only three kinds of results that is excellent, good and poor, and large number of rule layer neuron will affect the network convergent speed, so we choose the empirical formula (3) to calculate the number of rule layer neurons, that is 13, P and Q are represent the input and output layer neurons respectively, β is a constant in [1,10].

$$S = \sqrt{p+q} + \beta \qquad (3)$$

The fourth layer is fuzzy neural network output layer, whose result is the combat service operation comprehensive performance, and can be both a qualitative evaluation of the membership degree vector, or a quantitative evaluation value. We choose two kinds of evaluation results output forms, i.e. $\{y_1, y_2, y_3\}$ and U, while $Y = \{y_1, y_2, y_3\}$ is the qualitative evaluation results, the elements y_1, y_2, y_3 denote the excellent, good, poor evaluation performance in terms of membership degree vector, respectively. U is the quantitative evaluation result output of the combat service operation comprehensive perform, and can be gained as follows:

$$U = [100 \quad 70 \quad 55] \times Y^T \qquad (4)$$

B. The Fuzzy Quantification of InputLayer Data

The input layer are 4 neurons, $U_1 \sim U_4$ and {excellent, good, poor} is the comments set. Input data fuzzy quantification can be explained as follows: we determine the excellent, good, poor comments' membership function respectively according to the selected comments set, then calculate $U_1 \sim U_4$ evaluation performance belonging to each comment's membership degree respectively by means of programming in MATLAB, further calculate fuzzy evaluation matrix R, (refer to formula (5)), finally complete data fuzzy quantification. The row vector R_i is the corresponding input indicators data fuzzy quantification results.

$$R = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \\ r_{41} & r_{42} & r_{43} \end{bmatrix} \qquad (5)$$

Where R_{ij} represents the membership degree that the i-th neuron input belongs to the j-th comment, $i = 1,2,3,4;\ j = 1,2,3$.

C. Create BP Fuzzy Neural Network Using MATLAB

According to the step 1 and 2, the BP fuzzy neural network is set in this paper, in which input layer includes 4 neural nodes, fuzzy quantification layer has 12 neural nodes in total, neural node number in hidden layer is assumed to be 13 by experience, and the output layer has 3 neural nodes. Due to the input layer to fuzzy quantification layer data is calculate by MATLAB program, transfer weight coefficient from the input layer to the fuzzy layer is 1, which can regard the fuzzy layer as the network input layer directly, we create BP fuzzy neural network for combat service operation comprehensive performance evaluation by using the NN toolbox in MATLAB, refer to figure 3:

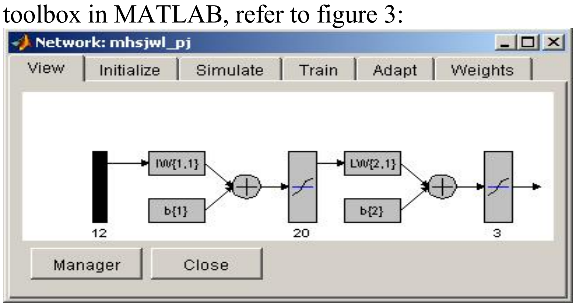

Figure 3 BP fuzzy neural networks

D. The training samples desired output obtained

We use BP neural network's fuzzy neural network evaluation method for evaluating combat service operation comprehensive performance. On the other hand, the BP neural network is a supervised learning method, so we should obtain training samples and ideal output, for training the network. In addition, the neural network evaluation has a poor interpretation, we uses FAHP evaluation method to obtain the network training samples expected output, in order to avoid the situation that appearing the evaluation result deviates from the actual result in process.

E. The Network Training and Testing Results Output

The transferring from input layer to the fuzzy layer is accomplished by means of MATLAB. The transfer functions from fuzzy layer to the hidden layer, from hidden layer to the output layer are logsig and tansig, respectively. Fuzzy neural network training function is traingdx, learning function is gradient descent learngdm. Test function is sim().

Ⅳ EXAMPLES OF SIMULATION

We take one Surface-to-Air missile weapon system as example, and select 10 groups of combat service operation data as the samples, refer to table 1. The ahead 8 groups of data as training samples, the latter 2 groups as the test samples, output results as shown in table 2:

TABLE 1 BP FUZZY NEURAL NETWORK INPUT DATA

Input	1	2	3	4	5	6	7	8	9	10
U_1	81.91	71.71	81.42	75.89	85.27	75.79	82.99	85.17	68.21	85.17
U_2	87.97	60.41	83.25	80.66	89.35	78.25	82.94	88.91	63.58	85.68
U_3	85.64	62.24	85.52	76.67	85.58	75.91	84.20	85.11	74.39	87.74
U_4	88.71	66.80	85.45	77.48	88.89	71.98	83.94	83.94	72.04	85.90

TABLE 2 BP FUZZY NEURAL NETWORK TRAINING AND TESTING SAMPLES OUTPUT AND ERRORS

Training	Ideal output	Quantized Value	Actual output	Qualitation	Quantitation	Error
1	[0.4708 0.3175 0.2117]	81.4784	[0.4764 0.3431 0.2153]	Excellent	80.689	-9.7e-3
2	[0.2492 0.4219 0.3289]	73.0095	[0.2491 0.4234 0.3292]	Good	72.594	-5.7e-3
3	[0.4603 0.3238 0.2159]	81.1100	[0.4943 0.3422 0.2249]	Excellent	80.4353	-8.3e-3
4	[0.3442 0.3934 0.2624]	77.0460	[0.3469 0.4019 0.2586]	Good	76.4799	-7.3e-3
5	[0.5110 0.2934 0.1956]	82.8842	[0.5034 0.3110 0.1849]	Excellent	82.3557	-6.4e-3
6	[0.3435 0.3939 0.2626]	77.0218	[0.3411 0.3816 0.2595]	Good	76.4565	-7.3e-3
7	[0.4825 0.3105 0.2070]	81.8881	[0.4767 0.3066 0.2229]	Excellent	80.9992	-1.0e-2
8	[0.5100 0.2940 0.1960]	82.8506	[0.5147 0.2927 0.1887]	Excellent	82.6589	-2.3e-3
Testing	Ideal output	Quantized Value	Actual output	Qualitation	Quantitation	Error
9	[0.2172 0.4343 0.3485]	71.7175	[0.2892 0.4021 0.3715]	Good	72.1217	5.6e-3
10	[0.5100 0.2940 0.1960]	82.8506	[0.5406 0.2773 0.1908]	Excellent	83.2388	4.7e-3

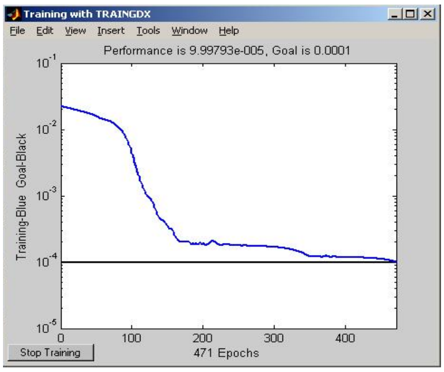

Figure 4 fuzzy neural network performance error convergence curves

In table 1 and figure 4, we use the proposed fuzzy BP neural network evaluation method for Surface-to-Air missile weapon system combat service operation performance evaluation. After 471 training steps, we simultaneously acquire the qualitative and quantitative evaluation results. The ideal output is gained by means of FAHP method, while actual output is the output results of the fuzzy neural network. The error between actual network output and desired output shows the BP fuzzy neural network evaluation method can perform the combat service operation performance evaluation better.

Ⅴ SUMMARY

With the development of Surface-to-Air missile simulation training equipment, implementation of combat service operations training has been largely replaced by simulation combat service operation training, combat service operation performance evaluation is vital beyond the combat environment. Scientific and objective combat service operation evaluation not only reflects combat personnel professional skills of participants directly, but also reflects the weak link in combat service operation training quantitatively. The system is helpful to promotion of “war to promote practice” instead of “promoting with evaluation to practice” system is formed, and can also make the combat service operation performance evaluation more scientific, humane. The simulation example above shows, the FNN evaluation method can be, effective for Surface-to-Air missile weapon system combat service operation performance evaluation objectively, and is also important for constructing reasonable combat service operation evaluation system has important military significance.

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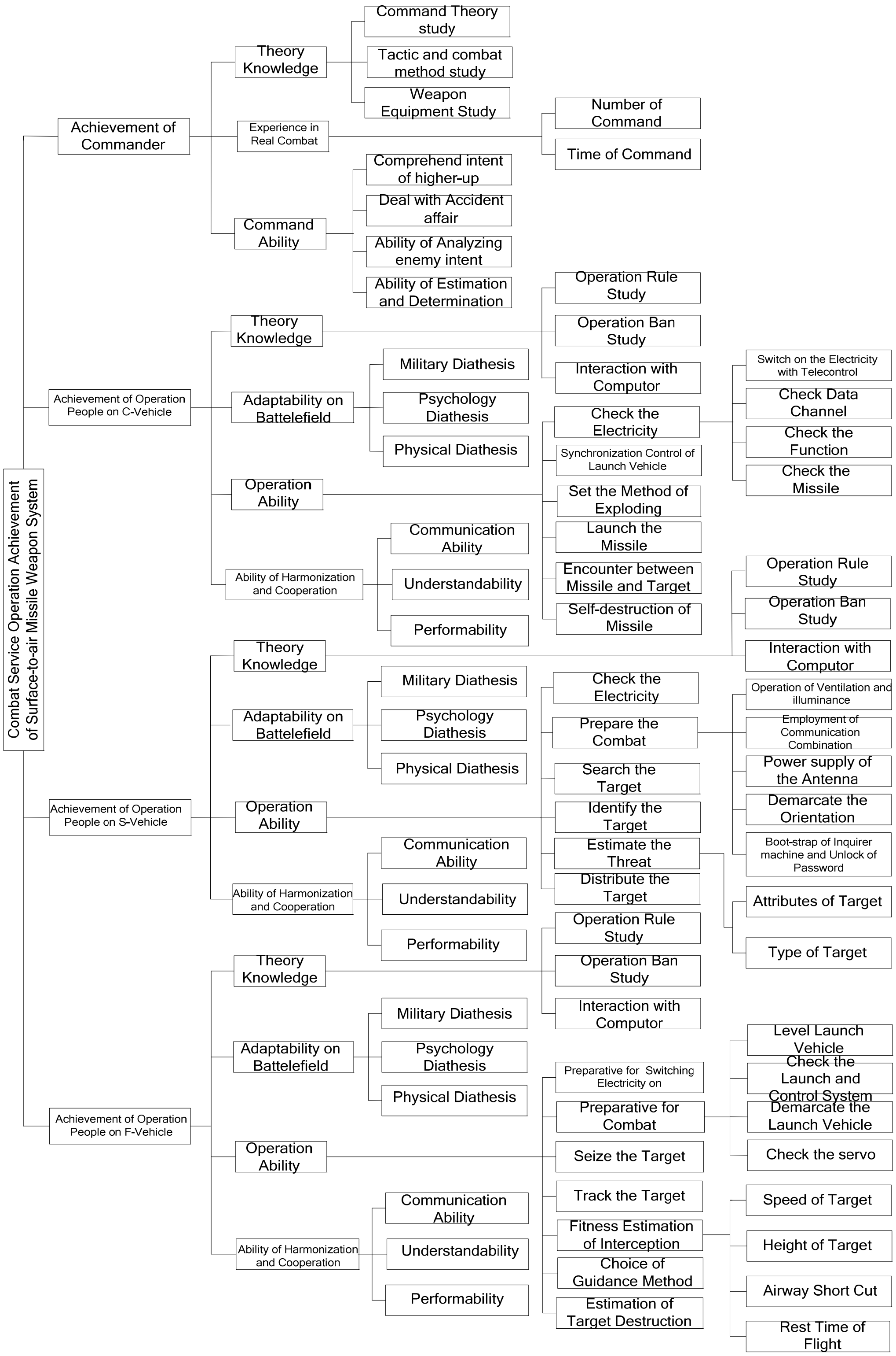

Figure1 Surface-to-Air missile weapon system combat service operation performance evaluation index system.